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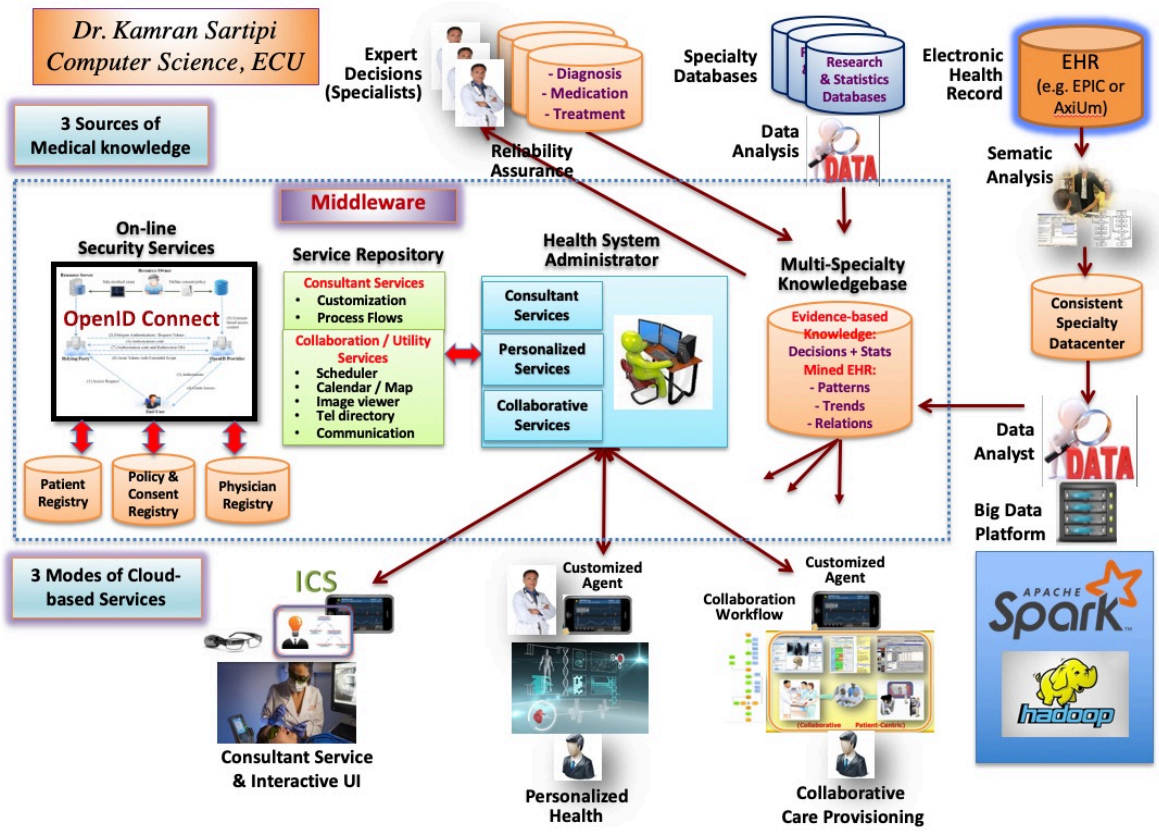
MEDICAL DECISION SUPPORT SYSTEMS & BIG DATA ANALYTICS

Overall, my research activities span different aspects of provisioning an intelligent middleware infrastructure for knowledge-driven and customizable decision support systems through cloud and mobile services. The characteristics of this infrastructure are as follows:

- Utilizes different machine learning and data mining techniques to process large and heterogeneous datasets using Apache Spark platform to provide fast in-memory and real-time data analytics power.
- Contains a knowledgebase with the representation format and annotations appropriate to the target application domain.
- Utilizes virtualized intelligent decision services with the capability of exploring the knowledgebase in order to provide selective and non-overwhelming consultation guides to the users.
- Provides customizable generic agents in mobile devices which invoke cloud-based decision services to effectively assist the users and utilize visually encoded technologies as well as augmented reality.

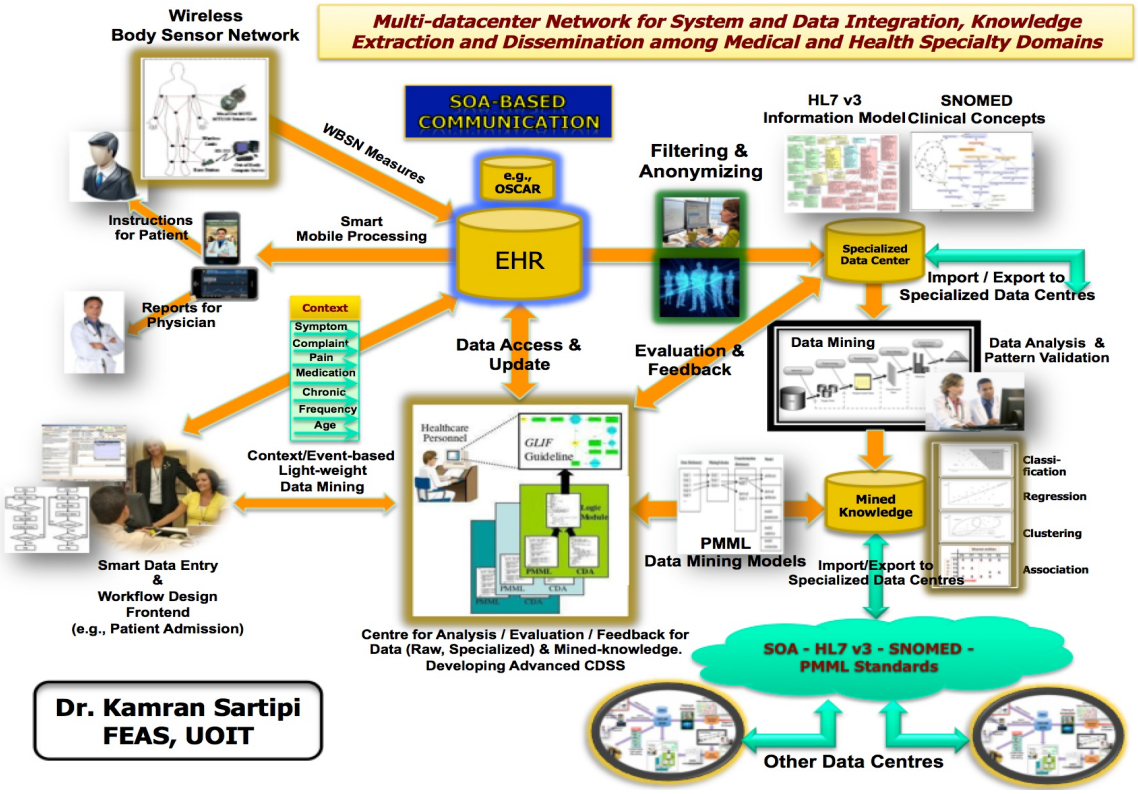
I have applied this infrastructure to "*assist physicians in underserved and poor regions to access medical knowledge of specific medical specialties to enhance their care provisioning*".

A Cloud Infrastructure for Intelligent and Customizable Medical Consultation Provisioning



This research project (shown in figure above) provides a secure datacenter and corresponding techniques and tools to extract information from heterogeneous sources, process information to generate mined-knowledge, and integrate and store them into a specialty knowledgebase within the middleware infrastructure. This knowledgebase is further utilized by a cloud-based intelligent decision support system which provides effective, personalized and customizable assistance to medical professionals in diagnosis and treatment of their patients. This datacenter utilizes three sources of medical knowledge which will be validated, integrated, properly annotated, and stored in the specialty knowledgebase using a new knowledge representation format we developed. The cloud services provide customization of the mobile devices for a new type of knowledge-driven and context-based decision support services (called consultant services), and for different collaborative tasks among physicians.

Multi-Datacenter Network for Data and Service Integration, Knowledge Extraction and Dissemination among Medical Specialty Domains.



his project is underway with collaboration of the Department of Medicine (Gastroenterologists) at McMaster University. The architecture of the multi-datacenter is shown below. In this project, we develop a data center for the McMaster IBD (inflammatory bowel disease) Clinic to extract knowledge from patient data that will be scaled up and applied to a multi-center collaboration to support a network of ambulatory care IBD clinics. Each datacenter is autonomous in terms of the adopted EHR (Electronic Health Record) system, data schema and communication protocols, and will be implemented using a private cloud infrastructure. The integration among the centers are based on standards, such as SOA (SOAP or RESTfull services), HL7 v3 (medical messaging standards) SNOMED CT (concept interoperability), and PMML (knowledge interoperability). The system security and intelligence will be

provided through OpenID Connect authentication and authorization technology. The sub-projects are as follows. (**b**:book; **ch**:chapter; **j**:journal; **js**:journal-submitted; and **c**:conference)

Below, my research projects are briefly described, with links to the PDF publications.

- **Smart decision support systems.** This project aims at providing a new generation of decision support systems where mined-knowledge at decision points (as reminders, alerts, recommendations) will assist the physicians (for patient diagnosis) or administrators (for resource allocation) to make effective decisions. In this context, mined-knowledge refers to the extracted patterns and trends from clinical data using data mining techniques. This research covers both rule-based and flow-based decision support techniques [j10, j4, ch3, ch2, c43, c41, c31, c13, c11].

- **Knowledge-driven user behavior-pattern discovery.** This research provides a new generation of intelligent decision support systems that effectively assist the system administrators to obtain deep insight into the system user's dynamic behavior patterns in order to refine the existing security policies using a novel behavior pattern query language (BPQL) **[**j9**,** j14**,** j8**,** c49**].**

- **Enhancing data privacy in service oriented architecture (SOA).** This research enhances data privacy and security, reduces network traffic, and provides new enterprise level features. It introduces two new concepts “task service” and “ service representative” in the SOA environment. Task service is a multi-component (model, knowledge, data) web service that can process the client data locally at the client side. Service representative is a generic agent at the client side that will be customized by the knowledge component and will execute the model component on both client and task service data. This approach will enhance the SOA architecture in different ways [j6, js2, js1, c39, c38, c36, c35, c34, c32].

- **Knowledge translation to HL7 v3 messages.** This project provides a well-defined process to guide translation of healthcare transactions (obtained from healthcare scenarios) to HL7 v3 Interactions. The approach re-categorizes HL7 v3 Interactions based on their behavioral traits in a messaging context and uses semantic analysis to automate the process of identifying HL7 v3 Interactions [j7, j2, c40, c30, c25, c21, c19].

- **Mobile eHealth.** This project provides efficient techniques to integrate different devices such as cell phones, tablets, and specialized devices such as pacemakers to be used seamlessly with other software services of the electronic health record (EHR) systems. In this approach data will be collected, maintained, analyzed and communicated using HL7 information models and messaging. [c35, c34].

- **Dynamic Analysis**. This research identifies the implementation of specific software functionality within a software system without any prior knowledge about the source code. The approach consists of applying specific sets of scenarios on an instrumented software system to extract execution traces. Next, sequential pattern mining algorithm and concept lattice analysis are applied to extract execution patterns and locate the target source code. We expanded this approach by applying it on service-oriented architecture (SOA) to measure the quality of web services in service selection and composition. [j5, c37, c26, c23, c20, c18, c17, c16, c15, c14, c12, c27].

- **Static Analysis**. This research addresses the design and development of an incremental software architecture recovery and evaluation environment using data mining techniques. The environment is interactive and provides: pattern-based architectural recovery using a query language and approximate graph pattern matching; optimization clustering; partitioning; and view-based architectural design evaluation. These techniques have been implemented within my Alborz toolkit, which are mentioned below [b1, ch1, j3, j1, c24, c10, c9, c8, c7, c6, c5, c4, c3, c2, c1].