Java Environment based Internet of Things in Healthcare

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ABSTRACT
The term IoT is used to define a system in which the Internet is connected to the real world via ubiquitous sensors. The vision of IoT is to integrate diverse sets of data from physical sensors and the rest of IT to enable analytics that can anticipate events, issues, and other needs. Remote patient monitoring system, part of mobile health where chronically ill patients are cared for outside of a hospital or providing other facility is one promising solution. Remote monitoring solutions also allow patients to be discharged from hospitals sooner, as their health can continue to be closely monitored from home. Java powers a world of compute resources with ubiquitous connectivity. Flexibility, security, maximum innovation, and total connectivity solution are the features of Java which made it versatile development platform for IoT based projects.

Keywords
Mobile Technology, IoT, mHealth, Java

1. INTRODUCTION TO IOT IN MOBILE HEALTH
Expenses for healthcare in general continue to rise, especially for those with chronic disease. Healthcare providers are searching for ways to control costs while increasing the quality of patient care. Remote patient monitoring, part of mobile healthwhere chronically ill patients are cared for outside of a hospital or providing other facility is one promising solution. Remote monitoring solutions also allow patients to be discharged from hospitals sooner, as their health can continue to be closely monitored from home.

At the end of 2016, there were three million patients using connected home medical monitoring devices worldwide. This figure comprises all patients that were remotely monitored by a professional caregiver. Additionally, it's expected that connected home medical monitoring devices will grow at a compound annual rate of 44 percent to reach over 19 million devices by 2018. The promise of improved care with reduced costs is driving innovation in remote monitoring solutions. Together, healthcare providers and product vendors are working with Java Embedded Systems to deliver solutions that include personalized medicine, improved healthcare management through advanced telemetry, and population health scenarios to better measure the effectiveness of care and treatment. Challenges include the need for connectivity, security, privacy, advanced analytics, data visualization techniques, and the remote management of monitoring devices. Java and integrated Internet of Things technologies directly address these and other challenges, further improving patient care and reducing costs end-to-end.

2. VALUE OF IOT IN HEALTHCARE
As more medical devices connect to the Internet, they become an important and growing segment of the Internet of Things (IoT). The term IoT is used to define a system in which the Internet is connected to the real world via ubiquitous sensors. The vision of IoT is to integrate diverse sets of data from physical sensors and the rest of IT to enable analytics that can anticipate events, issues, and other needs. As a result, the system as a whole can have a view of what's taking place at any location and any point in time. This vision leads to a world of connected systems that could greatly reduce waste, lower costs, and eliminate loss for just about any human-machine and machine-machine activity.

Given the daunting requirements of healthcare today (safety, regulations, security, privacy, and so on) and the rapidly emerging IoT technology wave, no other platform today is better positioned to enable an IoT strategy for healthcare than Java. With its ability to run on a wide range of devices from mobile and embedded systems with limited CPU and memory, to servers with immense power and capacity, Java powers a world of compute resources with ubiquitous connectivity.

3. REMOTE PATIENT MONITORING AND MOBILE HEALTH
According to the World Health Organization, mobile health (mHealth) covers medical practice and healthcare supported by mobile devices, patient monitoring devices, and other wireless devices. It also includes applications for improved lifestyle and fitness that may connect to medical devices or sensors (fitness bracelets or watches, for example). mHealth can also include personal health guidance, health information and visualization, medication reminders, and telemedicine and remote patient monitoring via wireless communications. Overall, there are five main segments of mHealth: [4]

1. **Solutions for healthcare professionals:** including visualization and review of medical device data, patient history, population health statistics, care and treatment information, and other centralized healthcare support systems.
2. In-patient **monitoring:** the support and monitoring of patient healthcare within a hospital, acute or long-term care facility, or other care facility.
3. **Remote patient monitoring:** the support and monitoring of patient healthcare from home or other remote location other than a hospital or care facility.

4. **Assisted living and tracking**: for patients who live on their own but may require emergency assistance or tracking by family members.

5. **Personal wellness:** for otherwise healthy individuals who want to take an active approach to maintaining their health and wellbeing through diet, exercise, and other lifestyle methods.

Solutions across all of these mHealth segments create a connected care value chain involving four categories of service providers:

1. **Sensors and medical monitoring device vendors**. Device examples include medical monitoring devices such as blood pressure cuffs, blood glucose measuring devices, and integrated solutions such as smart hospital beds.

2. **mHealth connectivity solution providers**. These are cellular service carriers such as AT&T and Verizon in the US, and other manufacturers of specialized embedded communication devices. These devices may include Continua-compliant Bluetooth devices, devices that communicate via Wifi, and so on.

3. **mHealth care delivery platform providers**. Examples include data collection and aggregation platform vendors such as Oracle, Axeda, and other IoT technology vendors with a focus on healthcare.

4. **Monitoring service providers**. This includes specialized providers who offer integrated services to monitor patients and provide emergency response, if required, between device and communication vendors. [4]

Across the mHealth segments and associated connected care value chain as shown in Figure 1 are patient mobility, device integration, and data analytics play a key role in adding value. The intersection of mHealth and IoT has uncovered a potentially huge area for cost savings within healthcare: monitoring and controlling the effects of non-infectious disease.

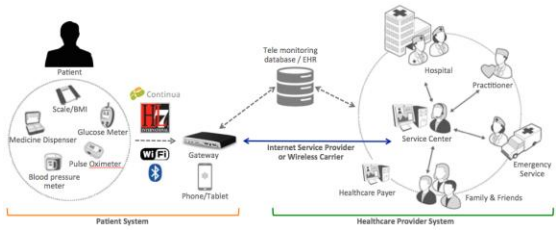

Figure 1. mHealth covers patient monitoring, mobile tools and communication, population health and analytics, and the payer.

4. THE CHALLENGES OF MOBILE HEALTH

Healthcare in general can be challenging and risky as people's health and lives are potentially at stake. Technology can help reduce risk and challenges in many cases such as remote monitoring, automated alerts, and accurate medication dispensing, but it can introduce new problems as well. While gaining approval from regulatory bodies it is usually the first step in bringing a new device or mHealth solution to the market, an additional challenge today is obtaining acceptance from reimbursement providers. To gain regulatory approval, a company needs to demonstrate functionality and safety. However, to gain acceptance from healthcare payers, a company needs to demonstrate the economic benefits of the new device or monitoring method. Some of the challenges are mentioned below.

- **Security, data safety and privacy:** Patient privacy and data safety are highly regulated and represent an area of liability to everyone involved. Therefore, both healthcare providers and solution providers need to find ways to ensure data security and privacy, including the security of remotely managed devices.

- **Implementation portability and cost**: Solution providers are challenged with the additional cost of connectivity. First, the cost of LTE cellular communications needs to be optimized. Second, many of the systems involved are embedded, traditionally requiring expensive specialized tools and implementation skills. As new medical devices are introduced, and advances are made in terms of remote patient care, everyone is looking for ways to cut costs through re-use and portability. This requires complex long-term planning for future mHealth device hardware upgrades to avoid re-creating systems due to evolving hardware. Standards and advanced development techniques are needed to offset added downstream costs and to remove portability concerns.

- **Enterprise integration**: The challenge is to find or build a platform that offers robust connectivity options, seamlessly connects to hospital or healthcare provider business systems, and remains cost effective over time.

- **Visualization:** There's a strong need to visualize data to convey information accurately and quickly, at a glance, allowing deeper inspection on demand as required. This requires integration with mobile devices, remote databases, remote analytics processing engines, and graphics systems with specialized algorithms.

- **Alarm fatigue:** Healthcare professionals are frequently bombarded with alarms and alerts, leading to a condition called "alarm fatigue" where alarms may not be noticed even when truly critical. The constant sound of alarms and noises from medical devices and patient monitors can cause staff to become desensitized to them. Alarm fatigue is present within hospitals, at-home care, nursing homes, and other medical facilities. The challenge is to establish alarm safety as a priority, help professionals identify the most important alarms, and create policies to manage alarms efficiently and properly. Further, increasing regulation in the area of alarm fatigue will require providers to add more complexity to their solutions.[6]

5. THE ADVANTAGES OF JAVA IN MHEALTH

Java and Java Embedded are key technologies for both the enterprise and embedded market, with billions of devices, gateways, desktops and servers dependent on Java to run their core functions. Java and Oracle's enterprise IT solutions work together to offer a single end-to-end IoT platform for all of your mHealth applications, so you don't need to build custom infrastructure each time. The Java Embedded is optimized to run on resource-constrained embedded devices, packs enterprise server power into small controllers and devices. Whether it's used in a medical device, data aggregation and edge-analytics server, or other hospital or healthcare system, Java technology offers a number of key benefits that make it

the ideal platform for mHealth. For example, it enables headless, lights-out operation, a robust and secure application environment, remote software provisioning and management, and reliable end-to-end connectivity, all built on the industry standard Java language and virtual machine already used in IT. Overall, Java Embedded addresses all of the challenges listed and more. Java offers the ability to analyze events at the right location, in the cloud or on-site with embedded devices, depending on the relative value and time sensitivity of the data. The flexibility of Java Embedded is ideal for mHealth solutions, as it enables more processing and decision making to take place at the patient location. Localized analytics to process patient medical data at the point of capture leads to personalization, enhanced reporting, data enrichment, meaningful alerts, and remote patient communication and feedback. Local, distributed analytics provide data aggregation and analysis, collection of patient feedback, and data safekeeping services for more effective healthcare management. [2]

Flexibility: The flexibility of Java to run analytics end-to-end enables population health solutions, as patient data is combined with community health data, and visualized to offer insight and innovative solutions. Examples include advanced disease awareness, measuring the effectiveness of medical care and medication for disease treatment, as well as providing insight into factors that contribute to these diseases. Overall, by offering this flexibility, Java enables the true power in IoT: advanced analytics for data discovery, advanced remote treatments, population health and the prediction of patient illness. [5]

Safety and Security: The Java Virtual Machine (JVM) is a proven secure technology, providing a secure environment to run multiple applications where each application is isolated from other applications, the operating system, and other software components. The JVM also abstracts the complexities of varying server and embedded hardware platforms, providing a consistent, reliable, and secure environment for your applications. Oracle focuses on security, with frequent patches and updates across varying server and embedded hardware platforms, so you can focus on your solution.

Ultimate Flexibility: To maximize the benefits of IoT, solution providers require full flexibility in terms of where processing is performed. Java Embedded offers total flexibility regarding where analytics and processing take place, allowing you to change it later without redesign. This flexibility makes Java ideal for mHealth solutions as it enables more processing and decision-making to take place close to the patient, where medical data is captured. In addition, changes can be provisioned to upgrade functionality remotely or enhance inspection of a specific patient data point. [1]

Optimized for Embedded: Java Embedded enables intelligent devices and distributed analytics to be developed rapidly and at lower cost, easily resolving many development and application issues. This includes easy integration with enterprise and internet-based environments. Oracle is focusing on helping the market reap the benefits of the transformation to smarter patient medical devices both in-hospital and in-home.

Maximized Innovation: According to software development rating and standards organizations, Java is continuously ranked as the most widely used development language in the world. There are over nine million developers who use Java to develop a wide range of applications from enterprise to embedded. The ability to leverage Java's large pool of talent and tools better enables mHealth innovation and reduces costs via a standardized, end-to-end development environment.

Total Connectivity Solution: There has been extremely rapid growth in remotely generated patient data, along with the need to send more data to the doctor and the patient. The importance of reliable connectivity will grow along with these data demands, and so will the risks if this data is lost. Java offers the robust communication services needed to reduce this risk. Java's connectivity frameworks, along with the wireless communication and web service APIs, allow Java Embedded applications to work seamlessly, reliably, and securely with cloud-based enterprise services. This capability is crucial when deploying remote devices and infrastructure as part of an IoT value chain. Often, the connection type chosen is based on multiple factors, including transmission cost and device accessibility. Because Java supports a broad range of connectivity options, you can choose the type best for your solution. The end result is that Java provides you with the processing and communication capabilities needed to integrate your mHealth solution, hospital records system, patient management system, and in-hospital solutions end-to-end. What's more, Java is engineered to work equally across your embedded devices, gateways, and IT servers, abstracting away the communication and hardware differences for ease of development.

6. JAVA REFERENCE ARCHITECTURE FOR REMOTE PATIENT MONITORING

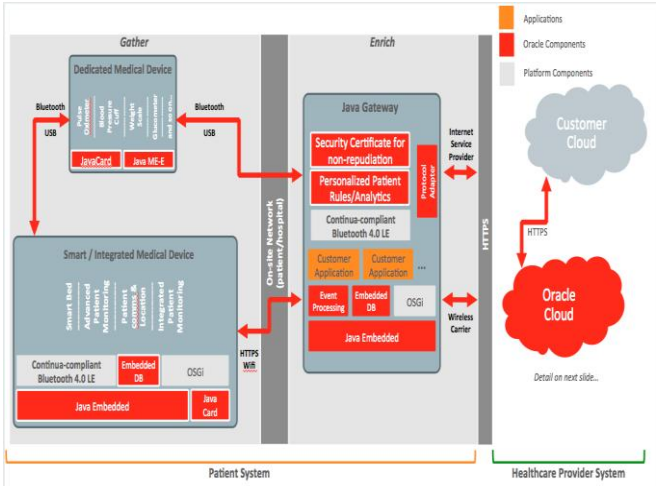

Figure 2: Oracle Java reference architecture for mHealth remote patient monitoring

The architecture covers and supports multiple applications within a single mHealth gateway, or distributed across multiple embedded computers and devices with high-speed reliable communications. [4] Example use cases include:

- Remote monitoring of patient vitals
- Correlation and trend-based analytics to identify and signal potentially life-threatening scenarios for chronically ill patients
- Remote operation and administration of infusion pumps and other automated medicine dispensers

- Combining real-time patient data with historical data to gain insight into population and community health issues and resolutions

To ensure safety and security of the systems created and managed, Java Embedded can support healthcare standards set forth by regulatory bodies via the following comprehensive set of industry standard implementations: [3]

- Certificate-based security, Java cryptography extension with crypto acceleration, and near field communication (NFC) support
- Java secure sockets extension (JSSE) for secure communication
- Java authentication and authorization (JAAS) for user, device, and data identity
- Public key cryptography standard (PKCS-11) for data encryption
- Security and trust services (SATSA) for additional encrypted security features and communication capability

7. CONCLUSION

An open, standards-based platform with an unequalled developer ecosystem, Java Embedded makes it faster and more affordable to get innovative, reliable, and secure mHealth solutions to market and provide the long-term support for success. Improved care with reduced cost is the heart of mHealth, and Oracle's Java-powered fast data and edge analytics are becoming just as critical. Now is the time to utilize analytics to uncover value and treatment optimization in mHealth with Java.

8. REFERENCES

[1] http://www.academia.edu/7135887/Evaluation_of_Java-Based_Platforms_for_mHealth_Solutions

[2] https://community.oracle.com/community/java

[3] Nicoals Guelfi, Scientific Engineering of Distributed Java Applications, Springer

[4] Jonathan Donner, Patricia Mechael, mHealth in Practice: Mobile Technology for Health Promotion, BloomsBury

[5] http://www.boston-technology.com/mhealth

[6] http://rapidsms.readthedocs.org/en/latest/internals/roadmap/interoperability.html