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# Integrating Social Networks and Remote Patient Monitoring Systems to Disseminate Notifications

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**Abstract**

*Healthcare workforce shortage can be compensated by using information and communication technologies. Remote patient monitoring systems allow us to identify and communicate complications and anomalies. Integrating social networking services into remote patient monitoring systems enables users to manage their relationships. User defined relationships may be used to disseminate healthcare related notifications. Hence this integration leads to quicker interventions and may reduce hospital readmission rate. As a proof of concept, a module was integrated to a remote patient monitoring platform. A mobile application to manage relationships and receive notifications was also developed.*

***Keywords:***

Social Networking; Patient Monitoring; Physiology

## Introduction

Healthcare systems might not properly accommodate all patients in the near future. There is a shortage of healthcare professionals according to World Health Organization [1]: healthcare workforce will be short by 12.9 million professionals in 2035. Also, the world population is demanding more care given the increased life expectancy and the occurrence of non-communicable diseases [2].

Remote patient monitoring systems may reduce the stress on healthcare systems. The stress relief is achieved via the use of technologies that enable communication between patients and health professionals at any time. Using information and communication technologies might also reduce personalized care delivery costs for patients who need to constantly visit a healthcare facility. There is evidence that 33% of patients, especially elderly individuals, want to have access to remote patient monitoring technologies. Furthermore, 40% of those elderly patients want technologies that notify their caregivers whenever there is an emergency situation [3].

Social network services can be integrated into remote patient monitoring systems [4-12]. This integration enables users to manage their relationships. User-defined relationships are used to disseminate notifications. In emergency situations, notifications lead to quicker interventions and may reduce hospital admission rate.

This paper presents an architecture for notification emission based on integrating social network services to a remote patient monitoring system. As a proof of concept a module was integrated into a remote patient monitoring platform. A mobile application to manage relationships and receive notifications was also developed.

## Methods

Our approach to enable notification dissemination in a remote patient monitoring system consists of the integration of social network services. This research evolved over three phases leading to a proof of concept: conceptual phase, design phase, and application development.

### Conceptual Phase

Remote patient monitoring systems are specializations of context-aware systems. In this case, context refers to the patients' health status. A context-aware system architecture, as proposed by [13, 14] is shown in Figure 1.

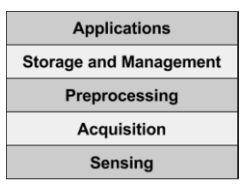



*Figure 1 – Context-aware systems architecture, adapted from [13,14]*

Context is acquired (Acquisition Layer) using sensors (Sensing Layer); then represented (Preprocessing Layer), persisted and made available (Storage and Management Layer) to the applications residing on the top layer.

Social networks model and manage relationship contextual information [15]. As a context-aware system, a remote patient monitoring system may use the relationship between entities to provide contextual information [16].

### Design Phase

Following the pattern present in social network systems, such as Facebook and Twitter, a user receives notifications regarding his/her relationships. A relationship management service can be seen as an event notification service in a publish/subscribe architecture [17]. Creation and destruction of relationships are mapped to subscribe and unsubscribe operations as shown in Table 1.

Subscriptions are content-based [18]. Messages sent to the event notification service have a field specifying the user who subscribed to the service. Information in this field is used to forward notifications.

*Table 1 – Relationship manager correspondence with event notification service*

| | Relationship manager | Event notification |
|---|---|---|
| Operation | Create relationship | Subscribe |
| | Destroy relationship | Unsubscribe |

Figure 2 shows a message example formatted using JSON.

```
{
  "id": 4,
  "payload": "message"
}
```

*Figure 2 – Message formatted using JSON*

Remote patient monitoring systems following this approach are in accordance with the steps proposed by Morrisey [3]; particularly when it comes to notifying designated responders, initiating rapid interventions.

## Results

### Architecture

Our proof of concept aims to deliver notifications to the caregivers. Notifications are sent whenever the collected physiological data presents an anomaly. Patients' relationships define the notification recipients.

Figure 3 outlines the architecture. Physiological data are collected and transmitted to the UbiCare platform (1, 2 and 3). Users can also interact with the platform using other applications that may be developed (3).

When a user accesses the UbiCare Social application, a device identifier is requested (A) and set (B). This device identifier is maintained in the UbiCare platform (C). To distribute a notification, the UbiCare platform sends a message and a device identifier list to the push service (D). Device identifiers are processed by the push service and the messages are sent to the caregiver and family devices.

### Scenario

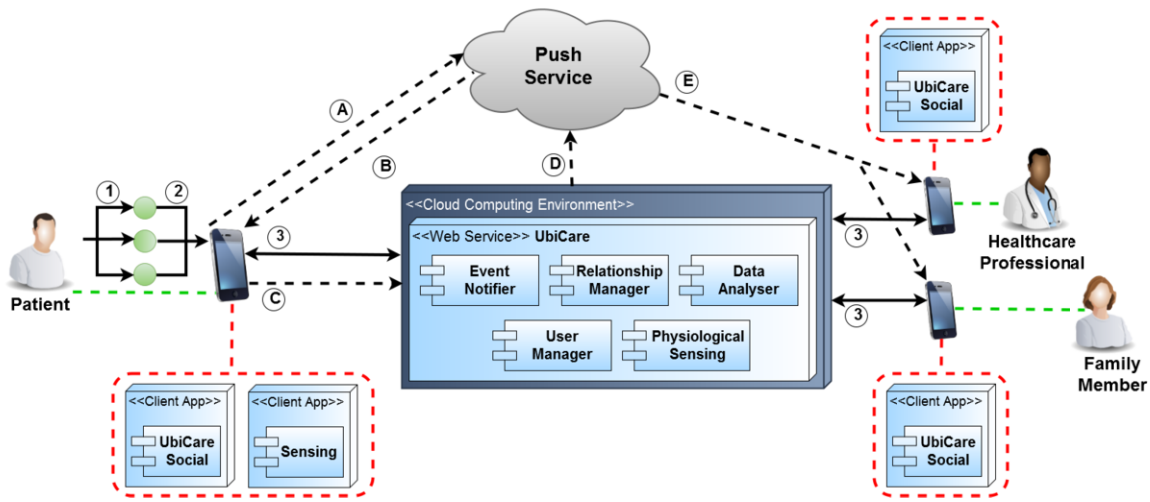



*Figure 3 – Architecture*

### Application Development

Two applications were developed: a relationship manager and a mobile application.

The Relationship Manager is a module integrated into UbiCare, a remote patient monitoring system being developed at Instituto de Informática [19]. This module was built using Flask[1], a web development framework for Python. Relationship data are stored in a MySQL database.

The mobile application, UbiCare Social, consumes the services provided by the Relationship Manager, allowing users to manage their relationships and to receive notifications. This application runs on Android operating system. In addition, Google Cloud Messaging (GCM) push service was used to distribute notifications.

Consider a scenario with three actors: one patient, one healthcare professional and the patient's relative. Their relationships are configured as shown in Figure 4.

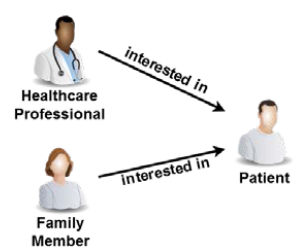



*Figure 4 – Relationship instance*

In a situation in which the patient is an elderly person in post-operative care, remote patient monitoring systems allow the patient to be transferred to home, reducing the number of

[1] http://flask.pocoo.org/

inpatients. Healthcare professionals and family members can assist the patient at home, with minimum impact on the pateint's privacy, as they will be notified whenever a physiological anomaly is detected.

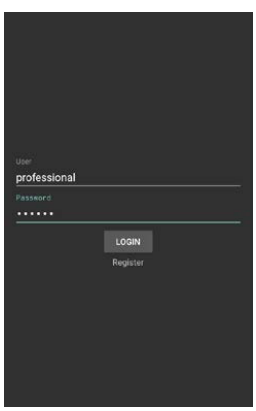
**UbiCare Social**

Relationship Manager services are accessed via an Android application, named UbiCare Social. Considering the Healthcare Professional from Figure 4, UbiCare Social behaviour is as shown in Figures 5(a), 5(b), 5(c) and 5(d).

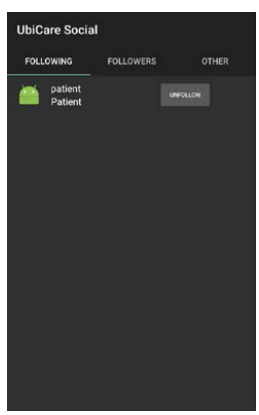
Whenever an anomaly is detected, a message with the Patient identifier is sent to the Event Notifier. Carers' device identifiers are retrieved and the push service (GCM) is triggered. Healthcare Professional and Family Member will receive a notification as the one show in Figure 6.

## Discussion

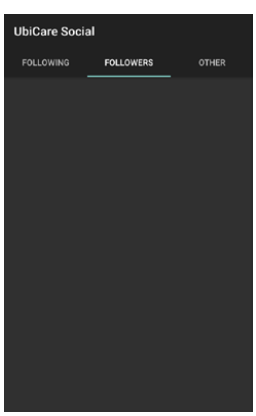
There are research efforts to distribute healthcare related notifications using social network systems [4-12]. Facebook, Twitter, and Google Plus were studied in order to check their suitability to solve this problem [6, 8]. Popular social network platforms have big user bases and provide services via APIs. Despite this, users have minimum control over their data and the platform functionalities. Furthermore, users tend to lack confidence in popular social network platforms.



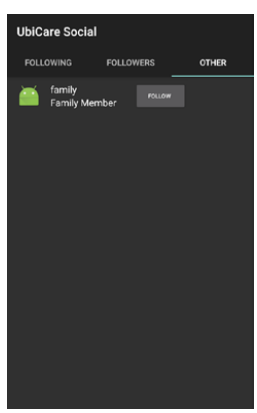

*(a) Login screen*




*(b) Healthcare professional interests*




*(c) Users interested in the Healthcare Professional*




*(d) Other users*

*Figure 5 – Mobile application behaviour*

Dedicated social networks, such as the one presented in this paper, have the potential to mitigate data ownership, functionalities extension, and trust issues; especially in a research scenario.


*Figure 6 – Notification issued by the UbiCare platform*

## Conclusion

Social network services may enhance remote patient monitoring systems. This integration leads to quicker interventions and may reduce hospital readmission rate.

Further research can be undertaken in the following areas: user acceptance testing, security, privacy, conformance with norms and standards, inclusion of social media services such as an audio-visual communication channel.

## Acknowledgements

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