Healthcare Data Mobile App linking Multiple Sources using FHIR

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One of the major trends in healthcare is an increasing desire for patients to exert more control over their Protected health information (PHI) which contains data that they create and control and data that is maintained in the different health information technology systems that are deployed at hospitals, clinics, medical offices, test laboratories, imaging centers, pharmacies, etc. One effort[1] allows patients to define fine-grained access control policies for data in personal health records (PHRs)[2] such as: ''Anyone whom I designate as a family member may view my medication list, except for one of my medications that I'd rather not share. . .''; ''Anyone whom I designate as a health care provider may view my medication list and my history of office visits and hospitalizations, but not modify these data. . .; ''My primary physician, Dr. Albright, may view and modify my medication list and may view and annotate my log of meals and physical activities. . .''' and, ''Dr. Albright's (Electronic Health Record) EHR system may automatically add new items to my medication list, but it may not change or retrieve any items unless Dr. Albright is logged in." In another effort,[3] a study of patients as conducted that focused on the type and granularity of health and other information that they wanted control of their data in electronic health records (EHRs). For a given patient, this effort highlights the potential recipients of the information (e.g., primary physicians, mental health providers, spouse, family, emergency medical providers, etc.) and the type of information to be controlled (e.g., contact info, current conditions, medications, recent test results, mental health information, genetic information, etc.). Patient health and fitness information needs to be gather from multiple sources.

For example, consider the proliferation of health and fitness applications on multiple mobile platforms for: pharmacies and organizing medications (myCVS,[4] MEDWatcher,[5] Drugs.com Medication guide and Pill Identifier Applications,[6] etc.); personal health record (PHR) applications (CAPZULE PHR,[7] MTBC PHR,[8] suite of WebMD Applications,[9] etc.); a wide array of fitness devices[10] and applications that work with phones and wearables;[11] Apple's HealthKit app[12] and the Google Fit fitness tracker,[13] where both companies have pushed strongly into the smartwatch market to track activity, heart rate, blood pressure, etc.[14] Patients also seek to have access via their mobile devices to the electronic health records (EHRs) utilized by their medical providers, as well as various health information technology (HIT) systems that contain medical testing results[15] or results from imaging testing.[16] In addition, there is an increasing interest for the use of mobile apps for chronic disease management – as published in the literature[17] and with the numerous results from a Google Search ("tracking chronic diseases with mobile apps 2015").[18] Further, many of the medical devices that are involved in tracking and monitoring chronic diseases are blue-tooth enabled devices. For example, the Microsoft HealthVault PHR[19] can accept patient supplied data from a wide range of devices[20] that include glucometers (for diabetes), weight scales, blood pressure monitors, peak-flow monitors, ECG (heart), etc. All of these systems must adhere to the Health Insurance Portability and Accountability Act (HIPAA)[21] for the security, availability, transmission, and release of a patient's medical information.

Patients are interested in tracking all of the data associated with fitness devices (wearable and others such as treadmills), medical devices for chronic disease management that patients own and control, and medical devices given to patients by medical providers in order to conduct certain tests at home under their supervision such as a Holter monitor for 24 hours.[22] This information from a myriad of different and non-integrated sources needs to be collected and made available to patients, and be easily provided to medical providers in either detailed or summary form. A patient may be utilizing multiple mobile apps to manage the different fitness and medical devices, each of which has their own data repository (perhaps SQL lite on a phone or SQL DB on a server) with limited ability to collect the data in a consistent format from multiple sources so that the information can be integrated. Further, medical providers (hospitals, clinics, MD offices, pharmacies, imaging centers, etc.) all have their own health information technology (HIT) systems to manage healthcare and medical data on patients. Challenges include:

- Patients need the ability to be able to manage health/medical/fitness/chronic disease data across a wide range of applications (may be both mobile and web-based) that involve separate and independent repositories.
- Patients need the ability to share such information with specific stakeholders that could include: patient him/herself, family members (child care, elder care, spousal care), nutritionists, personal trainers, therapists (physical, occupational, pulmonary), home health care aides, internist, family medicine MD, nurse practitioner, physician assistants, pediatricians, cardiologists, ENTs, orthopedic surgeons, physiatrist, phycologist, therapist, etc. Some of these stakeholders may be using mobile apps (family members,

trainers, etc.) while others will need the data provided in a manner that integrates with the treatment workflow (into the EHR).
- Medical providers need to have access to both granular and aggregated health/medical/fitness/chronic disease data that patients can provide within a wide range and type of Electronic Medical Record (EHR) systems which they interact with for patient care. Medical providers each have their own EHRs and the ability to share information among providers is not easily achieved in practice. Medical providers need this information in their systems since they are disinclined to use multiple systems and want data to be presented in a unified view integrated into their current workflow and systems.
- Medical providers who provide medical devices to patients to collect data over a specific time period (Holter monitor) that could be delivered back to the medical provider by phone, internet, or by returning the device itself.

The purpose of the SDP is to explore all of these different issues utilizing a variety of health information technology standards, frameworks, and systems (see below) in order to develop a healthcare data mobile health (mHealth) app that is able to gather information from multiple sources utilizing FHIR, Fast Healthcare Interoperability Resources. FHIR provide a RESTful Application Program Interface (API) to share data in a common format. FHIR conceptualizes and abstracts information for HL7 into Resources that effectively decompose HL7 into logical components for information usage and exchange.

The following is a list of the different components and tasks for the project which is broadly defined as a: healthcare data mobile app that can integrate with multiple HIT sources to gather health and fitness data.

- Design and development of a FHIR RESTful API that is able to load/store data into Google Fit. This will require utilizing the Google Fit API.
- Design and development of a FHIR RESTful API that is able to load/store data into Apple Healthkit. This will require utilizing the Apple Healthkit API. Note there is a FHIR effort ongoing in Objective-C.[23]
- Design and development of a FHIR RESTful API that is able to gather data from medical devices (Scales, Glucometers, BP, etc.) utilizing FHIR.[24]
- Design and development of a FHIR RESTful API that is able to load/store data into OpenEMR via the OpenEMR API.
- Design and development of a FHIR RESTful API that is able to load/store data into OpenMRS via the OpenMRS API.
- Other To Be Determined HIT systems – other EHRs, Patient Portals, etc.
- Explore the ability to design/develop a FHIR RESTful API for personal health records such as CAPZULE PHR,[25] MTBC PHR,[26] suite of WebMD Applications,[27]
- A Healthcare data mobile app developed utilizing a mobile API UI framework that leverages HTML5, CSS, and JavaScript to generate iOS and Android apps from one code-based.[28] This app with interact with all of aforementioned sources (Fit, Healthkit, OpenEMR, OpenMRS, etc.).

Note: Relevant fitness and Bluetooth devices will be purchased as needed to support the work during the semester. For FHIR, see: http://www.engr.uconn.edu/~steve/Cse5810/FHIRIntroGrahame101914.pptx

Standards, Frameworks and Systems

- JSON: http://www.json.org/
- RDF: https://www.w3.org/RDF/
- XML: http://www.w3schools.com/xml/
- HL7: http://www.hl7.org/implement/standards
- HL7 CDA: http://www.hl7.org/implement/standards/product_brief.cfm?product_id=7

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- HL7 CCD : http://www.hl7.org/implement/standards/product_brief.cfm?product_id=6
- ICD-10: https://www.medicaid.gov/medicaid-chip-program-information/by-topics/data-and-systems/icd-coding/icd.html
- FHIR: Fast Healthcare Interoperability Resources https://www.hl7.org/fhir/overview.html and https://www.hl7.org/fhir/index.html
- Argonaut Project: http://argonautwiki.hl7.org/index.php?title=Main_Page and https://mihin.org/wp-content/uploads/2015/06/argonaut.pdf
- SMART: An App Platform for Healthcare http://smarthealthit.org with multiple apps https://gallery.smarthealthit.org/ and the usage of FHIR http://smarthealthit.org/smart-on-fhir/
- Open mHealth: Open Source Code to Integrate digital health data http://www.openmhealth.org
- Open MRS: open source enterprise electronic medical record system http://openmrs.org with standalone version http://openmrs.org/download/
- Open EMR: A Stage II meaningful use certified EHR http://www.open-emr.org with standalone version http://www.open-emr.org/wiki/index.php/OpenEMR_Downloads

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[1] Sujansky, W. V., Faus, S. A., Stone, E., Brennan, P. F. (2010). A method to implement fine-grained access control for personal health records through standard relational database queries. Journal of Biomedical Informatics, 43(5), 46-50.
[2] A glossary of healthcare terms: http://www.engr.uconn.edu/~steve/Cse5810/HealthCareGlossary.docx
[3] Caine, K., & Hanania, R. (2013). Patients want granular privacy control over health information in electronic medical records. Journal of the American Medical Informatics Association, 20(1), 7-15.
[4] myCVS: http://www.cvs.com/mobile-cvs
[5] MEDWATCHER: https://medwatcher.org/
[6] Drugs.com: http://www.drugs.com/apps/
[7] Capzule PHR: https://www.capzule.com/
[8] MTBC PHR: https://phr.mtbc.com/
[9] WebMD: http://www.webmd.com/mobile
[10] The Best Fitness Trackers for 2016, PC Magazine, http://www.pcmag.com/article2/0,2817,2404445,00.asp
[11] Health and Fitness Apps: http://www.pcmag.com/article2/0,2817,2485287,00.asp
and http://www.forbes.com/sites/jennifercohen/2015/01/07/the-11-top-health-fitness-apps-that-achieve-the-best-results/
[12] iOS 8 Health: https://www.apple.com/ios/ios8/health/
[13] Fitness Tracker App: https://play.google.com/store/apps/details?id=com.realitinc.fitnesstracker
[14] "In Google Fit vs. Apple HealthKit, Fitness Apps Stay Neutral": http://mashable.com/2014/06/27/healthkit-google-fit-apps/
[15] MyQuest: https://myquest.questdiagnostics.com/web/home
[16] My Imaging Records App: http://myimagingrecords.com/
[17] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4423338/ and http://www.cdc.gov/pcd/issues/2015/14_0433.htm
[18] https://www.google.com/search?q=tracking+chronic+diseases+with+mobile+apps&oq=tracking+chronic+diseases+with+mobile+apps&aqs=chrome..69i57.8751j0j4&sourceid=chrome&es_sm=122&ie=UTF-8#q=tracking+chronic+diseases+with+mobile+apps+2015
[19] MS HealthVault: https://www.healthvault.com/us/en
[20] MS HealthVault Apps and Devices: https://account.healthvault.com/us/en-US/Directory
[21] Health Information Privacy: http://www.hhs.gov/ocr/hipaa
[22] https://www.nlm.nih.gov/medlineplus/ency/article/003877.htm
[23] https://github.com/duanebender/fhir-objectiveC
[24] http://www.engr.uconn.edu/~steve/Cse5810/PhillipsHealthSuiteFHIRAPI.pptx
[25] Capzule PHR: https://www.capzule.com/
[26] MTBC PHR: https://phr.mtbc.com/
[27] WebMD: http://www.webmd.com/mobile
[28] http://noeticforce.com/best-hybrid-mobile-app-ui-frameworks-html5-js-css, http://tutorialzine.com/2015/10/comparing-the-top-frameworks-for-building-hybrid-mobile-apps/, http://www.gajotres.net/top-7-mobile-application-html5-frameworks/, http://justcreative.com/2016/03/17/html5-vs-native-apps-whats-best-for-2016/