InHealth – A Rapid Medical Software Development Platform using "Internet of Things" (IoT) Communication Standards for Medical Device Interoperability

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Background: Clinical environments such as intensive care units, operating rooms, and increasingly general wards, are full of technically advanced monitoring (and therapy) devices. Unfortunately, and to the detriment of patient safety, many of these devices are unable to communicate with one another because of vendor incompatibilities and closed commercial standards. The lack of safety interlocks and limited information exchange between medical devices represent a very real and current safety risk to patients [1].

The Internet of Things (IoT), interconnecting uniquely identifiable (embedded) devices using existing Internet infrastructure, offers an exciting opportunity to connect legacy medical machines and create a safer, fully-interoperable hospital environment for the benefit of patients. Free and open-source IoT protocols such as the MQ Telemetry Transport (MQTT) protocol [2] or the Constrained Application Protocol (CoAP) [3] are rapidly gaining traction in the general IoT space, but have hardly been utilized in medical environments.

We recently described a push-based mechanism of information exchange between medical devices, whereby devices publish their data as topics to an MQTT data broker, from which other devices and applications get their data by subscribing to the same topics [4]. Here we present a rapid development mobile platform that, by using this new framework, can realize medical device interoperability with minimal effort.

Methods: InHealth, a rapid-development mobile platform prototype, was developed using the LambdaNative cross-platform software development framework [5]. It uses MQTT communication with a data broker to exchange patient data (vital sign trends, waveforms, patient information etc.), and integrates hardware device drivers (like gps, camera, or audio support), a forward-chaining decision support engine, bar code reader, and user-interface widgets into a single native application. Development of user interfaces do not require recompilation, and involve modifying structured Extensible Markup Language forms of S-expressions (SXML), which are packaged with sounds and images files and uploaded to the target device.

Results: The first application we have built using this new tool is a sleep monitoring application for use at home that includes survey-based data collection and overnight recording of pulse oximetry. The built-in MQTT-based IoT connectivity layer allows the device to obtain demographics information during setup and to share/upload summary data after each sleep. This information is then available for use by other applications within the perioperative information exchange.

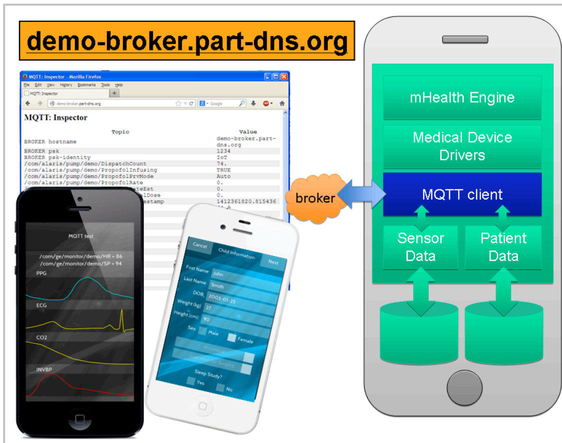

Figure 1: InHealth data flow, example screenshots and broker inspector example.

Figure 1 shows an overview of the system architecture, and example screenshots. A data broker with OR vital signs is available at demo-broker.part-dns.org to allow users to explore MQTT-based medical data exchange.

Conclusion: A simple approach using the MQTT device-to-device communication standard to build safe medical interoperability solutions, which can be broadly disseminated, was extended by adding a rapid-development mobile application framework. Precompiled versions of lnHealth for multiple platforms (Desktop, iOS, Android) will be made available in the near future to facilitate the open, collaborative development of new data collection systems for research, data integration and analysis tools for quality improvement or medical safety systems.

References: [1] D Arney, S Fischmeister, JM Goldman, I Lee, R Trausmuth, Plug-and-play for medical devices: experiences from a case study, *Biomed Instrum Technol*, 2009;43(4): 313–7. [2] D Locke, MQ Telemetry Transport (MQTT) V3.1 Protocol Specification, Armonk, NY, 2010. [3] Z Shelby, K Hartke, C Bormann, The Constrained Application Protocol (CoAP) , Reston, WA, 2014. [4] M Görges, CL Petersen, GA Dumont, JM Ansermino. Using machine-to-machine / "Internet of Things" communication to simplify medical device information exchange, *Proc 4th Int Conf Internet Things*. 2014: 1-6. [5] CL Petersen, M Görges, D Dunsmuir, M Ansermino, GA Dumont, Experience report: functional programming of mHealth applications, *Proc 18th ACM SIGPLAN Int Conf Funct Program*, 2013:357–62.