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Study on the potential for delay tolerant networks by health workers in low resource settings

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ABSTRACT

Background: Medical Informatics Systems (MIS) have been suggested as having great potential to improve health care delivery in low resource settings. One of the major barriers for adopting MIS in this context is a lack of adequate network/communication infrastructure. Delay Tolerant Networking (DTN) is an approach for establishing network connectivity in situations where it is possible to support physical transport of the digital information. To date most DTN research has been technically oriented, and very few services have been implemented to support healthcare systems using the technology. It is thus unclear about the potential that DTN may have for supporting MIS systems in low resource settings. The goals of the paper are twofold, first, to gain an initial estimate of interest in different services that can be supported by DTN. Second, to find out the necessary frequency associated with each service for supporting health work in low resource settings.

Method: Fifty questionnaires were distributed to attendants at the International Conference on Global Health that had acknowledged having health work experience in a poor connectivity context. The respondents were using a 5-point Likert scale regarding if 9 different potential DTN services "would be useful". They also were asked how often data delivery would be necessary for these services to be useful. The Chi square was calculated to measure acceptance.

Results: 37 responses were received, aggregating the response rate of 74%. The respondents represented having work experience from 8 months to 15 years from 35 resource poor countries. The Chi square test showed very high statistical significance for "strongly agree and agree" for the potential usefulness of the proposed DTN services, with a p-value less than 0.001. The frequency of data delivery that would be necessary for services to be useful varied considerably.

Conclusion: This study provides evidence of potential for DTN to support useful services that support health work in low resource settings, and that services like access to email,

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notification of lab results, backup of EHR and teleconsultation are seem to be most important services that can be supported by DTN. The necessary frequency of data delivery for each service, will be highly dependent on context. In a low resource setting with limited mobility, the physical transport of digital data at a frequency of less than once per week should still be sufficient for useful services like notification of lab results and ordering of medical supplies. Research comparing different methods for delivery of DTN data should thus be useful. Further research and collaboration between MIS and Computer Science research communities is recommended in order to help develop DTN services that can be evaluated. Efforts to enhance awareness among stakeholders about how DTN can be used to support health services should be worthwhile.

1. Introduction

Medical Informatics Systems (MIS) have been suggested as having great potential to improve health care delivery in developing countries [1,2]. General lack of access to medical information is noted as a serious problem [1], and specific MIS such as Teleconsultation have been noted as having great potential in this context [2]. Despite this potential, such services seem underutilized and have not yet met expectations. One study for example has estimated that roughly 0.1% of the potential Telemedicine utilization from the developing world has been currently met [3].

One rational for this underutilization is the significant number of barriers that can hinder the adoption of MIS in low resource settings [4]. One of the noted barriers in many settings is a lack of adequate infrastructure [4]. This infrastructure can include reliable and adequate power, and also access to Internet connectivity, and Public Switched Telephone Networks (PSTN). The increased utilization of mobile phone networks for supporting health ICT holds great potential to overcome these barriers with respect to infrastructure [5]. Health ICT services based on mobile phones do not provide a universal solution however. There are many rural places in developing countries and islands (i.e. atolls) that are not expected to be covered by mobile phone networks in the near future, due to population density that is too low to support the business model of Telecom companies [6]. Another drawback of mobile phone networks is that, even in areas where there is coverage, bandwidth can be quite expensive and thus not practical to, for example, support routine transfer of high quality medical images or videos from a clinic to a hospital. For these reasons additional strategies for supporting connectivity are being investigated.

Some work has been done for example on setting up point-to-point WiFi networks to support voice-messaging systems in South Africa [7] and implement a large scale videoconference based Telemedicine service for the eye care in South India [8]. Building custom communication networks like this has a number of advantages, such as allowing services to be set up without needing cooperation from Telecom companies, and without frequency licenses from governments.

In addition to point-to-point WiFi one of the more "hot" approaches being investigated in the Computer Science research community to support network connectivity in low resource settings is Delay Tolerant Networking (DTN) [9]. DTN was originally conceived by the father of the Internet, Vint Cerf, as a mechanism to support interplanetary Internet [10]. His idea was to extend the Internet protocol system so it could operate in conditions where there was longer delay times in signaling that it had previously been engineered to handle, for example because of the time it takes for light to travel between planets. It also needed to be able to handle disruptions in connectivity, for example because of interference from stellar radiation, or because a large planet temporarily blocked direct communication between the different nodes in the network.

Later on the DTN problem space was conceptualized further, as people began to realize that systems that can handle these conditions might be useful on planet earth for extending the Internet to settings where there are similar problems related to long delays and disruptions in connectivity. In a low resource setting for example, a lack of fixed communication infrastructure such as telephone lines, Internet cables and cell phone towers, may not allow for fast communication. If however, the physical transport of data can be supported, for example by sending a motorbike to carry the data, then DTN-based connectivity would be possible to set up. In this case the delay time would be encountered because the motorbike moves significantly slower than an electrical signal, rather than because of the large distance between the communication points.

Over time the technical development of DTN has advanced and a limited number of services based on DTN technology have been set up to support communication in low resource settings at very low cost. One of the first services to utilize DTN technology for example was the Sámi Network Connectivity (SNC) project [11]. SNC provides Internet services such as email to reindeer herders in Northern Sweden (an area with no fixed infrastructure such as power lines, telephone lines or mobile phone access), that used digital information passed by hikers or the helicopters used to transport goods. Another example is DakNet, which provides services such as e-mail and video and voice messaging to villages in India and Cambodia that do not have telephone or Internet access [12]. In this case the messages have been carried by busses that contained mobile WiFi hotspots, a delivery technique referred to as "driveby WiFi". The vast majority of DTN research to date has been highly technical in nature however, and the DTN community has recently begun to consider about how best to apply many of their technical achievements in a real world context [13].