DiaMonD:
Developing a Diabetes Monitoring Device in the Australian Context

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Abstract  
Diabetes is one of the leading chronic diseases affecting Australians and its prevalence continues to rise. Diabetes is therefore becoming a serious challenge for both the quality of healthcare and expenditure in the Australian healthcare system. The goal of this study is to investigate the development and application of DiaMonD – a diabetes monitoring device. Powered by pervasive technology software developed by INET, DiaMonD is a wireless enabled mobile phone that can facilitate superior diabetes self-management. The development and application of DiaMonD using the Adaptive Mapping to Realisation methodology (AMR) methodology is examined in addition to an appraisal of key adoption facilitators and barriers in the Australian setting.

Key words: healthcare, diabetes, self-management, wireless, pervasive technologies, Australia

1 Introduction
Diabetes is one of the leading chronic diseases affecting Australians and its prevalence continues to rise. The total number of diabetes patients worldwide is estimated to rise to 366 million in 2030 from 171 million in 2000 (Wild, Roglic, Green, Sicree, & King,
2004). With increasingly growing prevalence which includes an estimated 275 Australians developing diabetes daily (DiabetesAustralia, 2008), Australia is expected to be a significant contributor to this projected trend. In fact, an estimated 700,000 Australians representing approximately 3.6% of the population were diagnosed with diabetes in 2004-05 and between 1989-90 and 2004-05 the proportion of people diagnosed with this disease more than doubled from 1.3% to 3.3%. Additionally, between 2000-01 and 2004-05, diabetes hospitalisations increased by 35% from 1,932 to 2,608 hospitalisations per 100,000 people (AIHW, 2008). Recent statistics also show that for every person diagnosed with diabetes, it is estimated that there is another who has yet to be diagnosed which doubles the number of diabetes sufferers (DiabetesAustralia, 2008). Diabetes is, thus, one of the fastest growing chronic diseases in Australia (AIHW, 2008; Catanzariti, Faulks, & Waters, 2007; Chittleborough, Grant, Phillips, & Taylor, 2007).

Diabetes can have a major impact on the quality of life of its patients and its long-term effects can evolve into serious complications. For instance, people with diabetes are at greater risk of developing cardiovascular, eye or kidney diseases, lower limb amputation and even reduced life expectancy than people without diabetes (AIHW, 2008; Rasmussen, Wellard, & Nankervis, 2001; Tong & Stevenson, 2007). These complications can lead to death, and currently, diabetes ranks as the sixth leading cause of death in Australia (DiabetesAustralia, 2008).

Evidence also shows that diabetes and its complications incur significant costs for the health system in Australia including costs incurred by carers, government, and the entire health system (DiabCostAustralia, 2002). For instance, in 2004-05 direct healthcare expenditure on diabetes was A$907 million which constituted approximately 2% of the allocatable recurrent health expenditure in that year (AIHW, 2008). Further costs include societal costs that represent productivity losses for both patients and their carers (DiabCostAustralia, 2002).

Diabetes can, therefore, have considerable social, human, and economic impacts and tackling these requires solutions that substantially enhance the existing fragmented and uncoordinated capacity for effective prevention, early detection and management (VictorianGovernment, 2007). Hence, a treatment imperative is to provide patients with appropriate levels of monitoring to ensure containment of the disease and prevention of further complications. Given the exponential growth predicted for patients suffering from this disease coupled with the geographic spread across Australia (AIHW, 2008), a pervasive technology solution would offer the necessary monitoring that is both cost effective, convenient to both patients and clinicians and least disruptive to patient lifestyle.

Recognizing the need to have a solution that can enable the ubiquitous monitoring of diabetes patients while also continuously educating them, the goal of this paper is to investigate the development and application of DiaMonD – a diabetes monitoring device. Powered by pervasive technology software developed by INET, DiaMonD is a wireless enabled mobile phone that can facilitate superior diabetes self-management in the Australian setting. The realization of this goal can contribute by establishing a benchmark for theoretical and empirical testing. To achieve this goal, first, we provide a general background on the Australian health scene and critically review existing research. An elaboration of the proposed pervasive mobile technology solution and of
the anticipated barriers and facilitators the Australian setting is then provided. The academic rigor is achieved through various key components starting with the use of the chronic care model to identify support from findings the benefits and need of patient self-empowerment, to date not well recognised with the design of various technology solutions for all areas of chronic diseases, the research methodology of the refocused systems development model which incorporates the unique delivery framework from which a suitable business model is developed to support a sustained solution and the unique development and application of the AMR methodology. Future trends are subsequently discussed before the paper is concluded.

2 Current Australian Health Scene

Both healthcare professionals and diabetes patients require quality information if disease conditions are to be effectively managed. Extant research shows that there are several deficiencies in the information provided by the existing system for monitoring diabetes in Australia (Dixon & Webbie, 2006; Sprivulis et al., 2007; Swerissen & Taylor, 2008). First, data collected in hospitals are episode-based rather than patient-based which makes it difficult to determine statistics concerning individual admissions, re-admissions, and treatment patterns. Second, there is lack of data on incidence and prevalence by diabetes type that can help reliably assess the magnitude of the problem. Third, the accuracy of recording data in administrative data sets, such as hospital morbidity, mortality and general practice data is uncertain. Finally, clinical management information is derived from uncoordinated and fragmented data collections that are not representative of the entire population of diabetes patients making comparison, analysis and trend identification difficult.

These deficiencies are the result of the current health system set up. Based on fee-for-service episodic doctor-patient consultation, the current Australian healthcare system can handle short-term illnesses involving a limited range of interventions including their diagnosis and treatment (Hunt, 2007). However, this system is comprised of a mixture of fragmented private and public healthcare subsystems that provide both healthcare funding and delivery. Largely uncoordinated, these subsystems are deemed to be unsuitable for the treatment of long-term chronic diseases including diabetes (Dixon & Webbie, 2006; Sprivulis et al., 2007). In particular, diabetes requires teams of various health professionals and long-term support to help sufferers make effective healthy lifestyle changes and constantly maintain them (Hunt, 2007).

3 Current Diabetes Self-management Research

As there is no cure for diabetes, non-medical approaches are used jointly with medical approaches so that patients can have a life which is as normal as possible. However, non-medical approaches can be challenging as they require effective lifestyle management and meticulous attention and monitoring by both patients and healthcare professionals (Britt et al., 2007). Particularly, to be successful, patients to be both informed and active in their treatment regimen (AIHW, 2007, 2008). This can be achieved by effective self-management which is a non-medical approach and which constitutes the focus of this paper.

Self-management is important as it empowers diabetes patients while acknowledging their central role and responsibility for managing their healthcare (ICIC, 2008). Extant research indicates that active participation of diabetes patients in self-management is a
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key strategy for managing their condition and reaching improved treatment outcomes (Colagiuri, Colagiuri, & Ward, 1998; Poulton, 1999; Rasmussen et al., 2001; Wellard, Rennie, & King, 2008). However, self-management is constantly time-consuming and requires significant self-discipline (Russell, Churl Suh, & Safford, 2005) and support strategies including assessment, goal-setting, action-planning, problem-solving and follow-up (ICIC, 2008). Moreover, because effective self-management may require patient interaction with various healthcare professionals, including general practitioners, diabetes educators, dieticians, and community nurses (Knuiman, Welborn, & Bartholomew, 1996), difficulties can arise when diabetes patients encounter problems ranging from making appointments to needing to travel to many locations (Van Eyk & Baum, 2002; Wellard et al., 2008; Zigbor & Songer, 2001). Given both the importance and complexity of applying self-management effectively for both prevention and early detection of diabetes, there are increasing calls for further research to facilitate self-management (Wellard et al., 2008).

A model proposed by Wagner (2008) requires productive interactions between informed and activated patients and prepared and proactive healthcare professionals (ICIC, 2008). One of the most important ways to achieve or at least facilitate this, entails the development of suitable information systems for building patient capacity to undertake self-management successfully (Joshy & Simmons, 2006). These information systems should provide the possibility for ubiquitous monitoring of an individual’s diabetes conditions, thereby, supporting the effective self-management of the disease. While being useful and easy to use so that patients can readily accept and interact with them in a meaningful manner, these systems also need to be robust and cost-effective to implement and provide auditing and benchmarking tools that are critical for the surveillance of patients (Joshy & Simmons, 2006). Additionally, these systems should provide patient summary profiles in a cost-effective manner that can empower diabetes clinicians with the ability to manage diabetes issues on an ongoing basis to improve patient care (Joshy & Simmons, 2006).

Current methods used in Australia for achieving patient self-management include various types of training and education and support options including peer-led, generic and tailored chronic disease self-management planning, training and support, telephone coaching etc. (Francis, Feyer, & Smith, 2007; Harvey et al., 2008). Although these were found to be effective to various extents, they are also resource-intensive and their long-term sustainability is questionable (Francis et al., 2007). Additionally, current research shows that quality improvement factors including timeliness, confidentiality, continuity, dignity, communication, access, education, cost, amenities and autonomy, still remain relatively elusive in the ambit of chronic disease services including diabetes (Tabrizi, Wilson, Coyne, & O'Rourke, 2008).

Although current research has provided solutions for supporting self-management (Chau & Turner, 2006; Rudi & Celler, 2006) these have not always been effective due to the reality that “patients did not learn how to do it [apply the solutions] or they did not understand the rules which were explained to them, or they are not sure enough of their knowledge, uncertainty entailing indecision” (Reach, Zerrouki, Leclercq, & d'Ivernois, 2005). Nevertheless, research shows that computer-assisted telemedicine can help people with diabetes improve both their self-management (Balas et al., 2004) and their relationship with healthcare professionals (Bodenheimer, Lorig, Holman, &
Grumbach, 2002; Downer, Meara, Da Costa, & Sethuraman, 2006). Therefore, in this paper, we investigate the development and application of DiaMonD as a pervasive mobile technology solution to facilitate superior diabetes self-management.

4 The Development of a Pervasive Mobile Technology Solution

We propose DiaMonD – diabetes monitoring device – as a solution which incorporates software that facilitates the ubiquitous monitoring of an individual’s diabetes, thereby, contributing to diabetes self-management. The solution is grounded in trying to support key components of a chronic disease care model (Table 1).

The journey began by realizing that the traditional System Development Lifecycle (SDLC) was fundamentally flawed for healthcare initiatives. This was due to several reasons including the length of time it would take to realize the final application and the structures and inflexible stages that had to be traversed. Thus, INET developed a refocused SDLC model (figure 1a) and delivery framework (figure 1b). It was, thus, possible to keep the strengths of SDLC and yet move from start to finish in a much more compressed time frame (Table 2).

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Organisation of Health System</td>
<td>• Leadership in chronic disease management (CDM)</td>
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<td></td>
<td>• Goals for CDM</td>
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<td></td>
<td>• Improvement strategy for CDM</td>
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<td>• Incentives and regulations for CDM</td>
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<td>• Benefits</td>
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<td>Self-management support</td>
<td>• Assessment and documentation of needs and activities</td>
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<td></td>
<td>• Addressing concerns of patients</td>
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<td></td>
<td>• Effective behaviour change interventions</td>
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<td>Decision Support</td>
<td>• Evidence-based guidelines</td>
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<td></td>
<td>• Involvement of specialists in improving primary care</td>
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<td></td>
<td>• Providing education for CDM</td>
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<td></td>
<td>• Informing patients about guidelines</td>
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<tr>
<td>Delivery System design</td>
<td>• Practice team functioning</td>
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<td></td>
<td>• Practice team leadership</td>
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<td>• Appointment system</td>
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<td></td>
<td>• Follow-up</td>
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<td></td>
<td>• Planned visits for CDM</td>
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<td></td>
<td>• Continuity of Care</td>
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<tr>
<td>Clinical Information</td>
<td>• Registry</td>
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</tbody>
</table>
### Systems
- Reminders to providers
- Feedback
- Information about relevant subgroups of patients needing services
- Patient treatment plans

### Community
- Linkages for patients to resources
- Partnerships with community organizations
- Policy and plan development

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**Figure 1a: Refocused SDLC Model**

- Refocus 1 to 5 year systems development life cycle into small manageable pieces
- Many eBusiness Projects
- concurrent Acceleration
- Traditional 1 to 5 Year Systems Development Life Cycle Project
- Measurable Benefits

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The research goal is to use a standardized mobile Internet (wireless) environment to improve patient outcomes with immediate access to patient data and provide the best available clinical evidence at the point of care. To achieve this, INET International Inc.’s research (S. e. a. Goldberg, 2002a, 2002b, 2002c, 2002d, 2002e; Wickramasinghe & Goldberg, 2003, 2004) starts with a 30-day e-business acceleration project in collaboration with many key actors in hospitals, such as clinicians, medical units, administration, and I.T. departments. Together, they follow a rigorous procedure that refocuses the traditional 1-5-year SDLC into concurrent 30-day projects to accelerate healthcare delivery improvements. At completion, an e-business acceleration project delivers a scope document to develop a handheld technology application (HTA) proof-of-concept specific to the unique needs of a particular environment. The proof-of-concept is a virtual lab case scenario which operates within a mobile Internet (wireless) environment by working with hospitals and technology vendors. The final step is the collection of additional data with clinical HTA trials consisting of two-week hospital evaluations.

With the refocused SDLC model it was then possible to design a robust and rigorous web-based business model, the INET web-based business model (figure 2). This business model provides the necessary components to enable the delivery framework to be positioned in the best possible manner so it can indeed facilitate enacting the key components of the chronic disease model successfully (table 1). The model is positioned to suit the complex nature of healthcare environments by iteratively, systematically, and
rigorously incorporating lessons learnt data to healthcare processes for ensuring superior healthcare delivery. This manner does not only maximize the value of past data and organisational learning but it also makes processes amendable as complex needs and requirements evolve.

<table>
<thead>
<tr>
<th>SDLC (waterfall)</th>
<th>INET Mobile e-Health Project</th>
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<tr>
<td>I.T. Role &amp; Responsibility</td>
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<tr>
<td>Scope</td>
<td>Localize</td>
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<td>Project Management</td>
<td>Data Analysis</td>
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<td>Business Analysis</td>
<td>Technical Tools Expert</td>
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<td>Programmer</td>
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<tr>
<td>Investigation</td>
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<td>Problem Definition</td>
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<td>Feasibility Study</td>
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<td>– can objectives be met at a reasonable cost.</td>
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<td>Project Definition</td>
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<thead>
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<tr>
<td><strong>Scope</strong></td>
<td><strong>Localize</strong></td>
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<tr>
<td><strong>Analysis</strong></td>
<td>Define what the IS must do to fix the problem</td>
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<tr>
<td><strong>(Logical Design)</strong></td>
<td>Less temptation to follow existing practices which may not be best</td>
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<td></td>
<td>Define the user’s requirements and priorities Analyze existing system</td>
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<td></td>
<td>Develop logical design for the new system</td>
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<tr>
<td><strong>Design</strong></td>
<td><strong>Field</strong></td>
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<tr>
<td><strong>(Physical Design)</strong></td>
<td>Define how the new system will work</td>
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<td></td>
<td>Detail Schedule and budget</td>
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<td></td>
<td>Produce a physical design showing system inputs, outputs, user interfaces.</td>
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<tr>
<td><strong>Implementation</strong></td>
<td><strong>Evaluate</strong></td>
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<tr>
<td>Research technology</td>
<td>User’s Manual</td>
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<tr>
<td>Product Acquisitions</td>
<td>People Changeover Tasks</td>
</tr>
<tr>
<td>Test programs, sub-systems and systems</td>
<td>Data Conversion.</td>
</tr>
<tr>
<td>acquire or develop software</td>
<td>Technical Changeover Tasks</td>
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<tr>
<td>Code programs</td>
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<tr>
<td>Software developer manual</td>
<td></td>
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<td>System operators manual</td>
<td></td>
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<tr>
<td>Purchase and Install hardware and software package</td>
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<tr>
<td><strong>Maintenance</strong></td>
<td><strong>User’s Manual</strong></td>
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<tr>
<td>Fix Problem/Solution Determination</td>
<td>People Changeover Tasks</td>
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<tr>
<td>Fix Database, Network and 3rd Party Products</td>
<td>Data Conversion.</td>
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<tr>
<td>Fix security and access problems</td>
<td>Technical Changeover Tasks</td>
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<td>Fix learning curve time disruptions</td>
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<tr>
<td>Fix collaboration problems</td>
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**Table 2:** INET Practice Framework – Compressing the SDLC

It is important to note that in this business model the three key areas of risk, namely, people, processes and technology, are minimised through the use of pervasive
technology which we believe is a unique benefit of the INET solution. Specifically, since the proposed solution is an application that is compatible with any mobile phone or wireless device (e.g. a PDA) data transfers occur between patients and providers on a well vetted model. Therefore, the learning curve for patients may be minimal as they are likely to be in possession of mobile devices.

Successful web-based projects in healthcare require the consideration of many components. Figure 2 provides an integrative model for all key success factors that we have identified through our research (S. e. a. Goldberg, 2002a, 2002b, 2002c, 2002d, 2002e; Wickramasinghe & Goldberg, 2004; Wickramasinghe & Misra, 2004; Wickramasinghe, Schaffer, & Geisler, 2005). What makes this model unique and most beneficial is its focus on enabling and supporting all areas necessary for the actualization of ICT initiatives in healthcare. By design, the model identifies the inputs necessary to bring an innovative chronic disease management solution to market. These solutions are developed and implemented through a physician-led mobile e-health project. This project is the heart of the model that bridges the needs and requirements of many different players into a final (output) deliverable, a “Wireless Healthcare Program”. To accomplish this, the model is continually updated to identify, select and prioritize the ICT project inputs that will:
Accelerate healthcare system enhancements and achieve rapid healthcare benefits. The model identifies key healthcare system inputs with the four Ps, namely, 1) **People** that deliver healthcare, 2) **Process** to define the current healthcare delivery tasks, 3) **Platform** used in the healthcare technology infrastructure, and 4) **Protection** of patient data.

Close the timing gaps between information research studies and their application in healthcare operational settings.

Shorten the time cycle to fund an ICT project and receive an adequate return on the investment.

Together the components of the model will help in actualizing physician-led solution for the management of chronic diseases in general and of diabetes in particular. The delivery framework activities (Figure 1a and 2) are ongoing and represent a continuous improvement cyclical approach towards a given wireless healthcare program. These activities however require the relevant and complete inputs from the healthcare system if they are to be carried out successfully. With the refocused SDLC in constructing mobile e-health solutions, both the healthcare inputs (i.e. the four Ps) and the delivery framework may require funding from various sources in return for healthcare improvements and the building up of intelligence in terms of relevant research findings.

To successfully implement the business model described above it was, however, necessary to have an appropriate methodology. Based on this need the adaptive mapping to realization methodology (AMR) was developed (figure 3). The idea of the methodology was to apply a systematic rigorous set of predetermined protocols to each business case and then map the post-prior results back to the model. In this way, it was possible to compare and contrast both a priori and post priori findings. From such a comparison a diagnosis of the current state was made and then prescriptions were derived for the next business case. Hence, each pilot study incorporated the lessons learnt from the previous one and the model was adapted in real time.
Figure 3: AMR Methodology

By applying the tools and techniques of today’s knowledge economy as presented in the intelligence continuum (IC) it is possible to make the AMR methodology into a very powerful knowledge-based systems development model (figure 4). The IC was developed by Wickramasinghe and Schaffer (2006) to enable the application of tools and technologies of the knowledge economy to be applied to healthcare processes in a systematic and rigorous fashion and thereby ensure superior healthcare delivery. The collection of key tools, techniques and processes that make up the IC include but are not limited to data mining, business intelligence/analytics and knowledge management (Wickramasinghe & Schaffer, 2006).
Taken together, they represent a very powerful system for refining the raw data stored in data marts and/or data warehouses and thereby maximizing the value and utility of these data assets for any organization. To maximize the value of the data generated through specific healthcare processes and then use this to improve processes, IC techniques and tools must be applied in a systematic manner. Once applied, the results become part of the data set that are subsequently reintroduced into the system and combined with other inputs of people, processes, and technology to develop an improvement continuum. Thus, the IC includes the generation of data, the analysis of these data to provide a “diagnosis”, and their reintroduction into the cycle as a “prescriptive” solution. In this way, the IC is well suited to the dynamic and complex nature of healthcare environments and ensures that the future state is always built upon the extant knowledge-base of the preceding state. Through the incorporation of the IC with the AMR methodology we then have a knowledge-based systems development model that can be applied to any setting, not necessarily to chronic disease management. The power of this model is that it brings best practices and the best available germane knowledge to each iteration and is both flexible and robust.
Figure 5: ICT Support for Diabetes

Figure 5 describes succinctly the INET solution where patients in the program submit glucose readings through their cell phones. The patients’ primary care physician subsequently reviews the results and makes recommendations, which are transmitted back to the patients’ cell phones for review. This is an alternative method of communication between the patient and primary care physician to support the control of patient’s diabetes. The patient creates a bookmark in their cell phone, and then using a unique patient ID, they gain access to an application to quickly enter glucose readings and access messages. The physician is given an internet link, and using their unique physician ID, he or she can quickly access a list of patients, trends and a simple way to send messages.

Thus, DiaMonD represents a pervasive ICT enabled solution which while not exorbitantly expensive it facilitates the superior monitoring of diabetes (figure 5). The proposed solution enables patient empowerment by way of enhancing self-management. This is a desirable objective because it allows patients to become equal partners with their clinicians in the management of their own healthcare (Opie, 1998; Radin, 2006) by enhancing the traditional clinical-patient interactions (Mirza, Norris, & Stockdale, 2008). However, because most work has focused on specific applications and proof-of-concept studies, this paper would be incomplete without considering the critical success factors, including facilitators and barriers, that are expected to affect the ubiquitous adoption of the proposed solution in the Australian setting (Gururajan & Murugesan, 2005; Mirza et al., 2008).

5 Anticipated Barriers and Facilitators in Australia

In order to move smoothly from idea to realisation, we identify and discuss seven factors that may impede or facilitate the success of DiaMonD in the Australian setting. First, DiaMonD has the potential to reduce face-to-face interaction between patients and
their clinicians. While this may be favourable for some patients, it may impact on the social needs of others for human interaction. This may lead to resistance or even rejection for adopting DiaMonD at both conscious and subconscious levels (Vanjara, 2006). However, we argue that DiaMonD incorporates mobile phones which are perceived to confer a social status amongst some segments of society which may well become an adoption facilitator. Furthermore, usage of mobile phones may also help eliminate the social stigma that can occur with alternative obvious devices that are used for monitoring chronic diseases (Mirza et al., 2008).

Second, mobile phones are location-independent which makes healthcare monitoring both flexible and ubiquitous, that is, not confined to specific settings, such as hospitals (Istepanian & Lacal, 2003). While also generating potentially significant cost savings (e.g. by reducing false positive or non serious hospitalisations) for managing the care of non-critical diabetes sufferers DiaMonD will also improve their quality of life (Istepanian, Jovanov, & Zhang, 2004; Mirza et al., 2008; Norris, 2002). This may, thus, facilitate DiaMonD adoption.

Third, the ageing population in Australia combined with the fragmented nature of the Australian healthcare system that is designed to treat episodic conditions, and the generally poor awareness of life style implications will increase the pressure on this system for better chronic disease treatment standards over longer periods (ABS, 2003; Rowland, 2003). The pervasive nature of DiaMonD combined with its ability to offer targeted and tailored health messages can contribute to ease that pressure, and consequently, become a facilitator for its adoption in Australia (Neville, Greene, McLeod, & Tracy, 2002).

Fourth, there is evidence suggesting that to date, some sectors of the healthcare system in Australia have not been convinced of the benefits of ICT in general and pervasive mobile solutions in particular (Yu, Li, & Gagnon, 2008). At least partially, this is due clinicians’ preference and bias towards traditional face-to-face forms of interactions with their patients (Skulimowski, 2006). Furthermore, in a recent study, Australian nurses and clinicians considered that the vast majority of employers did not encourage ICT training, and for those for whom training was available, heavy workloads were considered to be major barriers for training uptake (Eley, Fallon, Soar, Buikstra, & Hegney, 2008). Taken together, these factors are expected to become barriers for the adoption of DiaMonD. Organisational changes, including establishment or awareness and training are, thus, required for extended adoption and diffusion (Mirza et al., 2008).

Fifth, DiaMonD is expected to be highly cost-effective for people with diabetes. For example, costs to patients are estimated to be confined to data transfer charges which include the systematic texting (e.g. by SMS) of glycemic levels (measured by HA1C readings). With increasing competition amongst Australian operators, data transfer charges are expected to decrease in the future (Troshani & Rao, 2007a). Another possible cost to patients may include mobile handset acquisition. However, with a very high mobile penetration rate in Australia, diabetes patients are likely to already be in possession of mobile phones (Rao & Troshani, 2007a, 2007b). Nevertheless, DiaMonD may require investment outlays from health providers. Initial setup, operational, and supporting infrastructure costs may be barriers for its smooth adoption in Australia (Khambati, Warren, Grundy, & Hosking, 2008).
Sixth, legislation and perceptions of security and privacy are likely to have a strong bearing on the successful adoption of DiaMonD in Australia. Although, the model underpinning DiaMonD accounts for protection of patient information in terms of privacy, security, and reliability, both individual and organisational adopters are expected to require solid guarantees that continuous security improvements will reliably safeguard the privacy of patient data. Nevertheless, extant research shows that these concerns may dissipate overtime as mobile technology matures and benefits and convenience begin to be experienced on a wide scale (Mirza et al., 2008).

Finally, other factors that, in various forms, may become barriers for the adoption of DiaMonD in Australia include existing disparate legacy systems and possible integration costs, lack of standards and limited bandwidth (Mirza et al., 2008). Additionally, prioritisation and decision-making processes concerning the introduction and diffusion of new health technologies in some areas in Australia are described to be ‘ad-hoc’ (Gallego, Fowler, & van Gool, 2008). Budgetary constrains often drive uptake and diffusion of new technologies (Gallego et al., 2008).

6 Discussion
Modern healthcare delivery can benefit from the incorporation of various technology enabled solutions. The preceding sections have served to describe and highlight the example of DiaMonD – a pervasive wireless technology solution. We stress that we use the name of the product not as a marketing ploy but rather to show that it is possible to create superior technology enabled solutions that are simple and inexpensive. More importantly, in many ways the strengths of this paper are not in the product or the solution but rather its academic rigor. The vast majority of healthcare technology solutions are developed and trailed by pharmaceutical companies and /or vendors. In this instance we describe an independent research study. From the very onset where the justification of patient self-empowerment was grounded in literature and the chronic care model to the development of the revised systems development model for the initiation and expansion of the physician-led pilot studies to the conceptualisation and design of the delivery framework which ensures both tailoring to the local context and yet a standard framework that thus support both between and within comparisons of directional data and randomised control trials, to the defining of a suitable business model to ensue that the solution is in fact sustainable to the role and incorporation of the AMR methodology to enable continuous improvement and the power of the tools and techniques of the knowledge economy to be accessed and utilised to ensure that the solution provided to patients is at all times derived from the best set of inputs and the latest knowledge. This in turn ensures that the principles of evidence based medicine are adhered to, something that one cannot validate externally when trials and research are being conducted by third parties such as vendors or pharmaceutical companies.

This paper then stands apart from the majority of healthcare IS/IT papers that describe a technology solution to address a healthcare problem in that it develops an objective set of criteria to measure success in a systematic fashion. Hence in the Australian context it is essential that the delivery framework be defined to capture the key and unique elements of the context as well as maintain the essential strengths of the solution. For example under: 1) scope - it would be necessary to investigate in the long term the role healthcare insurance companies would play; would they provide rebates or not for this treatment and/or would this rebate be provide through Medicare, 2: Localize – it would
be necessary to gather documents pertaining to current practices in Australia what is considered appropriate blood readings and whether these differed from other standards; 3) Field – it is necessary to undergo relevant and appropriate ethical clearance in the Australian context; 4) Evaluate – this would require several levels including comparing and contrasting directional data and data from randomised control trials to those of studies in other countries, across multiple studies within Australia and looking at patients with different diabetic conditions as well as within the one study. In addition, it would be essential to continuously update the inputs so as to preserve the AMR methodology.

It is also important to note that the approach and elements described in this paper can be used in other contexts in healthcare with other technologies. Thus, we believe another contribution of this paper is to recommend that a suitable approach for applied research initiatives in healthcare is to follow the essential steps we have outlined in this paper as follows: 1) ground the role for the technology in a medical need that is identified in the literature – e.g. in this study we have identified patient self-empowerment as identified in the chronic care model, 2) look at existing established models and adapt them if required rather than just move forward – i.e. the use of the refocused SDLC model, 3) design a robust delivery framework that is flexible and yet robust to apply in various contexts so as to facilitate between and within group comparisons of data, 4) design an appropriate business model that ensures a sustained solution – for healthcare nothing is worse than to offer patients a superior solution for only a short time – i.e. the use of the web-based model, 5) incorporate the tools and techniques of the knowledge economy – given the push to evidence-based medicine and the vast amount of data and information in healthcare this is essential – i.e. the use of AMR methodology.

7 Future Developments

Given the general global consensus that effective and efficient healthcare delivery will only occur through the judicious application of ICTs (FS, 2004; Kulkarni & Nathanson, 2005; Lacroix, 1999; Porter & Tiesberg, 2006; Wickramasinghe, 2007), it is inevitable that, as we move into the second decade of the 21st century, the prevalence of ICTs to facilitate the delivery of value driven healthcare will increase. We believe in such a climate DiaMonD will be even more appropriate not only because it utilises ICTs to provide superior healthcare delivery in the case of diabetic patients but it is also simple to implement and use and cost effective both at the micro and macro levels. These levels include both individual patients and clinicians and organisations including public and private healthcare providers.

Nevertheless, it is anticipated that increased adoption and diffusion of chronic disease mobile self-management solutions may depend increasingly less on technology and increasingly more on acceptability by both patients and clinicians, on the one hand, and on organisational healthcare providers, on the other. Clearly, mobile solutions such as DiaMonD need to suit and be consistent with both patient lifestyles and work practices undertaken by clinicians within healthcare provider organisations. This may be indicative that education programs and promotional campaigns may need to be undertaken for enhancing awareness and incentivising adoption. Tested processes and procedures will result that greatly facilitate the creation of personal medical records and effective and efficient forms of interaction with patients who suffer from a very debilitating chronic disease such as diabetes.
We also believe that the model underlying DiaMonD can be extended and adapted to provide the necessary monitoring and self-management to other chronic diseases including but not limited to hypertension, cardiac conditions and obesity. Diseases of this nature require daily tests and continuous monitoring which are typically essential to recommended treatment. However, widespread adoption and diffusion of mobile self-management solutions for chronic disease management also implies that practical steps may need to be undertaken in the future concerning the development, implementation, and evaluation of information standards as well as subsequent integration with healthcare legacy systems.

The effective application of wireless solutions such as DiaMonD entails the existence of a trusting environment amongst all stakeholders including patients, physicians, insurers and government. A trusting environment constitutes an important factor in the adoption of DiaMonD and diabetes self-management service it provides. Trust determines the patients’ expectations in their relationships with their healthcare providers, and it increases their perceived certainty concerning the provider’s expected behaviour. More generally, trust is essential in all economic activities where undesirable opportunistic behaviour is likely to occur (Gefen, Karahanna, & Straub, 2003). However, trust becomes particularly vital in a mobile environment in a healthcare setting, where situational factors such as uncertainty or risk and information asymmetry are present (Ba & Pavlou, 2002). On the one hand, patients maybe unable to judge the trustworthiness of healthcare providers, and on the other, the latter can also easily take advantage of the former by engaging in harmful opportunistic behaviours. For example, healthcare providers can engage in illicit behaviours including selling or sharing the personal information of its patients.

There are two key elements in any trusting environment including healthcare, namely, security and privacy (Lu, Yu, Liu, & Yao, 2003). Security encompasses confidentiality, authentication, and message integrity. Because DiaMonD can have limited computing resources and wireless transmissions are more susceptible to hacker attacks, security vulnerabilities can have serious consequences (Galaxi-Janaqi & Nah, 2004; Lu et al., 2003). These can be particularly serious in a healthcare setting. There are several remedies against the dangers of insecurity. For example, public key infrastructure and certification authorities which use public key cryptography to encrypt and decrypt mobile transmissions and authenticate both patients and healthcare providers.

Ironically, the same information practices which provide value to both patients and healthcare providers also cause privacy concerns. Some of these concerns include: the type of information that can be collected about patients and the ways in which it will be protected; the stakeholders and entities that can access this information and their accountability; and the ways in which the information will be used (Galaxi-Janaqi & Nah, 2004). In healthcare settings where solutions such as DiaMonD are used, a trusting environment can be encapsulated in perceived credibility (Lin & Wang, 2005; Wang, Wang, Lin, & Tang, 2003). Evidence shows that there is a significant direct relationship between perceived credibility and the intention to adopt general mobile services (Lin and Wang, 2005, p. 410). However, we call for further research to test if this relationship holds true in healthcare settings as well.

Finally, we are investigating the possibility of combining the wireless self-management initiative with a community support perspective. Specifically, future research is
currently being directed to investigate the manner in which social networks can be used jointly with DiaMonD to facilitate healthcare delivery (S. Goldberg, 2009). Particularly, we believe that this can be achieved through the development of diabetes patient’s own social network (e.g. in Facebook). In this way, we will not only be empowering diabetes patients to take control and responsibility for monitoring and managing their own care (i.e. via DiaMonD) but also making available to them as conveniently and as unobtrusively as possible access to the necessary community support via their social networks. Preliminary trials offer encouraging findings (S. Goldberg, 2009). We firmly believe that such a model has large and far reaching implications for delivery of care in general as well as the economics of healthcare delivery and further research is current underway.

8 Conclusions
We set out to present a case for the need to embrace a pervasive technology solution for the superior monitoring of diabetes self-management for patients in Australia. Developed by INET, we have argued that DiaMonD is a suitable wireless solution for many reasons including that it is equally successful in controlling both type I and type II diabetes, is as effective irrespective of patient’s age, socio economic standing or location and has minimal risks and a very slight learning curve (if at all). We contend that if such DiaMonD and its underlying model were to be incorporated into the Australian context the growing segment of the population suffering from diabetes would have a convenient, cost effective and superior means of monitoring and thereby controlling their diabetes while in turn enjoying a better quality of life.

DiaMonD facilitates governments, associations, pharmaceutical firms, researchers, healthcare professionals and other healthcare stakeholders that are looking for improved and measurable outcomes among patients suffering from diabetes. Specific benefits range from decreasing diabetes related complications to reducing the economic burden on the health system. We realise that further research is required to test DiaMonD in the Australian healthcare setting including testing of aspects, such as perceived ease of use, perceived usefulness, etc. Nevertheless, we conclude by warning that if a pervasive technology solution is not sought for the monitoring and support of diabetes self-management not only will this chronic disease become a silent epidemic but it will also be a very costly burden for both the healthcare sector and the community at large.

References


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