SMS4DADS – THE INFORMATION TECHNOLOGY ARCHITECTURE OF AN EHEALTH APPLICATION

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Abstract— Ongoing advances in web technologies has facilitated innovative opportunities for many traditional industry sectors to move services into the virtual realm. eHealth is one contemporary field that has come of age and continues to expand due to the rapidly evolving information and communication web based technologies it is founded upon. It is increasingly common to find systems integrating multimedia features, mobile and email messaging, customized user experiences and data analytics into a single system that provides enhanced eHealth services to an expanding global user base. Our research has contributed a number of significant innovative solutions to this area. SMS4Dads, detailed in this paper, represents an eHealth platform delivering support and mental health services to new fathers. Based on web technologies, SMS4Dads integrates personalized messaging services, surveys and data analysis of results, multimedia self-help resources in addition to traditional web site features. As part of the research, SMS4Dads included a Randomized Control Trial RCT stage preceded by the initial pilot case study. To date, SMS4Dads has received overwhelming positive feedback from users, peers, industry, and the media. It has formed the base architecture of a whole suite of follow on applications supporting a diversifying range of eHealth services.

Index Terms—eHealth, Mobile Architecture, Mood Tracker, Web Application, Web Technologies.

I. INTRODUCTION

eHealth research, most commonly defined as using information and communication technologies for health [1], is in demand both from academic and industry sectors. [2]. While eHealth has many academic definitions, common among them is its dependency on information and communication technologies. The term eHealth has been in accepted use since 1999, and one particularly early explanation of eHealth which remains relevant today is expanding the scope of the 'e' in eHealth [3]. The authors in [3] have defined ten additional academic environmental characteristics for the 'e' that are: efficiency, enhancing quality, evidence based, empowerment, encouragement, education, enabling, extending, ethics, and equity. These ten items provide a rudimentary but critical guide when designing new eHealth technologies. The authors expanding portfolio of eHealth technological innovations use these ten characteristics by integrating them into the system development life cycle of our eHealth applications and platforms. For this paper, the focus has been on Mental Health and parenting support for new fathers.

The projects name and tag line are descriptors of what the solution provides along with target demographic of its users. "SMS4dads – Info to your phone for dads on the go" is an eHealth application based on an ICT platform delivering services and information in the form of written and multimedia formats, messaging (SMS and email), mood tracking, data survey capturing and analysis, and access to real world mentors and health professionals. The context and of the application in parenting and mental health support for new busy fathers. The term 'busy' encompassing modern male adults already balancing many of life's challenges and hectic schedules that have become new fathers. Whether they are finding parenthood challenging or just looking for additional information and support on being a new father, SMS4dads provides support for their respective issues. Motivation for the project-based research came from traditional literature analysis and market studies identifying a distinct lack of support options for new fathers. Unlike new mothers, not many resources were available that focused on supporting new fathers.

The initial platform evolved from a previous research endeavor the authors completed as a pilot project. The initial concept came from the StayinOnTrack platform [4, 5], which provided culturally focused eHealth services to young Indigenous Australian fathers. The focus in this platform was one of peer and mentor engagement, allowing the young fathers to not only have access to information, but also custom built multimedia content such as videos of similar demographics discussing their early fatherhood experiences. At the time of development and design this approach was world leading and innovative in its integrated content and ICT usage. Since, then a number of similar initiatives have started to propagate in the literature and Industry, an indicator of success. As such, the StayinOnTrack architecture was an ideal foundation to build on for SMS4Dads. Since then it has evolved, encompassing the features and services discussed in this paper.

Besides detailing the ICT architecture of SMS4Dads the next section provides a brief literature review of background and related work. Section III provides the conceptual framework designed for implementation of SMS4Dads in addition to mention of the Mental Health and support services that had to be included in the final solution. Section IV explains the production

system, while Section V details the eHealth features of the innovative Mood Tracker module. The final section is the Conclusion followed by the paper references.

II. BACKGROUND AND RELATED WORK

Contemporary literature has an increasing mass of papers detailing recent research and projects in the eHealth space. Fortunately, the eHealth domain, more than any other emerging collaborative area, displays the ability to sit evenly between to the two primary disciplines driving its innovation and evolving its definition. The Health discipline provides the need and application context, while the Information and Communication Technologies (ICT) facilitate the creation, design and realization of the unique solutions. Similar to the eHealth domain, the author's collaborative team is composed of both Health and ICT academics. Such a grouping has provided a fruitful collaboration, generating a growing number of innovative research outputs. However, as briefly discussed in this section, it is a booming field, and the literature shows there is a wealth of similar successful research solutions. Due to the leading author, being from an ICT/Computer Science background, this paper is from this perspective. As such, the literature reviewed in this section focuses on the technological dimensions.

The literature has shown that a successful formula for eHealth initiatives and interventions is the integration of a number of ICT devices, platforms, and software applications [6]. In particular, the combination of eHealth interventions with health information systems has proven sustained success [7]. However, eHealth research is not without its challenges as discussed in [8], but consideration of the target user's perspectives, in addition to asking the right questions, such as "what can people do?" rather than "what can the computer do?" [9], contributes to the success of the delivered solution. Additionally, focusing on what the eHealth technology contributes in practice to all stakeholders [10] is an important design factor that influences the sustainability and effectiveness of the final system. For example, building a mobile based eHealth application to run only on the latest smart phones is doomed for failure if the target demographic of users (such as the elderly in this example) are not proficient with the use of the chosen technology, or do not even own the target device.

Likewise, not only does the design and development of the actual system need to be well planned but also the infrastructure and environment it is to run in needs careful analysis and consideration [11]. Essentially a more holistic approach is required when providing a future eHealth solution. It requires careful evaluation, planning, and where possible pilot studies to collect data for analysis before a full eHealth system implementation [12]. Elements to consider extend to include user competencies in the technologies for integration and development. In cases where user knowledge and skills are missing, suitable educational programs before or during the early stages of deployment are required [13]. In a Health context it means both the health provider and the patient would need to be technically competent in the new eHealth service [14]. Again highlighting pilot study importance and choosing the right demographic to provide the targeted eHealth services.

The Simple Message Service (SMS), a rather fundamental technology nowadays, has become the cornerstone of many eHealth innovations over the last decade. The literature provides a wealth of research studies that utilize SMS as the preferred medium of communication with participants. While limited by the message size, it provides numerous other benefits, primarily the fact it only requires low bandwidth (and hence mobile/cell signal strength) in addition to the fact that most generations of mobile/cell phones support it. Further, it is a globally accepted medium, easy to use form of messaging and interaction, and able deliver information or 'links' to more detailed knowledge sources. Other advances in Internet technologies allows SMS 'messages' to be composed dynamically and sent from a Web Server using the appropriate SMS gateway. With good system design and integrated software development, semi-autonomous two-way interactions can occur between users and contemporary eHealth systems. When required, interactions escalate and human health professionals automatically receive notifications that their intervention is now required [15, 16].

SMS use in eHealth services is very diverse and covers many areas within the health sector. These include asthma control [17], measles immunization [18], medication monitoring [19], physical activity and nutrition [20], and support for pregnant woman [21] to list a few. The eHealth areas of the authors' research Centre are the domains of mental health and family support. Specifically for the project detailed in this paper, the focus is on mental health for new fathers and basic parenting information. Reviewing the literature reveals minimal research or industry support for this sector. While there are an increasing number of eHealth initiatives for new mothers [22, 23] new fathers do not have many options to get help. Some related literature provides services for fathers understanding and supporting breastfeeding [24], helping their partners with perinatal depression, and the importance of including men in prenatal health [25].

The lack of literature, active research, and industry based eHealth support for expecting and new fathers was the motivation for the authors work. From a health perspective, the early foundational ideas and concepts appear in [26]. The results of the initial pilot study, detailed in [27], provide the necessary health related background information to support the Information and Communication dimensions explained in this paper. EHealth, due to its cross-disciplinary nature,

affords such a dual publication path, as targeted publications sources allow the expansion of the respective discipline technical dimensions. Thus providing more complexity within the domain of expertise, rather than a single more generic paper.

III. CONCEPTUAL FRAMEWORK

The project represents a cross disciplinary collaboration between health and engineering Faculties at the University of Newcastle (UoN). Specifically, the initial concept was devised through a group of leading family health academics from the UoN Family Action Centre [19]. As the conceptual idea and deliverable involved the use of ICT collaboration was sought from the lead author of this paper from the School of Electrical Engineering and Computing. From there the project gained momentum and conceptual design rapidly evolved to become a full-fledged merging of health services delivered through an ICT medium. That is, the research and project was quickly classified under an eHealth initiative. Fortunately, due to the high demand and urgent need of services to support the indigenous population the project was well received and garnered a wealth of support and attention.

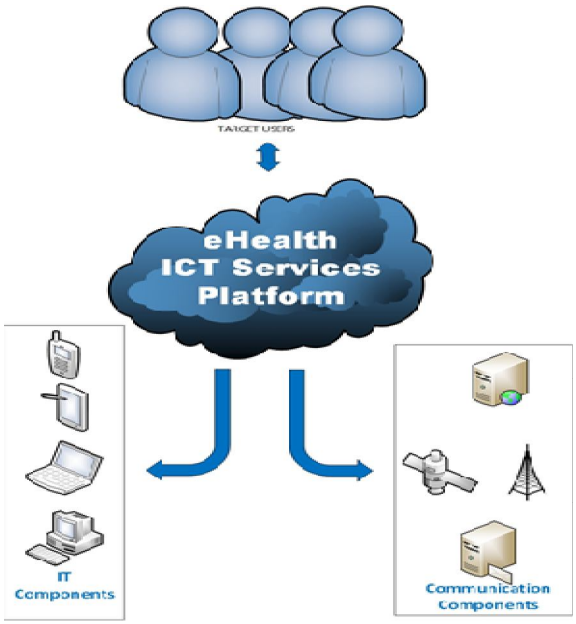


Figure 1. Required ICT features for conceptual artefact

The next phase of evolving the conceptual design included integrating both the research objectives from both a health and IT perspective, while also being able to produce a viable and usable artefact that was comparable to a commercial equivalent. As the target demographic was already in place: first time or new fathers the next step was to design and optimize the resulting artifact to best meet the needs, lifestyle, and capabilities of the desired user group. As such a mobile platform was deemed most appropriate and preferable, in addition to parallel standard web application interface design to accommodate all required access mediums (mobile, tablet, laptop, and desktop). With the IT dimension in place the communication formats needed to be defined. It was determined that due to the preferred mobile platform, then an initial point of contact along with follow up communications should be SMS based. The reasons being that they only require limited bandwidth to work, and also a baseline mobile device to access. In addition, where available emails will be used to provide enhanced multi-media communications, while a web based mobile application will store the bulk of the features, knowledge and processing requirements. Figure 1 displays the various conceptual design elements that were deemed necessary.

As the conceptual design continued to evolve it was decided to integrate video messages into the web application. In addition, a few other features were deemed necessary to satisfy other research objectives. These included: collection of demographical personal details, tracking of user browsing through click collection, and an interactive feature to capture the mental state or 'mood' of the user. The initial conceptual model involved the use of SMS messages containing personal custom links, a set of web pages to collect the user 'mood' then an automated email feature that triggered based on the 'mood' entered. As such the infrastructure hardware and software requirements needed to be expanded to not only include a web server, but also a database server, an SMS scheduling and sending service, and also automated email generation and messaging capabilities from the web application. The final conceptual design model that was the basis for a pilot implementation as shown in Figure 2.

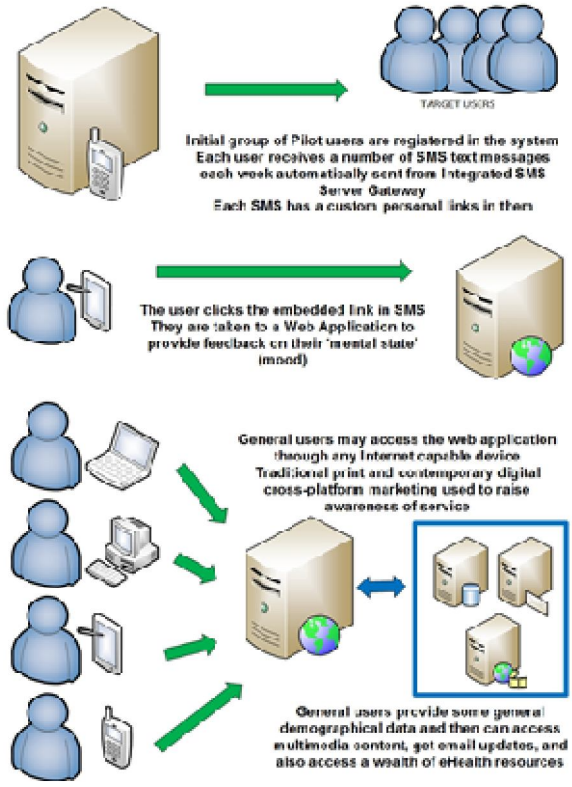


Figure 2. Final conceptual design model

IV. PRODUCTION ARCHITECTURE AND SYSTEM

Like many research projects, the common process is to perform a validation study, or in ICT terms the testing and evaluation of a prototype. Once the validation study, in this project an integral part of that research work is the ICT Artefact discussed in this paper, then often the next stage for health related projects is a Randomized Controlled Trial (RCT). This section details the prototype and the 'final' implemented eHealth platform used in a number of further RCT's and eHealth research projects. Due to the success of the SMS4Dads platform, a number of other similar projects have evolved, expanding the scope and application context of the core platform. Essentially, from an Information and Communication Technology perspective, the key elements include SMS, email, multimedia resources, surveys, and explained in the following section a 'Mood Tracker'. At its technological core it is a 3-layered/tier web application written in ASP.Net and C#.Net supported by a Microsoft SQL Server database backend. The platform has auto-detect user-layer features to increase user experience and redirects to a mobile screen version on device detection. The business layer manages two main modules, the first for user registration and the second for mood tracker management. The mood-tracker management module handles interaction with an SMS gateway that automatically and dynamically generate user specific SMS messages and emails. The user registration module additionally handles sending of user emails, processing surveys responses, and tracking user application access and navigation history. The infrastructure is all in house on virtual servers and protected by very secure firewalls and secure programming protocols at the University of Newcastle. The computing environment is very robust with high performance availability and accessibility.



Figure 3. SMS4Dads Landing Page.

A team of academic and industry professionals did the application design and development. The collaboration included graphic/user experience designers, software architects, application developers, and database designer. Due to being a research project with grant funding, where possible, academics performed most duties and high-end specialist tasks outsourced to industry. The landing page shown in Figure 3 represents the 'home' screen. A very simple easy to navigate design provides users graphically rich welcome, that includes embedded video about the application and project. The menu system is limited to five items, again ensuring straightforward navigation. Standard features include an 'About' page, a resources area, a contact feature, and finally a 'Join Up' process. The resources page in Figure 4 provides links and other multimedia content for the users in regards to parenting, fatherhood, raising children, etc.



Figure 4. SMS4Dads Resouces Page

The system process for new user registration is straightforward and involves the collection of personal data, the completion of a number of surveys and most importantly, the baby's expected birth date. Besides a mobile phone number, and name, nearly all other personal detail fields are optional. However, one useful feature added upon revision was an optional field called "Partners Mobile Number". As early users plus studies supported the notion of notifying the mother of the baby when their partner has enrolled in the SMS4Dads 'program'. The Survey start page in Figure 5 provides a important information statement detailing data use and collection, and a brief introduction to the program and collection of the baby's actual or expected birth date. As fathers can enrol in the program before, during, and after the baby's birth. Data validation ensures that based on the mobile number provided users could only enrol once with that number. As the mobile number is used as the point of contact for all future SMS messages. Once personal data is entered and stored, users are presented with a number of surveys to complete. Survey details along with a explanation of the innovative Mood Tracker are provided in the next section. These two features represent the major eHealth contributions of the project around mental health.



Figure 5. Join Up Survey start page.

V. EHEALTH SUPPORT AND MOOD TRACKER

Mental health and new father parenting support presented in two formats. The first being a number of surveys the user completed at registration, and at various times during the course of the first 48 weeks from date of expected birth. Surveys employed in the study include the Depression Anxiety and Stress Scale (DASS-21) – 21 items [28], the AUDIT-C – 3 items [29], the Short Version Co-parenting Relationships Scale (CRS) – 14 items [30], and the Karitane Parenting Confidence Scale (KPCS) – 15 items [31]. All measures have been shown to be valid in the perinatal period. The DASS-21 is a truncated version of a 42-item measure designed to assess three distinct but empirically related states of mental health. The validity of the three scales (depression, anxiety and stress) that make up the DASS-21 has been demonstrated through strong correlations with established measures of each factor in diverse populations. The reliability of the subscales has been established in a large normative sample (N=717) with the alpha values of the scales reported as depression 0.81, anxiety, 0.73, stress, 0.81 [28]. Higher subscale DASS scores mean greater levels of depression, anxiety or stress respectively. The scores on the three subscale are combined to give a total DASS score.

The AUDIT-C is a 3-item measure of alcohol consumption. The AUDIT-C was found to be more reliable than telephone interview in detecting heavy drinking in a sample (N=243) of known drinkers [29]. The CRS short version is a truncated version of the 35-item multi-domain survey designed to assess parent perceptions of the strength of their parenting relationship with their partner. The validity of the CRS has been determined against established scales of co-parenting quality and the total scale reliability (alpha) across three waves of measurement ranged from 0.81 to 0.85 [30]. The KPCS is designed to assess maternal and paternal perceptions of parenting self-efficacy (PSE) in the Australian context. The validity of the KPCS has been demonstrated against established measures of PSE and the authors report a total scale reliability (alpha) of 0.81 in a normative sample (N=27) [31]. Fathers are asked to repeat the surveys (DASS-21, AUDIT-C, CRS and KPCS) at 24 weeks after receiving their first message and again at completion of participation; 48 weeks after the expected or actual birth of their child. Family Action and Mental Health experts review the survey findings. Expert intervention through user contact is possible when user health and wellbeing indicates a potential 'crises' from analysis of survey results and mood tracker data. Additionally, the user has access to links and access to other mental health support resources. The second major eHealth innovative contribution was what we have termed the mood tracker. With this feature, Dads receive a number of SMS messages each week checking in on how they are. Embedded in the SMS is a link to the SMS4Dads website, which takes them to the Mood Tracker application. The initial landing page for mood tracker, shown in figure 6, provides five options the dad can select. The dad selects a single option that best represents how they are feeling at the time of the SMS. User responses are recorded in the database and are analyzed for consecutive low responses (shaky and bad). Ongoing 'bad' responses can escalate to the point that a mental health professional contacts the user to 'check in' and see if the dad needs some support and help. Also, the user on selecting the bad response has an on screen option presented to them that allows them to "request a call", which is manually initiating an escalation, and likewise a health professional then gets in contact with the user. The current SMS4Dads Mood Tracker version is a single question and single layered module, with a standard five-response selection panel as in Figure 6. However, at time of writing the latest Mood Tracker (v2), called Mood Tracker Interactive, allows for various questions to be asked, on recursive multiple layers, and with custom selectable responses based on the question content and context. That is, a tree question structure is developed for the eHealth area in question, and populated dynamically from a database. As such, the mood tracker interactive is adaptive to all types of eHealth contexts, from Alcohol and drug use, to quitting smoking, and like SMS4Dads, support now for mothers. Once the application context is determined, the next step is to formulate SMS question sets and stored in database tables. The SMS questions then link to sets of custom responses that may also lead to further nested questions. The new interactive version allows much more detailed mental health support and analysis for users, in addition to being a reusable module for integration to many other platforms and apps.

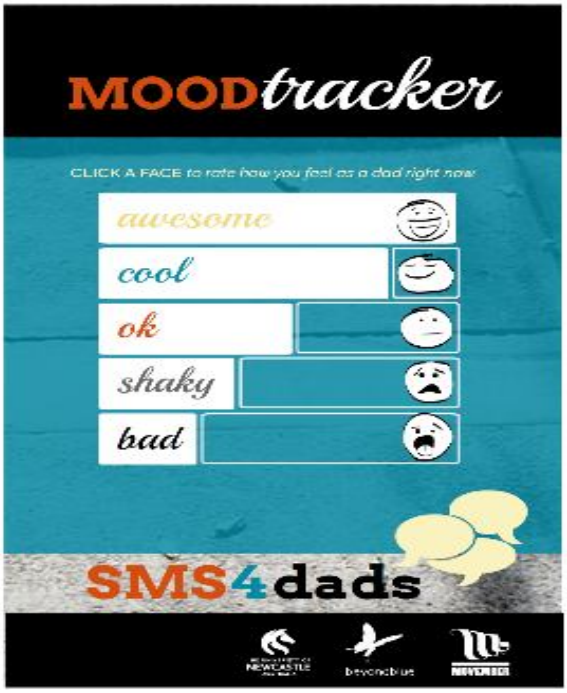


Figure 6. Mood Tracker user response page.

CONCLUSION

The eHealth domain presents many innovative opportunities for the collaboration between Information and Communication Technologies and the discipline of Health. SMS4Dads represents such an innovative joint project delivering an eHealth service for new and expecting fathers. SMS4Dads was designed to support fathers with helpful and encouraging text messages, links to relevant web resources, mood monitoring and connection to a crisis telephone support if needed. Due to its success, the foundational ICT architecture of the system has been re-used in a growing number of diverse health contexts.

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