Situational-Aware Notification System: a hospital-wide communication system

Erik Koomen1, MD and Teus Kappen,2 MD PhD

Introduction
A hospital is one of the most technically advanced and logistically complex environments in health care. High quality care in such an environment requires optimal information exchange. Hospitals typically have multiple communication systems in place to relay medical messages – or notifications – to different healthcare providers, such as alarm, nurse call, and pager systems. These communication systems are often poorly interconnected, making it difficult to prioritize notifications over each other. The result: noise pollution due to many audible notifications, data overload and alarm fatigue. At high care wards, such as an adult ICU, a single provider may receive a notification every four minutes. This degrades the patient’s healing environment and compromises patient safety by constantly distracting healthcare professionals.

Solution
We propose the use of a Situational-Aware Notification System (SANS). Traditional notifications – especially alarms – are sent by a single device when “something is wrong”, unaware of the clinical context, and poorly prioritized over other notifications: first in, first out. Notifications from a SANS are sent “when something can be improved”, as they include the clinical context of the notification, resulting in a problem-specific rather than device-specific approach that allows for more realistic prioritization.

Figure 1 – dynamic prioritization

Figure 2 – fast and gradual deterioration

Adding context to notifications
A notification that communicates “when something can be improved” should add context to the primary message and could include actionable recommendations. For example, a patient with low oxygen saturation at a surgical ward should generate the message: “Low oxygen saturation on patient using opioids. Please check the respiratory rate and exclude opioid overdose.”

Realistic priorities: no one-size-fits-all
The primary message of a notification can already be quite helpful in determining priorities. Nonetheless, disconnected communication systems simply push their notification immediately to the end-user as they are unaware of other notifications, regardless of the true priority of the notification. The proposed SANS solution would be aware of different notifications being sent to a single provider. For example, the SANS would delay or defer a call for a glass of water and all other low priority notifications when the receiving provider just got an emergency alert for a patient having an astystole.

Problem-specific notifications: context improves prioritization
Adding context to notifications requires integrating data from all available sources. For example, an drug infusion pump typically pushes a “red alert” notification to a nurse to indicate when it notices an empty syringe. However, a single bolus treatment of acetaminophen is totally different from a multi-medication schema of chemotherapy and demands a different priority.

Changes in clinical context and priority: the problem of time
The clinical context of a patient in a hospital typically fluctuates over time. For example, a patient who is on a patient monitor may require different alarm threshold settings as her clinical condition deteriorates (Figure 1, from threshold set 1 to threshold set 2 or 3), but also when her condition improves (Figure 1, from threshold set 3 to threshold set 4). A system that is constantly aware of the clinical context would be able to set these thresholds dynamically, which would be almost impossible for a single device.

Integrating high- and low-priority notifications
The proposed SANS solution aims to integrate high-priority and low-priority messages. This requires several technical adaptations to the traditional a “bunch of individual devices” approach. First, SANS requires that priorities can be set in a numerical scale with a larger range – e.g., 1 through 100 – than traditional priority scales, such as “red” and “yellow” alarms. A too simple priority scale does not allow for the contextual differentiation that is required for the system to decide which notifications to delay. Second, a maximum delay that is acceptable for a specific priority level should be decided on. This maximum delay does not only depend on the primary message, e.g., a systolic blood pressure crossing the “yellow threshold alarm” of 90 mmHg, but also on its context, i.e., is it a rapid decrease in blood pressure (Figure 2, Notification A) or a more gradual decrease (Figure 2, Notification B). Third, update frequencies may greatly vary between different data sources (Figure 3).

Conclusion
A Situational-Aware Notification System (SANS) generates and prioritizes messages that depend on the clinical context. SANS will optimize the healing environment for patients and creates an efficiency and safety step in the work processes of health care.

The SANS requires a solution that can handle both “slow” and “fast” data. One possible solution would be to parse all data in the cloud. The drawback of such a system is that the natural latency of such a solution may exceed the maximum acceptable delay for notifications with the highest priority. We propose a cloud-edge solution for high-level notifications: “slower” data are parsed by the cloud to provide the context and dynamically set more simple rules and thresholds for patient monitoring alarms and other high-priority notifications that are based on “fast” data, which are parsed by an edge system, located on premise (Figure 4).

Figure 3 – integrating “slow” and “fast” data

For more information: E.Koomen@umcutrecht.nl or T.Kappen@umcutrecht.nl