Industrial-Strength Interoperability Platform for Health (IOP-H)

● Pierre Coderre

To sustain the evolution toward pan-Canadian electronic health records, Fujitsu was mandated to develop the InterOperability Platform for Health (IOP-H), which can be viewed as a robust, flexible, and high-performance integration platform that ensures the reliable, secure, and traceable flow of patients' clinical information between applications located in technically diversified and physically or organizationally distributed environments. This flow is controlled by rules governing the access rights and the logical sequence of events and conforms to pan-Canadian standards for the health sector. This paper outlines IOP-H by introducing its architecture, services, and implementation.

1. Introduction

Evolution toward an electronic health record (EHR) system[note 1)] has been progressing for many years, but having secure EHRs that can be shared across different jurisdictions and a large geographical territory with different languages has always been impeded by the lack of generic interoperability between EHR systems. In the context of a Canadian nationwide effort to deliver EHRs, Fujitsu was mandated by the Government of the province of Quebec to deliver the core interoperability services to connect health service providers. The phenomenal quantity of health information already existing and the mobility of patients between healthcare providers make it unthinkable to conduct such EHR standardization and implementation without an evolution path for what exist now. Fujitsu's InterOperability Platform for Health (IOP-H) implements the requirements of Canada Health Infoway[note 2)] for the health information access layer (HIAL)[note 3)] services of an EHR solution (EHRS)[note 4)] as

note 1) An EHR system provides each individual in Canada with a secure and private lifetime record of their key health history and care within the health system. The record is available electronically to authorized healthcare providers and the individual anywhere and anytime in support of high-quality care. The EHR system is also the central component that stores, maintains, and manages clinical information about patients/persons. The extent of the clinical information sustained by the EHR component may vary according to mainly the presence or absence of domain repositories in any given jurisdiction.

note 2) Canada Health Infoway is a Canadian not-for-profit organization financed by the Canadian government that collaborates with the provinces and territories, healthcare providers, and technology solution providers to accelerate EHR use in Canada.

note 3) HIAL is an interface specification for the EHR infostructure that defines service components, service roles, the information model, and messaging standards required for the exchange of EHR data and execution of interoperability profiles between EHR services.

note 4) EHRS represents the combination of people, organizational entities, business processes, systems, technology, and standards that interact and exchange clinical data to provide high-quality and effective healthcare.

described in the EHRS blueprint, version 2.0 published by Infoway in March 2006. As such, IOP-H processes standardized health messages based on HL7 v3.0 (HL7: health level 7[note 5)], v3.0: version 3.0). This version of HL7 is the first to incorporate object oriented and Internet concepts to define the structure of messages in the health domain. Most of the current health message interchange is based on the major release 2 (R2), which left a lot to interpretation for peer-to-peer interoperability. IOP-H therefore implemented extensions that allow the conversion of messages to and from noncompliant HL7 v3.0 message sources.

With IOP-H, Fujitsu took great care to ensure conformity to the Service Oriented Architecture (SOA), as recommended in EHRS. IOP-H therefore meets Web Services (WS) standards, especially those related to security. The two main goals for IOP-H are to promote the implementation of the new health interoperability standards and, at the same time, provide a secure bridge for rapidly gaining access to key existing health information.

2. Background of Canadian EHRS

Infoway's goal is to fully implement an interoperable EHR solution across Canada's population. It is currently investing in nine targeted program areas, one of which is the interoperable EHR program. The goal of this program is to implement solutions that will allow authorized healthcare providers to view key integrated patient-centric health data anywhere and anytime in support of high-quality care. Patient information will be shared among health providers via the EHR. This secure lifetime record is designed to facilitate the sharing of data across the continuum of care, healthcare delivery organizations, and geographical areas.

Interoperability among all of the solutions in use across Canada is key to the sharing of patient health data between providers. To achieve such interoperability, it is fundamental that all parties develop their solutions using the same basic rules. Two of the key elements on which to build common rules are architecture and standards.

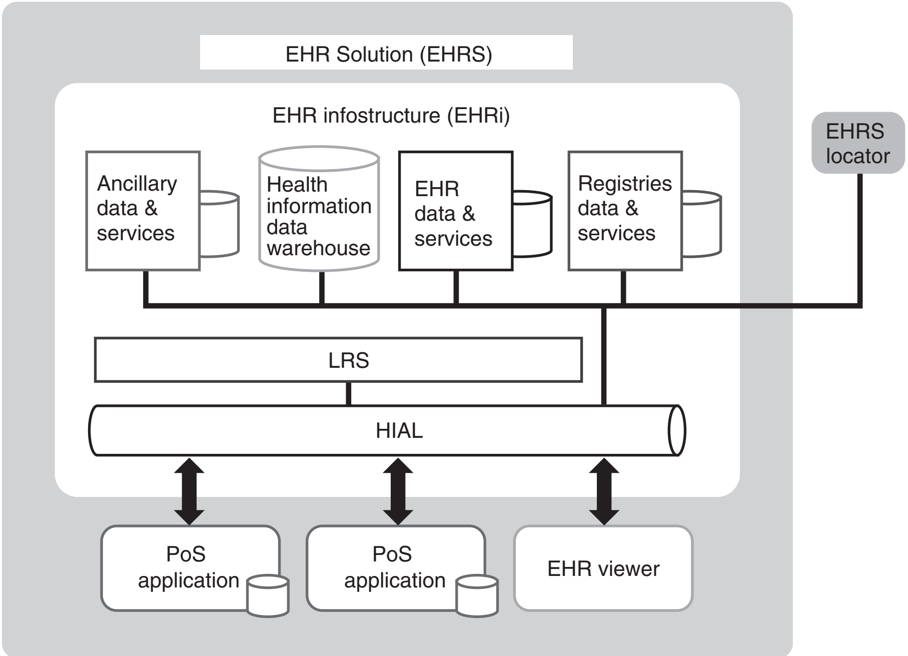
Infoway has developed a blueprint that meets this goal and also allows the jurisdictions to address their own priorities. It has also set up a standards collaboration process to guide and govern the establishment of pan-Canadian EHR standards.

The high-level architecture of the overall Infoway EHRS is shown in **Figure 1**. This diagram can be divided into three main sections. The upper portion contains the data repositories holding the patient information by category, such as identification (client, provider, and location registries), patient-specific information (drugs, allergies, referral summaries, hospital discharge summaries, laboratory and diagnostic imaging results, etc.), and public health surveillance information.

The middle level of the diagram includes the Longitudinal Record Services (LRS) and HIAL. These components can be viewed as the spine connecting all the components of the solution. The main role of LRS and HIAL is to track and organize relevant historical health information about any given patient.

Finally, the bottom section of the diagram corresponds to the points of service (PoSs) where this information can be viewed. The viewer allows authorized health professionals to view the consolidated information contained in the data repositories described above. The EHR viewer is meant to present healthcare providers with key shared patient-centric information—it

note 5) HL7 is an all-volunteer, not-for-profit organization involved in developing international healthcare standards. It is one of several standards developing organizations (SDOs) accredited by the American National Standards Institute (ANSI) operating in the healthcare arena to produce communication standards (sometimes called specifications or protocols).



Source: Extracted from EHRS blueprint Infoway version 2.0.

Figure 1
Key concepts of EHRS architecture.

is not meant to replace the provider's clinical information system[note 6)] or medical records, but to provide supplementary information. However, the information obtained through the viewer comes through HIAL from different healthcare locations or resources and can include results (such as diagnostic images or laboratory tests) requested by different providers, as well as details of distinct healthcare encounters.

note 6) A provider's clinical information system is dedicated to collecting, storing, manipulating, and making available clinical information important to the delivery of healthcare (usually within larger healthcare delivery organizations, such as hospitals or health districts/regions). Clinical information systems may be limited in scope to a single area (e.g., laboratory systems and electroencephalography management systems) or they may be comprehensive and cover virtually all facets of clinical information (i.e., electronic patient/person records, the original discharge summary on the chart, with a copy of the report sent to the admitting physician, another copy existing on the transcriptionist's machine, etc.).

HIAL is a gateway that acts as an abstraction layer to separate PoS applications from the EHR infostructure (EHRi).[note 7)] It is made up of service components, service roles, information models, and messaging standards required for the exchange of EHR data and the execution of interoperability profiles between EHR services. Its interaction model is illustrated in **Figure 2**.

HIAL is the single entity in EHRS that can track a business transaction from start to finish through all the intermediary steps. It consists of two layers of services: the common services and the communication bus services.

The common services layer is an aggregation of services that provide common and reusable functions for the systems participating in an EHRi. It is focused on integration, privacy and

note 7) EHRi is a collection of common and reusable components supporting a diverse set of health information management applications. It consists of software solutions to support integration with the EHR, data definitions for the EHR, and messaging standards for integration and interoperability.

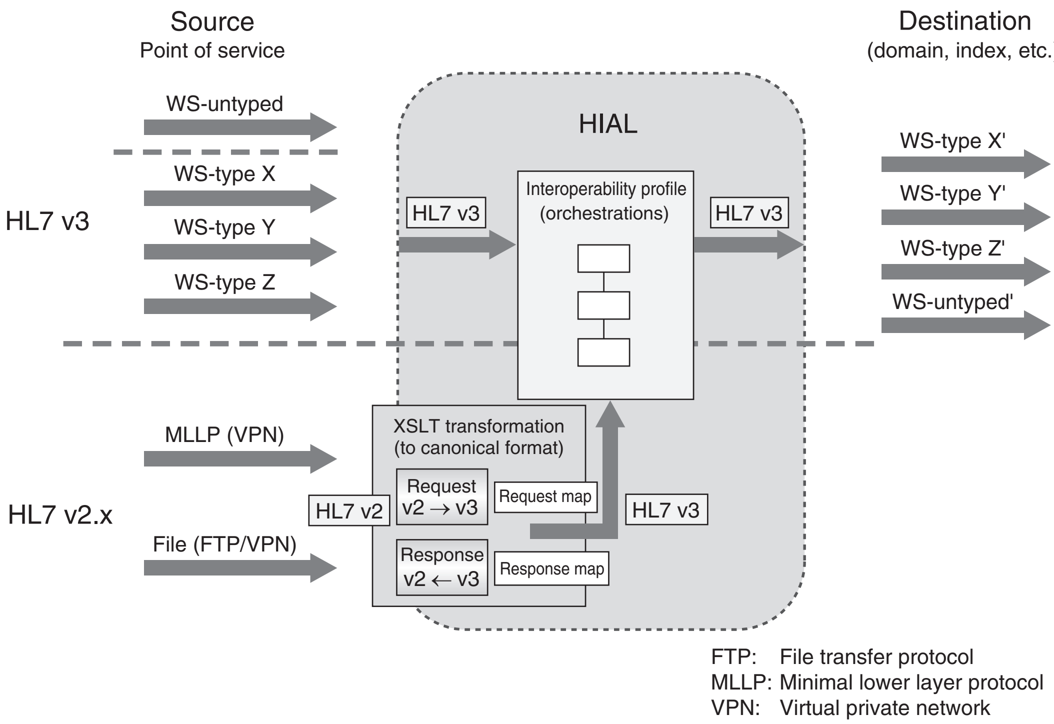


Figure 2
HIAL interaction model.

security, system configuration, management, and monitoring functions and makes those common functions available for all services in a given EHRi.

The communication bus services layer is an aggregation of services that pertain specifically to enabling communication capabilities. It is focused on the receiving and sending of messages and support for valid communication modes, primarily between PoS applications and an EHRi, EHRi-to-EHRi, and possibly between components within an EHRi (e.g., the LRS to the client registry).

LRS is the central component that coordinates and manages the existence and location of clinical information about patients. One of its main features is an index of all events tracked or maintained in an EHRi. Through this index, a consistent longitudinal and cross-domain view of the clinical information about a patient is always available.

3. IOP-H's implementation of HIAL

IOP-H is a robust, flexible, and high-performance integration platform that ensures the reliable, secure, and traceable flow of patients' clinical information between applications located in technically diversified and physically or organizationally distributed environments. This flow is controlled by rules governing the access rights and the logical sequence of events and conforms to pan-Canadian standards for the health sector.

Fujitsu's approach in implementing HIAL was not to reinvent the wheel for each SOA service to be delivered but to focus on integration and performance while ensuring loose coupling of components. The goal was not only to deliver the first iteration of HIAL, but also to make it an evolving assembly of components delivering services implementing the best practices of health standards, SOA, and information security. This philosophy enabled IOP-H to evolve and adapt throughout the project delivery process.

The philosophy behind IOP-H has been to develop a solution involving clinical specialists throughout the process with the clinician's business process in mind to promote favorable adoption. It is a total business concept that includes the software and professional services to help users with customization, deployment, and change management. And as such, the following benefits are expected at the business level.

- Seamless interoperability between PoS applications and data repositories that can be grouped geographically, functionally, and organizationally
- Easy customization and rapid adoption
- Reduction in underlying business risks
- Cost effectiveness through maximum reuse of existing hardware, software, and processes and rapid professional implementation
- Robust and proven solution
- Extended portability and interoperability
- Extensive security and traceability
- Flexible solution with dynamic evolution of profiles
- Evolution and operations facilitated by use of best practices

3.1 Multilevel IOP-H architecture

3.1.1 Services

IOP-H services, illustrated in **Figure 3**,

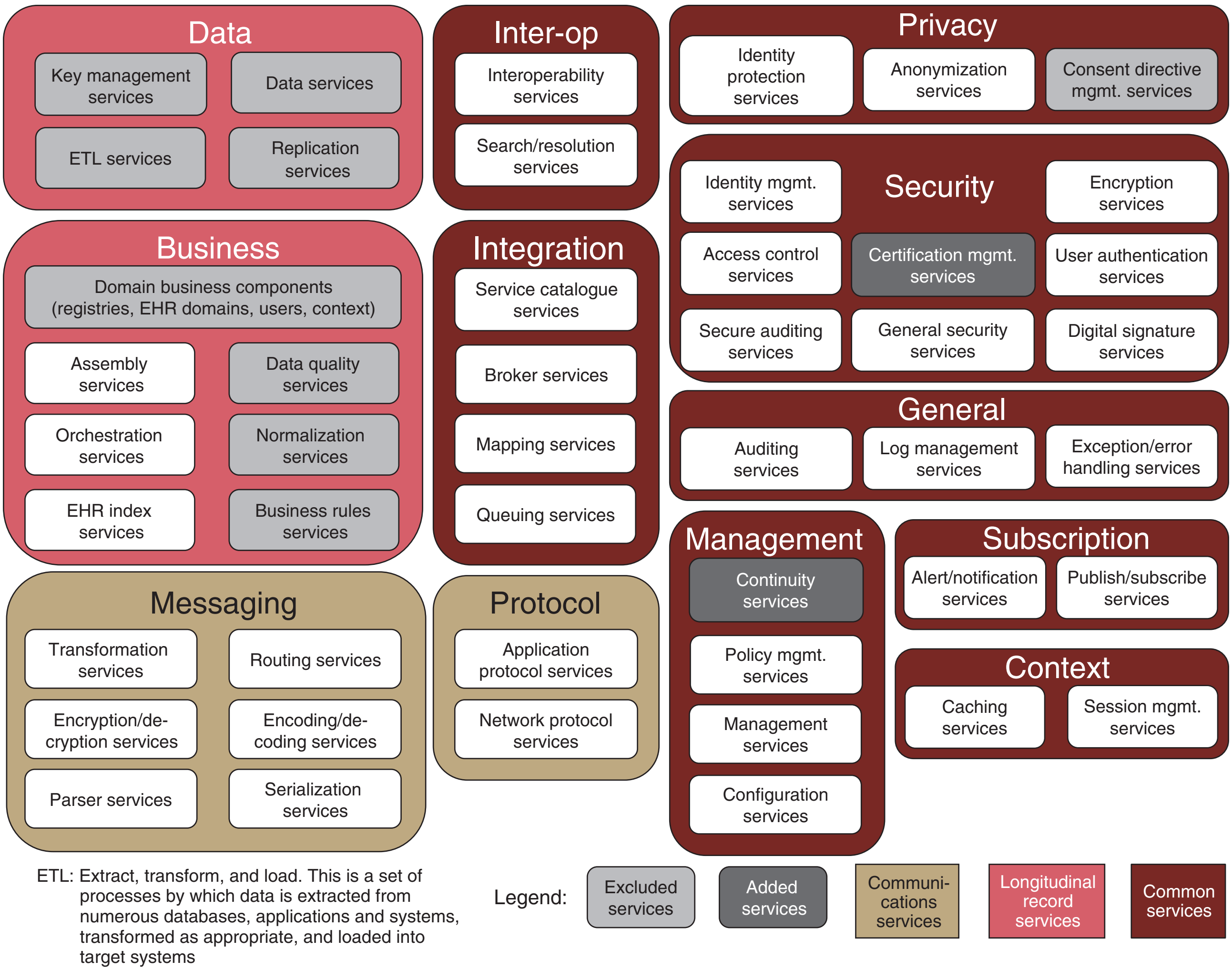


Figure 3
LRS and HIAL services.

are the core functionality of the product. Fujitsu was mandated to deliver three of the LRSs (Orchestration, Assembly, and EHR Index) and all the HIAL common services and communications services (except Consent Directory Management). They were designed to meet EHRS requirements and functionalities, as described in the EHRS blueprint.

3.1.2 Subsystems

IOP-H also contains a number of supporting subsystems to assist in the management of the solution: the Self-Service Portal, Operations Management Support Toolset, and Infostructure (also known as generic orchestration and interoperability profiles).

3.1.3 Extensions

Extensions provide extra functionality that can be optionally added to IOP-H when clients do not already have equivalent functions in place. Available extensions are listed below.

- Certification Management Solution
- Transformation, orchestration and assembly services beyond those covered by the initial professional services that form an integral part of the solution
- Transformation and Assembly engines are also available as WSs that can be used as part of other EHRS components such as PoS and other source applications (drugs, laboratories, etc.).

3.2 Four key features of IOP-H

3.2.1 Performance and robustness to meet the needs of the health industry

IOP-H has proven to have industrial strength. It has been developed using industry standard tools and techniques, but the end-result is a business solution tailored to meet specific health-sector needs. IOP-H has been designed to cater for the heavy performance needs within the health sector. In a nutshell, it receives messages from external services, validates them according to user specifications, ensures their conformity to role-based authorization rules, and invokes a series of WSs to obtain a final reply message from diverse sources. It can process messages in synchronous mode as well as asynchronous mode. In its native form, it interfaces with WSs using extensible markup language (XML) HL7 v3.0 type messages, but it can be configured to interface with external applications and invoke services in a variety of modes. The flexibility of the platform allows its performance to be tuned for a wide range of applications and throughput requirements.

3.2.2 Cost-effective rapid implementation that reduces risks and fosters adoption

The deployment of complex systems inevitably brings risks and often causes business disruptions. These aspects are greatly mitigated by the use of templates and frameworks. Moreover, clinical specialists have been actively contributing to the design of the solution so as to meet the expectations of clinicians and thus help reduce resistance to change. Together, the tools, templates, and expertise provided with the solution will ease the solution's tailoring to meet any local requirements (coding, message structures, interfaces with existing systems, etc.).

3.2.3 Conformity and security

In its core, IOP-H processes HL7 v3.0 messages and permits extensions that allow the conversion of messages to and from noncompliant message sources. Great care has been taken to ensure SOA conformity, as recommended in EHRS. IOP-H meets WS standards, especially those related to security (WS-Security).[note 8)]
IOP-H's reliance on established industry standards facilitates the maintenance and

note 8) WS-Security is a flexible feature-rich extension to the simple object access protocol (SOAP) for applying apply security to Web services.

evolution path of the underlying software platform.

3.2.4 Flexibility

Because of its flexibility, IOP-H will allow clients maximum reuse of existing hardware, software, and processes and extended portability and interoperability. This means a gentler learning curve, which translates into faster and cheaper implementation.

The security compliance and great flexibility are not gained by limiting the evolution of the solution: all profiles and rules can be dynamically updated and version control is provided.

IOP-H has been designed in a manner compliant with the simple object access protocol (SOAP) and other WS standards. Apart from the Microsoft platform upon which it is built, it has also proven its integration capability with UNIX and a Java-based SOAP framework. It therefore interfaces easily with existing applications and should interface easily with future ones. It is also designed to be managed according to best practices such as the Information Technology Infrastructure Library (ITIL).

IOP-H is responding to critical needs within the health industry. Although originally used in an EHRS context, it can be used in any situation where clinical information is exchanged between applications located in technically diversified and physically or organizationally distributed environments. Its underlying architecture splits the functions in layers in order to allow the people managing HIAL to ignore the specifics of the business domains while allowing the domain experts (or domain-specific application developers) to safely ignore the inner workings of HIAL. This is therefore consistent with the best practices of SOA.

IOP-H's architecture and its underlying technology enable flexible and rapid deployment, avoiding time-consuming, risky, and expensive implementation projects. The core inner working of IOP-H is built on a standardized message exchange structure with predictable behavior and performance. The noncompliant systems are interfaced with edge components that are reusable and specialize in conversion to ensure structural integrity of the transformed messages to be exchanged.

There are already 23 specific transaction profiles defined in the Quebec implementation that follow the interaction model shown in **Figure 4** to support patient clinical data, laboratory results, drug prescriptions, and radiology to query and maintain that information. More are constantly being added. Once the messages and rules have been defined, the configuration process is straightforward. Moreover, although it has been designed for the health sector, where integrity, reliability, security, and confidentiality requirements are most stringent, it can be reused in any environment where players, using incompatible technical platforms, have agreed to transact with each other according to an agreed set of messages and rules.

4. IOP-H services

IOP-H services are organized and implemented to maximize reuse and are sequenced to optimize the flow of information (Figure 4). Therefore, IOP-H will ensure the following.

1) Only correctly formatted/structured messages will be processed.
2) Only legitimate and correct combinations of user, patient, and message will be processed.
3) The message data content will not be modified while being processed by IOP-H.
4) The message will be processed to its conclusion according to the rules defined for its profile; error/exception handling is incorporated into the processes (so that transactions will always complete, but the answer may contain an error message).
5) All steps in the processing of a message will

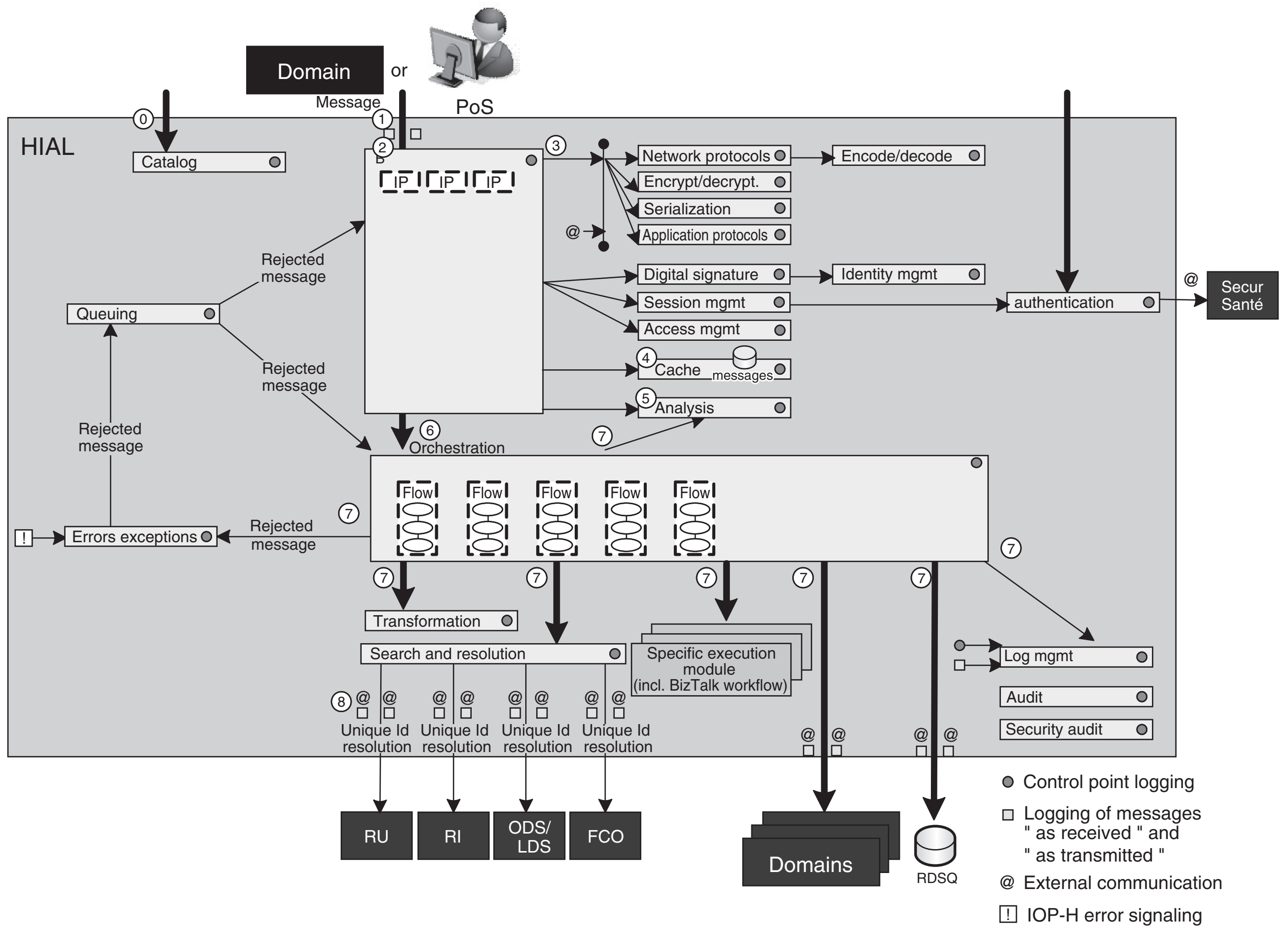


Figure 4
LRS and HIAL service architecture.

be logged.

IOP-H contains its own services search and resolution services and can be configured to invoke a business process execution language (BPEL)[note 9)] engine (or any WS) that can interface with other implementations of IOP-H (or similar platforms) to produce vast networks or hierarchies of applications.

Invoked IOP-H services must also be able to perform according to the profile requirements defined by clinical specialists to maintain the business workflow integrity that would allow for processing steps of any type, including manual interventions such as signatures and answers to information requests that have to be provided by human intervention.

5. IOP-H implementation

A typical IOP-H implementation project unfolds as follows.

1) The prerequisites are installed and configured according to IOP-H's infrastructure setup guide supplied with the core product.
2) The product is installed and configured through professional services.
3) Generic interoperability profiles are instantiated/modified to meet the general requirements of the client.
4) EHRS interoperability profiles are created/

note 9) BPEL is an orchestration language that specifies an executable process that involves message exchanges with other systems, such that the message exchange sequences are controlled by the orchestration designer.

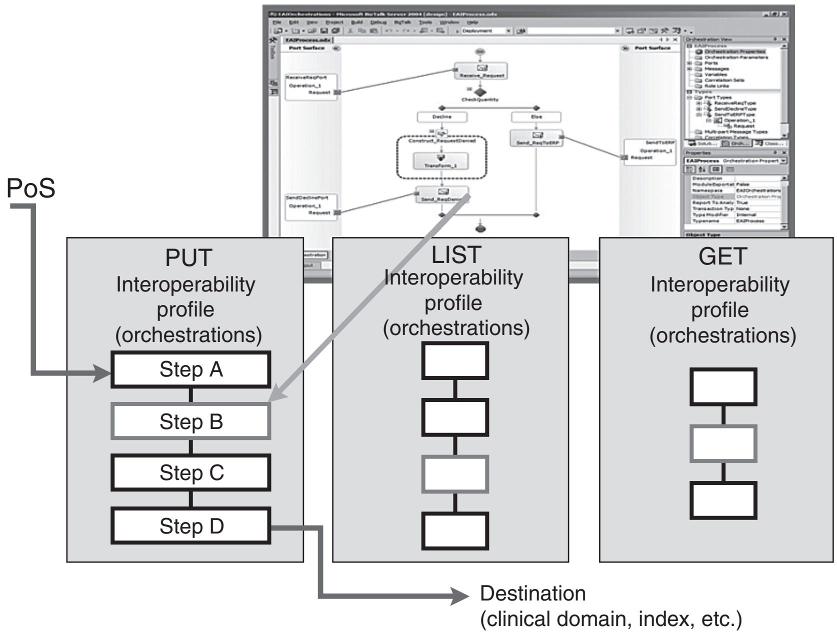


Figure 5
Interoperability profile information flow definition.

modified according to which transactions need to be supported. This includes defining the WS description language (WSDL)[note 10)] to call services, integrating the WS's uniform resource locators (URLs) in the generic profile and defining the XML schema definition (XSD)[note 11)] for message input and output.

5) Support tools and procedures are put in place to monitor the operation of the system at the technical and functional levels.

When interoperability profiles are created, they usually uses existing generic interoperability profiles as templates. A typical profile will perform the following actions.

1) Initiate a secure sockets layer (SSL) session after reciprocal authentication.
2) Receive and acknowledge the message.
3) Authenticate the user and validate his or her access.
4) Verify the patient's consent.
5) Validate the message.
6) Transform the message if required.
7) Route the message through the required services according to the message EHR interoperability profile routing specifications.
8) Assemble responses if required.
9) Return the answer to the message initiator.
10) Log all steps.

A number of specific interoperability profiles are currently being defined in the Quebec implementation. Although these profiles are based on Infoway standards, they have been modified to suit Quebec's real-life requirements. They are currently operational, and more are being added as the project unfolds. As shown in the example in **Figure 5**, a Put profile for the imagery domain could have the following steps.

- Step A: Perform patient resolution (find the

note 10) WSDL is an XML-based language that provides a model for describing Web services.

note 11) XSD is used to express a set of rules to which an XML document must conform in order to be considered valid according to that schema.

unique patient identifier) with the patient name, date of birth, and address.

- Step B: Perform clinician resolution (find the unique clinician identifier) with the clinician name and professional number.
- Step C: Perform clinic resolution (find the unique clinic identifier) with the clinic name and care facility number.
- Step D: Update the imagery LRS with the given imagery studies and the EHRi with the proper identifiers.

Each of these steps also contains error- and exception-handling to ensure EHR integrity. They can be modified to suit the interface requirements of other health jurisdiction: such modifications will be covered by the professional services included in the license fee for the jurisdiction.

When messages from source (or destination) applications do not comply with published Infoway standards, specific transformations and interoperability profiles can be defined, either directly in HIAL or by using the external transformation WS. This can be done by an interoperability profile as long as the client can provide an interface specification (WSDL, URL, or XSD formats for in and out messages).

The benefits of this structure are to isolate the various layers of standards and minimize the impact that changing one level may have on the other levels. At the same time, the overall infostructure is kept flexible enough to accommodate any jurisdiction's legal or process requirements and local variations in messages.

6. Conclusion

IOP-H has proved that it is possible to create an HIAL that can meet the Infoway EHRS blueprint requirements and conform to all provincial legal requirements to preserve patient information privacy. Moreover, clinical field experiments have demonstrated its flexibility and ease of use for both clinicians and healthcare solution developers. The major challenges that the project team faced were more often than not related to harmonizing the use of WS standards for external component connections and establishing an optimized interaction model that ensures that parties using IOP-H are not individually duplicating services already provided by the framework (i.e., logging and error handling), which would lead to poor overall performance.

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