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On behalf of the e-Health Technical Committee (TC) of the IEEE Communication Society (ComSoc), we wish the readers a very happy and productive Spring 2014 ahead! The contribution for this edition comes from authors in Sevilla, Spain, and is a description of the "e-Nefro" project.

Aravind Kailas and Hsi-Pin Ma

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Publish/Subscribe Architectures as Communication Middlewares for Health Alert Dissemination

Laura M. Roa Romero, et al.
University of Sevilla
Sevilla, Spain

1. INTRODUCTION

The health domain is heterogeneous and complex, and healthcare professionals need more and more resources, mainly in critical settings, to be informed of events at the time they happen. In home-based care scenarios, the detection of alarm events or risk trends can prevent serious complications and ease an early response by healthcare professionals, raising also the confidence of patients on remote care.

The project e-Nefro [1] aims to establish a flexible architecture for the remote care of patients in pre-dialysis and peritoneal dialysis (PD) at home. A crucial requirement of the architecture to be deployed is to provide capabilities of event detection and alert triggering and dissemination, to proper users (e.g., health professionals or carers) at anytime. Table I shows a sample of relevant events to be triggered as an alert for patients in pre-dialysis and PD at home.

The remote monitoring of a single patient could be addressed by means of traditional communication models (i.e., client/server), but current scenarios involve more and more separated entities working together from different administrative domains, and home-based care settings are expected to be the preferred approach for a vast majority of patients. Thus, several requirements are imposed for communication infrastructures (e.g., coping with the distribution of components, transmission of data from heterogeneous sources, real-time operation, dynamic gathering of entities…) that require new communication paradigms. The publish/subscribe interaction pattern (pub/sub for short) emerged trying to address requirements for a more flexible interaction schema than the client/server model. In the pub/sub model, the different communication nodes can play the publisher role, the subscriber role, or both at the same time. Information is generated or consumed through a channel (called event or topic according to the technology) that serves as nexus among publishers and subscribers. This communication model offers a powerful abstraction for group communications since publishers can disseminate information to a set of on-listen subscribers with no knowledge about who are those subscribers or if they have changed. Moreover, the cost associated with the deployment of nodes has also been studied, positioning the pub/sub model as the most economically sustainable, which is even better compared to the rest of alternatives as the number of nodes grows.

Table I. Sample of clinical and technical alerts for monitored renal patients at home.

Alert	Type	Thresholds
Clinical	Arterial Pressure	80/40 - 160/85
	Body Temperature	35 - 38
	Weight Gain	> 2
	Glycaemia (if Diabetes Mellitus)	60 - 200
Technical	PD exchange volume	< 1000 | > 2000
	PD Machine Failure	No

The Data Distribution Service (DDS) [2] is a specification by the Object Management Group for the data exchange in real-time distributed systems. The DDS specification adopts the pub/sub model, decoupling data producers from consumers in time and space. Subscribers only determine the kind of information they wish to receive, and the communication conditions by means QoS policies. As it is shown in Figure 1, the DDS nexus between publishers and subscribers is the topic, and several topics can be grouped to form a multi-topic achieving a more advanced pub/sub model. Through QoS policies, DDS supports a wide spectrum of temporal requirements for real-time systems.

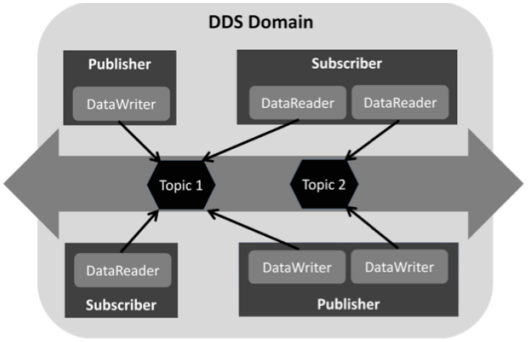

Fig. 1. Model of participant entities in a DDS domain.

wide spectrum of temporal requirements for real-time systems.

Among its most important advantages in contrast to other messaging-oriented middlewares, DDS excels as platform-independent and object-oriented. The interoperability between software provided from different DDS vendors is also guaranteed thanks to the Interoperability Wire Protocol specification (DDSI). Moreover, the performance of DDS over competitors has also been analyzed using benchmarking environments, which showed significantly better results in terms of latency and jitter compared to other publish-subscribe technologies.

To date, DDS has been shortly applied in the health domain. Nevertheless, it has a great potential as a communication infrastructure easing the data transmission in real-time from different and separate sources to the components that process such data efficiently to generate new knowledge about patients.

In the e-Nefro project DDS has been adopted as a communication middleware for remote monitoring of renal patients at home due to two main features. Firstly, dissemination of health alerts and risk events is a priority that must be tackled in real-time to early execute the most suitable protocol in order to prevent severe damage for patients. DDS provides communications in real-time that adjust conveniently to e-Nefro requirements. Secondly, the adoption of DDS for health alert dissemination enhances greatly the independence of components, i.e., new publishers or subscribers can join the DDS infrastructure at runtime with no need of network reconfiguration or node adaptation. This leads to a system highly flexible and evolvable where new participants (patients, health professionals, carers, systems…) can publish in topics and/or subscribe to the information of their interest by means of DDS filters. The e-Nefro scenario is depicted in Fig. 2.

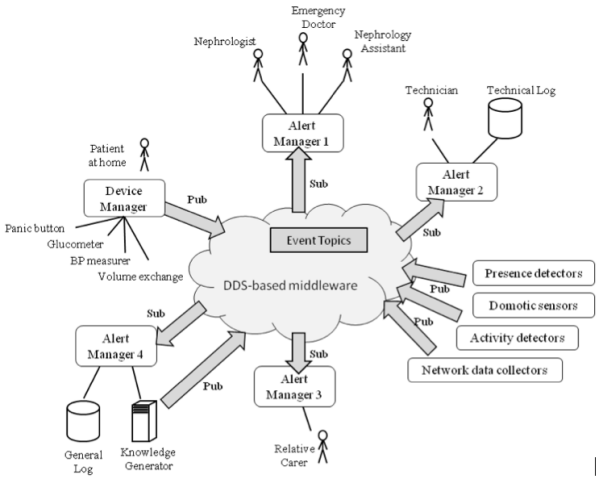

Fig. 2. Illustrative scenario of adoption of a DDS-based middleware in the e-Nefro project.

Event generators (e.g., home devices, patients, event detection systems) act as publishers, and subscribers filter events disseminated according to preferences and interest of their users. For sake of clarity, the scenario is focused on only one patient monitored at home and a set of users (health professionals, a device technician, and a carer/relative) interested in events related to the patient.

Home-based care devices (e.g., glucometer and arterial pressure meter) publish data measurements and technical failures through a device manager as events. Other data sources can be present, as activity detectors, domotic sensors at patient's home, and network data collectors. A generic element called Knowledge Generator may use patient data for performing simulations and predicting trends of patient's conditions. Resulting evidences are published as new events. As subscribers, four alert managers have been deployed in this scenario. Each alert manager subscribes to data events of interest for its users. For example, Alert Manager 2 can establish its content filters to receive only events of technical failures or warnings from devices; Alert Manager 1 can subscribe only to health alerts that require an action by the health professionals; finally, Alert Manager 4 can subscribe to all the events in order to maintain a event log.

FURTHER READING

[1] PI11/00111 - Adaptive Modular Architecture for the comprehensive telecare of renal patients (e-Nefro Application). Health Institute Carlos III – Health Research Fund (Spain), 2012-2014.

[2] Object Management Group. Data Distribution Service (DDS) for Real-time Systems, Version 1.2, 2007.