Interoperability in Healthcare

SIEMENS

White Paper

A comprehensive review of past, present, and future interoperability standards, and how Siemens reinforces them.

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The national push for a connected, integrated healthcare system is putting increased demands on our IT infrastructure. Data, that in the past was isolated within an application or healthcare entity, needs to be shared in ways that will benefit the health of individual patients as well as reduce costs. Our challenge today is to find ways to integrate our healthcare networks with other communities, states, and perhaps countries.

Contents

What is interoperability?

The term interoperability is broadly defined as:

- The ability to exchange and use information, usually in a large heterogeneous network.
- The ability of diverse systems and organizations to work together.
- Connecting people, data and diverse systems in a technical or broad way, taking into account social, political and organizational factors.

And more specifically to healthcare:

> *Interoperability means the ability of health information systems to work together within and across organizational boundaries in order to advance the effective delivery of healthcare for individuals and communities.* (HIMSS.org)

From a healthcare technology perspective, interoperability specifically involves:

- Data exchange
- Infrastructure interoperability
- User interface interoperability

Siemens has identified these three categories as the keys to broad health system interoperability. In this paper we will outline Siemens answers to these challenges as well as our strategic interoperability direction.

Health Information Exchange and Health Portals

Before delving into different standards and solutions for interoperability, we need to touch on a topic that is central to any healthcare interoperability strategy today – Healthcare Information Exchange. This term can be used either as a *verb* or a *noun*. The verb form is the actual process of exchanging or moving data between two systems, providers, or entities. The noun, frequently abbreviated as HIE, is an organization that oversees and governs the exchange of health-related information, usually via recognized standards. Both the *process* of exchanging the data and the *actual* HIE organizations that exchange data are affected by the broader topic of "interoperability."

Health Portals are another way to communicate patient-specific data between authorized parties, patients, and family members. While Healthcare Information Exchange usually refers to the movement and storage of various pieces of healthcare data, a portal is typically the "viewer" or gateway to bring it all together. Portals, like HIEs, benefit from the various interoperability technologies that will be explored in this paper.

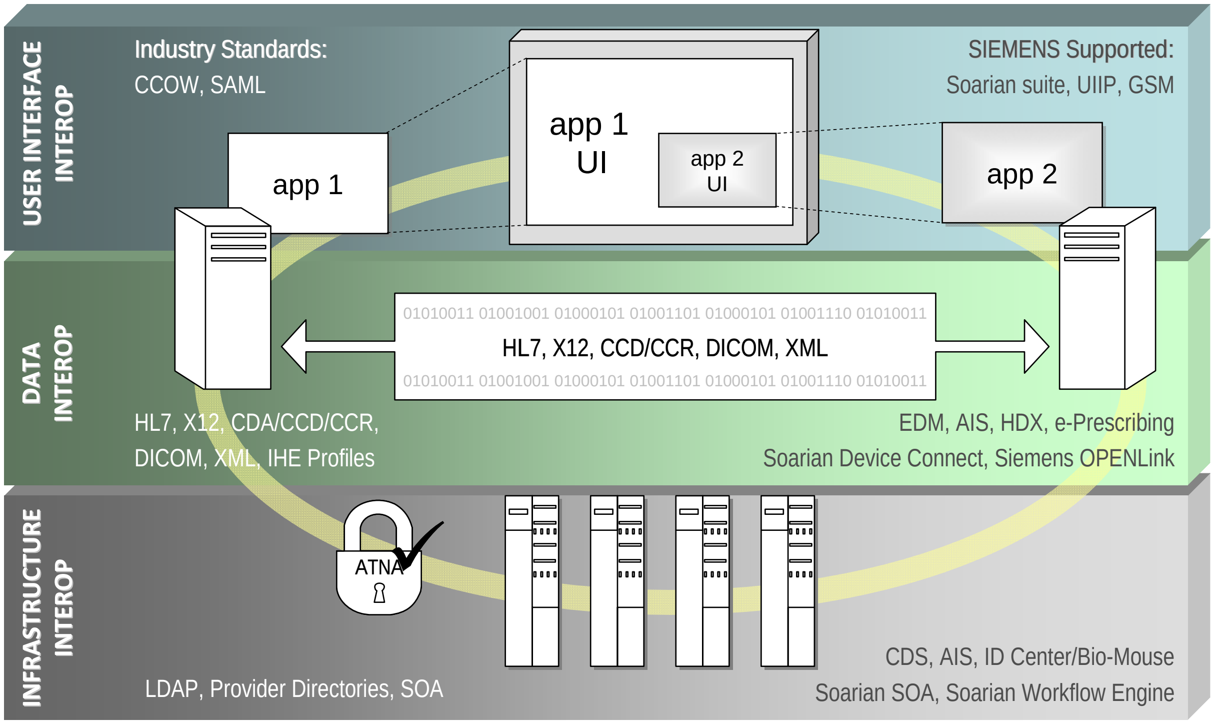

Figure 1. Components of Interoperability
Interoperability in healthcare revolves around three major layers of technology – user interfaces, data, and infrastructure.

What are the data exchange implications of interoperability?

Traditional Data Exchange Interfaces

For more than 25 years, interfaces between separate healthcare IT systems have exchanged data such as admissions, discharges, and transfers (ADT), orders, results, and charges. Originally many of these interface solutions were designed to solve very specific connectivity issues and were written as direct connections between two specific systems. Today, these interfaces handle the vast majority of data interoperability between healthcare IT systems.

Over time interface standards were developed to structure the data for the most common types of interfaces. Vendors implemented these standard interfaces in ways that best suited their system configurations. But this often resulted in a proprietary standard interface that needed modification before data could be transferred to a foreign system.

To streamline these modifications, "interface engines" were developed to format and sometimes reinterpret the data as it was moved from one system to another. These interface engines are responsible for receiving the data from one system, reformatting it as needed for the receiving system, and then forwarding it on. Modern interface engines perform additional features, such as verifying the receipt of data and auditing interface reliability and performance.

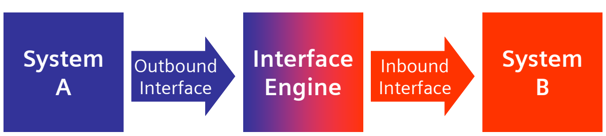

Figure 2. Data transformation via an interface engine
Data leaving System A is reformatted by an interface engine so it can be forwarded and interpreted by System B.

Healthcare IT remains a very fragmented environment, with solutions from multiple vendors and custom applications using a wide variety of technologies. The use of a standardized implementation process for custom and model interfaces that includes thorough testing and appropriate documentation helps to ensure that the entire integration or interface environment is stable and supportable, and achieves its overall objectives for the healthcare organization.

While these long-established interfaces are very powerful, they may not easily scale nationwide or globally to share patient information. Limitations of this traditional approach include, but are not limited to:

- Technological
- Economic
- Privacy and Security

Data Exchange Standards

Regardless of the design nature of an interface, standards are frequently employed. The following are some of the most common healthcare interface technologies, and their standards bodies who author and maintain them.

X12

ASC X12 is not a technology. It is a body of experts chartered by the American National Standards Institute (ANSI) in 1979 to develop electronic data interchange (EDI) standards for national and global markets. With more than 315 X12 EDI standards and an expanding number of X12 XML schemas, ASC X12 enhances business processes, reduces costs and expands organizational reach. Members include standards experts from health care, insurance, transportation, finance, government, supply chain, and other industries.

The ASC X12 body comes together three times each year to develop and maintain EDI standards that facilitate electronic interchange relating to business transactions such as sales order placement and processing, shipping and receiving information, invoicing, payment and cash application data, and data to and from entities involved in finance, insurance, transportation, supply chains, and state and federal governments.

HL7

Health Level Seven International (HL7) is a not-for-profit, standards-developing organization dedicated to providing a framework for the exchange, integration, sharing, security and privacy, and retrieval of electronic health information. HL7's members represent more than 90% of the information systems vendors serving healthcare. The term "HL7" is also used to refer to specific standards created by the organization, of which their v2.x standards are the most commonly used in the healthcare world.

HL7 version 2.x

The HL7 version 2 standard aims to support healthcare workflows. It was originally created in 1989. It defines a series of electronic messages to support administrative, logistical, financial, and clinical processes. Since its adoption, the standard has been updated regularly.

HL7 v2.x mostly uses a textual, non-XML encoding syntax based on delimiters.

HL7 v2.x has allowed for the interoperability between electronic patient administration systems (PAS), electronic practice management (EPM) systems, laboratory information systems (LIS), dietary, pharmacy and billing systems as well as electronic medical record (EMR) or electronic health record (EHR) systems. Currently, HL7's v2.x messaging standard is supported by every major healthcare information systems vendor in the United States.

HL7 version 3

The HL7 version 3 standard aims to support all healthcare workflows. Development of version 3 started around 1995, resulting in an initial standard publication in 2005. The v3 standard, unlike v2, is based on a formal methodology (the HDF) and object-oriented principles. While HL7 version 2.x is much more widely adopted in the USA, HL7 v3 has a better adoption rate in other countries such as Canada. The HL7 v3 messaging standard defines a series of electronic messages called "interactions" to support all healthcare workflows. HL7 v3 messages are based on an XML encoding syntax.

RIM - ISO/HL7 21731

The Reference Information Model (RIM) is the cornerstone of the HL7 v3 development process and methodology. RIM expresses the data content needed in a specific clinical or administrative context and provides an explicit representation of the semantic and lexical connections that exist between the information carried in the fields of HL7 messages. The RIM is essential to increased precision and reduced implementation costs.

CDA / CCD / CCR

Clinical Document Architecture (CDA) Release One (CDA R1), became an ANSI-approved HL7 standard in 2000, representing the first specification derived from the HL7 Reference Information Model (RIM). CDA R2 became a standard in May 2005.

CDA is a document markup standard that specifies the structure and semantics of "clinical documents" for the purpose of exchange. CDA documents derive their machine-processable meaning from the HL7 Reference Information Model (RIM) and use the HL7 v3 data types. CDA itself is not a specific document, but a flexible XML architecture that can be used to express many types of documents.

A CDA document can contain many data sections, all of which contain mandatory narrative text (for human readability and interpretation), and some of which contain structured data elements which may be coded using standard vocabularies for purposes of software processing.

This architecture provides the framework for the more commonly referred to CCD and CCR.

A **Continuity of Care Document (CCD)** is one specific example of a CDA document. It is a clinical summary document for an individual patient, formatted to a specific technical standard to facilitate accurate exchange between systems.

This patient summary contains a core data set of the most relevant administrative, demographic, and clinical information facts about a patient's healthcare, covering one or more healthcare encounters. It provides a means for one healthcare practitioner, system, or setting to aggregate all of the pertinent data about a patient and forward it to another practitioner, system, or setting to support the continuity of care. Its primary use case is to provide a snapshot in time containing the pertinent clinical, demographic, and administrative data for a specific patient.

The CCD specification contains U.S. specific requirements. Its use is therefore limited to the U.S. The U.S. Department of Health & Human Services Office of the National Coordinator (ONC) for Healthcare IT has selected the CCD as one of its standards.

The **Continuity of Care Record (CCR)** and CCD are often seen as competing standards. However, CCD R1 is an HL7 CDA implementation of the Continuity of Care Record (CCR) and their contents have been harmonized. But in the view of Siemens, the CDA standard, including the CCD, provides a more comprehensive and extensible framework for defining clinical documents. Siemens, collaborating with the HIMSS EHR Association, has created a detailed spreadsheet (available upon request) showing how CDA includes all CCR data and much more.

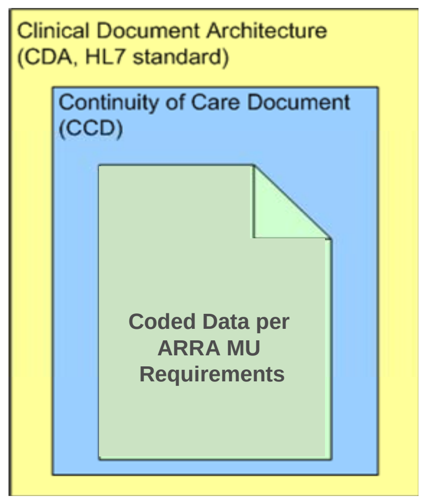

Figure 3. Anatomy of a CCD
The CCD leverages standardized clinical summary data as defined by a CCR, which is then wrapped inside the architecture of the HL7 CDA standard. The CCD is now endorsed by the U.S. ONC as the harmonized format for exchange of clinical information.

IHE Profiles and Standards

Integrating the Healthcare Enterprise (IHE) International, Incorporated is a non-profit organization that enables users and developers of healthcare information technology to achieve interoperability through the precise definition of healthcare tasks, the specification of standards-based communication between systems required to support those tasks, and the testing of systems to determine that they conform to the specifications. The output of the organization is managed by IHE committees and sponsored by various national and international bodies.

IHE Technical Frameworks provide standards for sharing information within care sites and across networks. Each framework contains integration "profiles" that address critical interoperability issues related to information access for care providers and patients, clinical workflow, security, administration and information infrastructure. Each profile defines the actors, transactions, and information content required to address the clinical use case by referencing appropriate standards. Siemens has successfully contributed to the development of many IHE profiles including, but not limited to, IT infrastructure, patient care coordination, and radiology technical frameworks.

IHE IT Infrastructure Profile Examples

- XDS – Cross-enterprise Document Sharing, registers and shares electronic health record documents between healthcare enterprises, ranging from physician offices to clinics to acute care in-patient facilities. A typical use of XDS would be to deposit and retrieve CCDs to and from an HIE.
- XDR – Cross-enterprise Document Reliable Interchange, provides a standards-based specification for managing the interchange of documents that healthcare enterprises have decided to explicitly exchange using a reliable point-to-point network communication. A typical use of XDR would be to *move* CCDs between and acute care facility and ambulatory practice *without* connecting to an HIE.
- PIX – Patient Identifier Cross Referencing, synchronizes patient identifiers between hospitals, care sites, health information exchanges, etc. A typical use of PIX would be to link or associate medical record numbers between an acute care or ambulatory practice and an HIE, thus enabling accurate XDS transactions when clinical data exchange becomes necessary.
- Audit Trail and Node Authentication Integration Profile (ATNA) establishes security measures which, together with the Security Policy and Procedures, provide patient information confidentiality, data integrity, and user accountability.

The Direct Project

The Direct Project is an ONC-sponsored collaboration comprising more than 50 organizations. Its purpose is to define standards and services that enable simple, direct, secure, scalable transport to support meaningful exchange among known trusted participants. These exchanges include common use cases, such as a "push" of information for referrals and consultations between providers collaborating in a patient's care. The project produced specifications for secure encrypted e-mail exchanges among providers with and without EHRs, as well as a bridge between direct SMTP and the IHE XDR and XDM specifications used by many EHRs.

The Direct Project was not intended to replace other ways information is exchanged today (e.g., HL7 or IHE) but to augment them. Siemens supports the Direct protocol as well as the bridge to IHE. Siemens actively participates in the project, and co-authored the Direct Project Overview, editing many of the specifications and supporting documents. Siemens is now working in New York with Albany Medical Center, MedAllies, and several other EHR vendors to implement direct exchange in one of the first Direct pilot projects. This project was prominently showcased at HIMSS 2011.

DICOM

Digital Imaging and Communications in Medicine (DICOM) is a standard for defining how to handle, store, print, and transmit medical images such as CT scans, MRIs, and ultrasound. The DICOM standard was created by the National Electrical Manufacturers Associations (NEMA) to aid in the distribution and viewing of medical images.

The DICOM standard defines a file format for medical images and related information (such as scheduling, dose reports, etc.) and network protocols to transmit this information. Many hospital information systems (HIS), radiology information systems (RIS), and picture archiving and communication systems (PACs) support the DICOM standard. This allows different vendors to accurately exchange electronic medical images and associated information.

XML

Extensible Markup Language (XML) is a standard defined by the World Wide Web Consortium (W3C). XML is a markup language, similar to HTML, although XML was designed to *transport* or *store* data rather than to display it. Many applications use XML to import and make data available to application programming interfaces (APIs).

Semantic Interoperability

Transmitting information electronically among providers' systems is advantageous, but it does not fully realize the potential of healthcare IT. Text documents or screen displays are fine for humans, but they don't help EHR systems *understand* the contextual meaning, or *semantics*, to accurately and safely process the information received from other systems. Without semantic interoperability, EHR interfaces aren't much more than glorified fax machines.

Semantic interoperability is not unique to healthcare. Wikipedia defines it as:

> *". . . the ability of computer systems to communicate information and have that information properly interpreted by the receiving system in the same sense as intended by the transmitting system. 'Proper interpretation' means that the transmitted information will be used appropriately by a receiving computer system because the logical implications derivable from transmitted information will be the same as those that the sending system would derive."*

Essentially, computer systems, and not just humans, must be able to interpret the information in the same way.

HL7, in its white paper titled "Coming to Terms", concludes that "in healthcare, the ability to use the information that has been exchanged means not only that healthcare systems must be able to communicate with one another, but also that they must employ shared terminology and definitions." For example, if the information exchanged is a patient's list of medications, the sending and receiving systems must "understand" the list in the same way, and discern when terms are synonyms or related (e.g., Advil vs. Ibuprofen) as well as where they are different. Anything less could risk patient safety.

Support for industry standards is a prerequisite to semantic interoperability. The ONC has already defined many standards as part of Stage 1 Meaningful Use (MU). These include formats like HL7 2.5.1 and the CCD, vocabularies such as SNOMED-CT for problems, LOINC® for lab observations, CVX for immunizations, and ICD9 or CPT4 for procedures. Siemens supports all MU standards and more within its product portfolio.

Siemens Answers – Data Exchange Interoperability

Siemens Clinical and Revenue Cycle Applications

Siemens applications like Soarian®, INVISION®, and MedSeries4® may not be considered "interoperability solutions" in themselves. Yet they are essential participants in an interoperable healthcare IT infrastructure. These critical applications both *provide* and in some cases *consume* the data that is exchanged (e.g., prescriptions sent to a retail pharmacy, results received from a lab system, clinical data packaged into a CCD). These "primary" applications have an impact on data exchange by utilizing data that conforms to industry standard vocabularies (e.g., SNOMED-CT and ICD9 codes for problems).

Siemens OPENLink

Siemens OPENLink™ is an application-independent interface engine that connects a wide range of healthcare IT solutions, enabling organizations worldwide to achieve their connectivity goals and support secure communications within and beyond the enterprise. Siemens OPENLink supports the interchange and formatting of messages in various formats including, but not limited to HL7, XML, and X12, delimited and fixed-length formats. Messages can be exchanged using communication protocols such as TCP/IP, SNA/SNA LU6.2, HTTP/HTTPS, file processing, and secure file processing.

Advanced Interoperability Service (AIS)

AIS is a comprehensive set of hosted interoperability technologies that provides for the exchange of CCDs and reportable patient information via industry-standard formats and exchange mechanisms such as IHE XDS, XDR, and PIX Profiles. AIS enables the exchange of clinical information between systems within and beyond the enterprise, including those used by HIEs, public health registries, and ambulatory systems. Healthcare institutions may also leverage AIS as a key component of their strategies for meeting ARRA-HITECH meaningful use (MU) requirements.

Soarian Enterprise Document Management (EDM)

Soarian EDM is a system that not only manages an enterprise's internal documents, but provides ways to exchange them with others outside the enterprise, through features such as automated document routing, secure sharing of electronic copies of documents with patients (including but not limited to CCDs), and the ability to securely send documents to patients and to Personal Health Records (PHR) via the Direct Project protocol.

e-Prescribing

The Soarian Clinicals and INVISION medication reconciliation capabilities support e-prescribing as a way to send prescriptions electronically to the retail or mail order pharmacy. As a process within discharge reconciliation, the capability helps physicians to create discharge prescriptions. Soarian Clinicals or INVISION can then send the prescription via an outbound transaction through Surescripts® to the retail or mail order pharmacy of the patient's choice. The solution can also receive a confirmation from Surescripts of the prescription's updated transaction status.

HDX

Healthcare Data Exchange (HDX) is regarded as a market leader in the healthcare industry for the delivery of Electronic Data Interchange (EDI) services to providers, payers, and third-party customers. Its combination of expertise in both healthcare and information technology has firmly established HDX as trusted subject matter experts and policy shapers for EDI standards.

HDX services are designed to support each aspect of the revenue cycle workflow, taking advantage of the standardization made possible by ASC X12 and HIPAA's transaction and code sets to offer a complete patient financial service solution. HDX's comprehensive, integrated support of the revenue cycle from pre-registration to financial settlement is unsurpassed in functionality, interoperability, and security.

Medical Device Interoperability

Siemens offers interoperability solutions that enable electronic flow of vital patient information from medical devices, under different care settings, into the enterprise patient health record.

For the intensive care settings, Soarian Critical Care helps the clinical staff streamline their workflow by collecting continuous physiological parameters and other types of patient data from various critical care bedside devices. The solution allows clinicians to review the information via the clinician flowsheet and validate the information prior to saving it in the patient's enterprise health record.

For vital signs data collection, Soarian Device Connect helps clinicians reduce the number of manual steps involved in this process. Data from portable, noninvasive vital signs monitors flows electronically from the monitor to the patient’s enterprise health record. With a few clicks, the clinician validates that the collected information is correct, and Soarian Device Connect sends the data to the clinical repository for access by other clinicians caring for the same patient.

These device connectivity solutions can help reduce opportunity for human error that can occur when a clinician transcribes or enters data into the system. And by facilitating the flow of data into the clinical repository, vital patient information becomes more quickly available to other clinicians.

Siemens interoperability solutions follow a standardized approach for communicating with non-Siemens systems and devices. They employ proven standards and protocols, such as HL7 and IHE-PCD, in communicating medical device information.

Customer Scenario 1 – Data Exchange

The ability of systems to exchange and even "understand" data in the same way can support provider efforts to improve efficiency and care quality, and reduce the opportunity for human error. But how would a healthcare professional see it come together? What does the actual application of these technologies look like? The following example is the first stage in a hypothetical, but entirely plausible, patient story regarding the utilization of data exchange technologies.

1) Patient Claire Long suffers a fall in her assisted living facility. Her personal physician is contacted and he suspects she may have fractured her hip. She is pre-admitted to her local hospital by the facility's staff.

2) When Claire arrives at the hospital, she is taken to the radiology department where her x-rays confirm she does indeed have a fractured hip. A custom interface connected to the hospital's Soarian HIS system sends an email message to Claire's personal physician. The email contains an HTML link to a secure website, linked to the DICOM x-ray image. While securely connected to Soarian, he initiates a fractured hip order set.

3) Claire is taken to a room where an admissions representative admits her. During the process, via a model interface, Soarian initiates a request to HDX for validation of coverage. HDX formats the data request according to various X12 EDI standards and communicates with the insurance carrier. Appropriate results are then returned, and from there Soarian will link every encounter to the responsible guarantor.

4) Concurrently with the registration process, Soarian triggers a PIX IHE Profile message to the regional HIE to synchronize the hospital medical record number with the HIE's numbers. This will facilitate swift and secure retrieval of relevant documents from the HIE.

5) As Claire's admissions process continues, the admitting nurse accesses the "External Documents" tab in Soarian Clinicals to see if there are any relevant documents in the regional HIE. (The PIX transaction enabled this link.)

6) Soarian connects to the HIE through the Soarian Advanced Interoperability Service (AIS) via an ATNA Profile and returns several CCDs for Claire via an XDS IHE Profile transaction.

7) The nurse views and accepts the most recent CCD generated by Claire's personal physician, and with one click, stores the document in the hospital's local document management system, Soarian EDM.

8) Due to some complications after surgery, Claire is admitted to the ICU where she is placed on a near-real-time monitor, which interfaces with Soarian via Soarian Device Connect. Claire's vital signs data streams are sent directly to Soarian Clinicals via another model interface.

9) Once Claire is stable and ready for discharge, her discharge medication prescriptions are sent via Surescripts to her pharmacy where a Semantic Interoperability strategy is leveraged to make sure the hospital's medications are properly received and understood by the local pharmacy computer.

10) As part of the discharge workflow, Soarian Clinicals automatically generates Claire's CCD (which is an XML file wrapped in and HL7 message format).

11) Because Claire's family requested it, discharge personnel use Soarian EDM to generate a password-encrypted copy of Claire's CCD on a thumb drive.

12) At the same time, Soarian's workflow triggers AIS to send Claire's CCD to the regional HIE via an XDS IHE Profile message.

13) Later, when Claire visits her personal physician for a follow-up visit, her doctor pulls the discharge CCD from the HIE, bringing it back into his practice management systems via another XDS transaction.

All the transactions in this story line leverage a form of data exchange – one of the three key components to a complete interoperability strategy. Next we will explore the infrastructure implications of interoperability.

What are the Infrastructure implications of interoperability?

Exchanging data is the underlying assumption for driving interoperability efficiency in a modern health-care system. But efficiencies can also be realized by tying systems and infrastructures together more effectively. The following technologies enhance the entire system by streamlining and automating the network itself.

User Authentication and Identification

Integration with Customer LDAP

Increasingly, customers are looking to tie their LDAP infrastructures (e.g., Microsoft Active Directory, Novell eDirectory™, Siemens DirX) to their application infrastructures to centralize user-credentialing administration for multiple applications into one directory. Initially, such efforts have been focused on maintaining user identities that manage application access. However, standards are being developed that look to use that same infrastructure to manage other information related to users, staff, and medical practitioners at healthcare facilities.

Provider Directories

As previously defined, HIEs aggregate patient data, but may not connect an organization with all possible providers. Provider Directories are a proposed tool, analogous to the "411" telephone directory assistance service, focused on secure exchange of health information. These directories would supply information to help the organization connect to providers not in their HIE and not previously known to the sending system.

According to the HIT Standards Committee (HITSC), Provider Directories are “an electronic searchable resource that lists all information exchange participants, their names, addresses and other characteristics and that is used to support secure and reliable exchanges of health information.” These directories could facilitate patient information exchange across the country. They would become the “master provider indexes” for regional HIEs.

Currently, two types of Provider Directories are being considered by the committee:

- Entity-Level Provider Directory (ELPD): a directory listing provider organizations
- Individual-Level Provider Directory (ILPD): a directory listing individual providers

A special Provider Directory Task Force within the HITSC has made several recommendations to the U.S. government relative to the formation of these directories, and is still developing others. Their first priority is to standardize queries for Provider Digital Certificates that can be used to securely encrypt electronic messages. The result of this initiative, and the committee’s stated objective, will help “facilitate the rapid increase in secure electronic health information exchange throughout our health system.”

Service-Oriented Architecture

What is SOA?

A Service-Oriented Architecture (SOA) is a modern method of building an application or enterprise-wide infrastructure comprising assorted applications. This is in contrast with older architectures, such as monolithic two-tier models (client app/database server), and API-based three-tier models (thin-client/business logic/database server). Older, non-SOA infrastructures are recognized by point-to-point interfaces and APIs, proprietary network communications, and screen-scraping workarounds.

SOA infrastructures share several common characteristics:

- They involve *loosely coupled* applications and components that interact without the need for heavy compile-time, version dependence, or synchronization at the data exchange level.
- The provide *course-grained* business functionality encapsulated as "services" that accomplish larger business goals at a more abstract level without having to orchestrate dozens of smaller operations.
- They use *standards-based* integration technologies that ensure applications can interoperate without difficult proprietary integration.
- They *reuse* application-provided functionality, allowing a service to be built once and used in multiple contexts and processes.
- They enable *workflow/process choreography* based on the composition of services that provide new business functionality and patterns not originally conceived by the application designers.

What is a service?

A service is a small, encapsulated piece of code that performs useful business functionality through data access and business logic and is reusable across many business processes.

Benefits of SOA

SOA enables application modularity, workflow engine integration, and reuse of business functionality. Applications based on SOA principles benefit from increased scalability, and separation of concerns. From a business perspective, SOA allows an increased ability to adapt to changing business environments, faster speed of development, and enablement of more complex functionality through application and workflow compositions.

SOA and Interoperability

Well-established technical standards, such as Web Services, HTTP, SOAP, and REST, allow for syntactic interoperability and network interoperability. Healthcare-related semantic service standards, such as HL7 v3, lead towards more capability, interoperability, and semantic interoperability.

Workflow Engine (Business Process Management)

What is a workflow?

The word "workflow" is often used to refer to the steps people perform for a given task. However, in the context of Business Process Management Systems (BPMS), the following definition of "workflow" focuses on the different aspects that enable a healthcare enterprise:

“Workflows are business processes that are customer-configurable and execute an objective over time. They involve multiple persons, domains, human activities, automation technologies, and products that don’t normally interoperate.”

What is a workflow engine?

A workflow engine is a software component or system that actively manages and executes business process models by starting, continuing, and ending processes in response to enterprise events. The workflow engine “listens” for events of interest, invokes business and clinical rules, and interacts with data and business services. Rounding out the capabilities of a workflow engine are managing work lists or queues and communicating information to and from users.

Workflow Standards

The level of maturity for standards in workflow models and engines is still evolving. Some standards such as Business Process Execution Language (BPEL) and Business Process Modeling Notation (BPMN) have some traction, but are incomplete in expressing the workflows completely. Most workflow engine products (including the Soarian workflow engine) provide some capabilities for import and export of process models, particularly to and from design layout tools such as Microsoft Visio® or TIBCO Business Studio™.

Process interoperability via a workflow engine

A workflow engine can provide "process interoperability" that crosses system boundaries. Processes are usually measured for effectiveness, quality, time, or cost improvements. To that end, workflow engines can be coupled to analytics tools which enable monitoring of key performance indicators (KPIs).

Siemens Answers – Infrastructure Interoperability

CDS – Customer Directory Support

Customer Directory Support (CDS) is an optional Siemens feature that enables a customer to manage user identities and permissions for supporting Siemens applications within the customer's Microsoft Active Directory infrastructure rather than within each Siemens application independently. (Permissions management is also available for portions of the Soarian application suite.)

Customer Directory Support relies on the customer's Active Directory for user credentials and group memberships. The customer is responsible for loading user credentials into the Active Directory using various tools and preferred methods.

ID Center/Biometric Authentication

ID Center is a central authentication service that provides the basis for deciding who will get access to mission-critical software applications and data. Users can log on to a Windows® network via their fingerprint or palm vein patterns. Identification schemes can include combinations of biometric data (what you are), smart cards (what you have), and PINs or passwords (what you know). In ID Center it is also possible to manage the biometric data needed for controlling access to buildings and synchronize this data with door readers via a network connection.

Soarian SOA

Soarian was designed with a Service-Oriented Architecture from the beginning. For example, Soarian Clinicals has over 50 services that can be orchestrated from within the Soarian workflow engine. As time goes on, additional application services will be available for use from outside Soarian by other applications. Additional product capabilities such as the Web Service/XML capabilities of Siemens OPENLink also contribute to the expansion of SOA throughout Siemens customer organizations. But the real power of Soarian's SOA is in enabling how the Soarian workflow engine leverages software services.

Soarian Workflow Engine

Because Siemens is leveraging modern SOA architecture, Soarian is essentially a sophisticated collection "service bundles," or simply "services." These services can be connected to, called upon, and even rearranged to provide customer-unique functionality. This is achieved via the Soarian workflow engine.

Features and Benefits

The Soarian workflow engine provides enterprise-wide workflow controls as part of an enterprise SOA infrastructure. While rigid rules-based systems can provide similar functionality, the goal of a *true engine* is to orchestrate complex and unique <u>time-based</u> processes across an entire enterprise. Additional engine differentiators include these capabilities:

- *Simultaneous* coordination of tasks across care provider settings.
- Quiet "listening" in the background, constantly reviewing event criteria.
- When a condition or set of conditions signifies a potential issue, the workflow engine has the ability to engage and address the issue as designed by the organization's <u>unique</u> process.
- The ability to provide responses in the form of a simple end-user notification or a more complex series of notifications, calculations, actions, or orders.
- Support for visualization of business processes via a design tool. This allows processes to be rapidly adapted by analysts *without* custom coding.

Benefits in a healthcare setting include:

- Improved ability to monitor processes for continuous improvement and to adapt to changing patient requirements.
- Enhanced clinical decision-making.
- Reduced costs through streamlined processes and elimination of manual steps.
- Promotion of best practices by reducing variability in old, manual workflow processes.
- Proactive identification of risks that impact outcomes.

Customer Scenario 2 – Infrastructure

In the first customer scenario we followed *data* relative to a patient experience. For our infrastructure scenario, we will focus on broader processes that still affect a patient, but cross over organizational lines and affect many more people. The following graphic and storyline represents a workflow process for infection control in a hospital setting. A service-oriented architecture, in conjunction with a workflow engine, allows various infrastructure components to be leveraged to give organizations control over complex, and previously immeasurable time-based events.

1) Upon patient registration, a workflow event is triggered to query the HIS for positive patient history of Methicillin-resistant Staphylococcus aureus (MRSA).

2) If history is positive, multiple events are initiated by the workflow engine:

3) The nursing bed supervisor is informed, and she must acknowledge the message or the system will send a notification.

4) The doctor, staff nurse, and infection control department are also notified by various communication forms (email, text, pager, etc.), and the patient is flagged to remain in isolation.

5) If the MRSA history is negative or unknown, a MRSA screening is initiated.

6) The workflow engine "listens" for a result.

7) If the MRSA screen returns a positive result, the remaining processes are triggered to update all systems and notify appropriate personnel to maintain isolation.

8) If screening returns a negative result, the remaining processes are triggered to update all systems and notify all appropriate personnel to remove the patient from isolation.

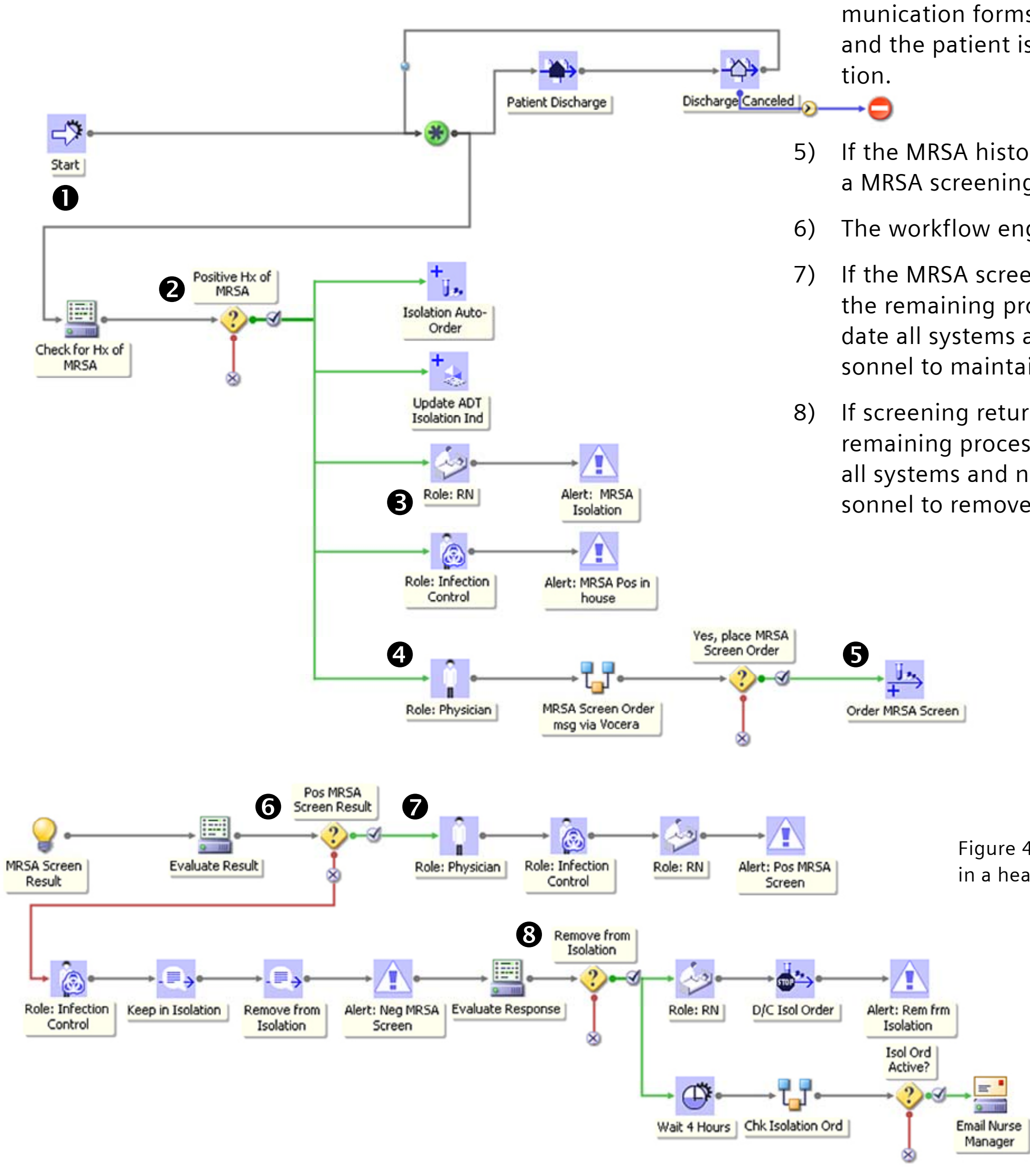

Figure 4. Visual Editor for a workflow engine in a healthcare setting.

What is User Interface Interoperability?

Most healthcare organizations rely on several specialized applications to enable clinicians and other professionals to provide care to patients. Often an individual user may need data or functionality that is available in several different applications to perform a given workflow. User Interface (UI) interoperability enables the user to easily move between multiple applications quickly and accurately.

Levels of UI Interoperability

The simplest form of UI Interoperability is the ability of one application to launch another. This could be a button or a link in the primary application that launches a second application on the same workstation. From that point the two applications are simply running on the same workstation with no other interaction.

A more sophisticated and helpful UI interoperability solution involves "context sharing." In this interoperability framework, a *context* is defined as "a set of common things that frame and constrain the user's interactions with applications." *Context sharing* occurs when one application not only launches another, but it passes unique information, such as a medical record number, to improve end-user efficiency and accuracy in completing a workflow objective. The context passed will vary depending on the applications involved or the needs being addressed by the launch. In healthcare scenarios, the most common contexts are the identity of the person using the application and the identity of the patient whose data is being managed.

Security and Privacy Considerations

HIPAA rules demand that security and privacy concerns are addressed when integrating user interfaces. First, when the user context is passed, systems must make sure the end user has sufficient access privileges to view the information being requested.

Second, consideration must be given to secure the transmission of contextual data. For example, browser-based applications can frequently accept context or other information as parameters passed in a URL. However, that information may be passed "in the clear," meaning that the context information can be read as it crosses the network. Various forms of encryption should be considered to pass the parameters securely.

Industry Standards

Today, UI interoperability standards are still emerging. Healthcare IT vendors like Siemens contribute to standards bodies to evolve these technologies. At the moment, most of these standards are being applied to applications within a single vendor's portfolio, but participation between different vendors is increasing.

CCOW

The HL7 Clinical Context Object Workgroup's (CCOW) mission is to define standards that enable the *visual* integration of healthcare applications. The group has created a standard to manage the *context* between two or more applications running on the same desktop. CCOW is a peer-to-peer protocol, meaning that all applications participating in the context can change the context information.

The CCOW standard defines several contexts, the most common of which are "patient" and "user." CCOW also provides a framework that enables applications to "join a context" managed by a separate "context manager."

A CCOW transaction functions as follows:

- When a CCOW-enabled application is started, it communicates with the context manager to find out if a context already exists for that workstation.
- If a context already exists for that workstation, the application "joins" the context and displays information consistent for the context. For example, if the "patient" context is set to patient X, the application will display information for patient X.
- Finally, if a context match does not exist, it is the responsibility of the context manager to create a new context and set the context based on information provided by the application requesting the context.

Even though CCOW is considered an industry standard, challenges still exist that are slowing its widespread adoption:

- The standard has not been implemented by many vendors. As a result, there is no guarantee that all applications installed at a site support the CCOW standard.
- CCOW requires a separate context manager application, which facilitates the exchange of context information between applications. These context managers can have significant license and support fees.
- Implementation of CCOW can be challenging and expensive:
  - Vendors have interpreted the CCOW standard in different ways, resulting in the need to tweak configurations during implementations. Some vendors have had to create "CCOW enablers," which provide CCOW-like functionality to non-CCOW-enabled applications.
  - Since different applications typically use different identifiers for patients and/or users, it is necessary to implement "context mapping" so applications know how to find the correct context.

SAML

Security Assertion Markup Language (SAML) is an XML-based open standard for exchanging authentication and authorization data between security domains. SAML is a product of the OASIS Security Services Technical Committee.

SAML's primary objective is to provide a solution for web browser Single Sign-On (SSO). Single sign-on solutions are abundant at the *intranet* level (using cookies, for example) but extending these solutions beyond the intranet has been problematic and has led to the proliferation of incompatible proprietary technologies.

The typical SAML workflow involves three participants:

- The user agent, typically a browser that the user is running to request a service such as access to an application
- The service provider, typically an application that can provide a service that the user is requesting access to
- The identity provider, which verifies the identity of the user to the service provider

When a user requests a service from a service provider, the service provider in turn requests the identity. This request is fulfilled by the identity provider, which passes a "SAML assertion" to the service provider. An *assertion* contains a packet of security information that includes a time stamp for the assertion issuance (t), the issuer (R), the subject (S), and validation conditions (C). On the basis of this assertion, the service provider decides whether or not to provide the service to the user.

SAML can be used to pass other information to the service provider, although currently no industry standards exist that define this use case. SAML can be used to authenticate the user using UI interoperability to launch a second application if both applications support SAML.

Siemens Answers – User Interface Interoperability

Proprietary standards are simply standards that are specific to a single application or vendor. For this discussion, these standards can be used to enable interoperability between applications from one vendor but usually are not used to interoperate with applications from other vendors.

UIIP

Siemens has developed the proprietary User Interface Interoperability Protocol (UIIP), which is used to enable interoperability between Siemens applications. The UIIP enables many applications to share a common user session with a single log on / log off and a single coordinated inactivity timeout. It also provides ways to pass context between participant applications.

GSM

The key element of the UIIP architecture is the *global session*. A global session is used to share key data between different applications running under a single user. The Global Session Manager (GSM) is a software module responsible for managing user sessions. The first application (parent) establishes a session with the GSM; when launching other (child) applications, the parent passes session information to enable the child to contact the GSM and retrieve the user ID.

Many Siemens applications support GSM interoperability workflows which use GSM to enable one application to launch and pass context information to another application.

Customer Scenario 3 – User Interface Interoperability

In our final customer scenario we will see how interoperability technologies can be applied to user interfaces. In this case, our script will follow a nurse's experience as she works with an unfamiliar patient in an acute-care environment.

1) Jane Grafton, an 85 year-old female, is brought to the emergency room complaining of chest discomfort. Jane's first stop is with triage nurse, Sandy, who gets her vital signs. Sandy easily logs into Soarian via a fingerprint reader on a biometric mouse. Sandy's biometrics are stored in the Siemens ID Center, which interoperates with the hospital's Microsoft LDAP Active Directory to validate her network credentials and application access parameters.

2) Once logged in, Sandy documents the history of Jane's complaint, past medical problems, current medications and allergies. But Jane's memory isn't what it used to be, and when asked about her medications, she has trouble recalling what she's taking for her heart condition. Jane also says that she has a drug allergy to penicillin—she thinks. She does remember her doctor's name—Dr. Judd Borden.

3) Because Dr. Borden uses an interoperable ambulatory EHR system, Sandy is able to access Jane's ambulatory record. Leveraging the CCOW patient context sharing capabilities of both Soarian and the ambulatory system, Sandy is automatically directed to Jane's ambulatory medical record, where she can review Jane's current medications, problems, and allergies.

4) Sandy learns that Jane is indeed allergic to penicillin. She also learns that Jane was recently diagnosed with chronic Atrial Fibrillation for which Dr. Borden has prescribed Digoxin and Coumadin®. In addition, Sandy is able to see that last month Jane had an EKG, which was normal, and that Jane has a hiatal hernia for which Dr. Borden has prescribed Nexium.

5) The emergency room physician, Dr. Spidell, orders a new EKG for Jane, which she immediately compares with the previous EKG from Dr. Borden. She is able to make the comparison because she too has access to the ambulatory EHR via CCOW interoperability. She also orders lab work, which includes a Digoxin level and a CBC.

6) The Digoxin level comes back normal, but Jane's WBCs are elevated. The ER physician notes that Jane's lungs are clear and orders a urine test, which comes back positive for a urinary tract infection. Because of access to current and accurate medical information via user interface interoperability, the ER physician knows that Jane is allergic to penicillin, so she orders Bactrim as an oral antibiotic treatment.

7) To administer the medication, the nurse notes the medication order in Soarian Clinicals and launches the Med Administration Check™ application from a GSM-enabled link within Soarian Clinicals. This connectivity enhances the efficiency of the clinician and helps improve provider drug administration accuracy.

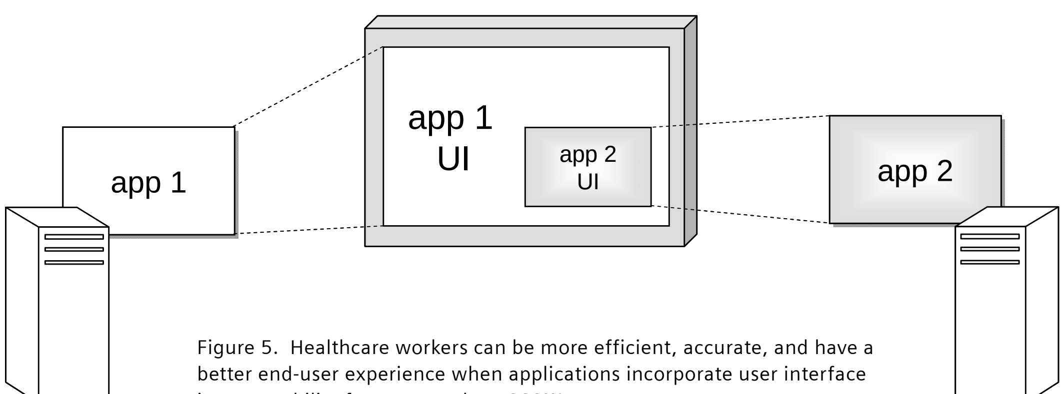

Figure 5. Healthcare workers can be more efficient, accurate, and have a better end-user experience when applications incorporate user interface interoperability features, such as CCOW.

Conclusion

Interoperability, in all its forms, is critical to the efficiency and accuracy of our entire healthcare system. And for the foreseeable future, providers will face increasing pressure to both share and receive data as well as connections to third-parties. That is why interoperability requirements are either explicitly or implicitly stated throughout much of the American Recovery and Reinvestment Act of 2009 Meaningful Use Core and Menu sets. Enhanced interoperability is a key factor in supporting provider initiatives for improving patient outcomes, patient affinity, and clinician satisfaction, as well as in helping to reduce provider inefficiencies, medical adverse events, and medical costs.

Siemens is committed to being flexible and adaptable to these changes in addition to the requirements of its customers. Siemens actively participates in numerous industry standards organizations and regulatory bodies. As additional standards and regulations develop, we will continue to lead the industry and work them into our formal product plans.

Glossary

CCOW Clinical Context Object Workgroup is an HL7 standard protocol designed to enable disparate applications to synchronize in real-time, and at the user-interface level. It is vendor independent and allows applications to present information at the desktop and/or portal level in a unified way.

CCOW is the primary standard protocol in healthcare to facilitate a process called "Context Management." Context Management is the process of using particular "subjects" of interest (e.g., user, patient, clinical encounter, charge item, etc.) to 'virtually' link disparate applications so that the end-user sees them operate in a unified, cohesive way.

EHR Electronic health record (also electronic patient record or EPR) is an evolving concept defined as a systematic collection of electronic health information about individual patients or populations. It is a record in digital format that is capable of being shared across different health care settings, by being embedded in network-connected enterprise-wide information systems.

EMR Often used interchangeably with EHR and EPR, the Electronic Medical Record can be defined as the legal patient record created in hospitals and ambulatory environments that is the data source for the EHR.

HIE Health Information Exchange (noun)
An organization that oversees and governs the exchange of health-related information among organizations according to nationally recognized standards. Capabilities include but are not limited to the ability to electronically move clinical information among disparate health care information systems while maintaining the meaning of the information being exchanged.

Health information exchange (verb)
The electronic movement of health-related information among organizations according to nationally recognized standards to provide safer, more timely, efficient, effective, equitable, patient-centered care.

LDAP Lightweight Directory Access Protocol helps manage information about authorized users on a network such as names, phone numbers, addresses, and what a user is and is not allowed to access. LDAP is vendor- and platform-neutral, working across otherwise incompatible systems.

LOINC Logical Observation Identifiers Names and Codes is a database and universal standard for identifying medical laboratory observations. LOINC applies universal code names and identifiers to medical terminology related to the electronic health record. The purpose is to assist in the electronic exchange and gathering of clinical results (such as laboratory tests, clinical observations, outcomes management and research). The database includes not just medical and laboratory code names, but also: nursing diagnosis, nursing interventions, outcomes classification, and patient care data set.

Microsoft Active Directory Active Directory is a technology created by Microsoft that provides a variety of network services, including: LDAP directory services, Kerberos-based authentication, DNS-based naming and other network information, Central location for network administration and delegation of authority.

Semantic Interoperability The ability of computer systems to communicate information and have that information properly interpreted by the receiving system in the same sense as intended by the transmitting system. A key concept is that both computer systems and humans must be able to interpret the information in the same way.

SNOMED (SNOMED CT) Systematized Nomenclature of Medicine (Clinical Terminology) is a clinical healthcare terminology resource with comprehensive, scientifically-validated content that cross-maps to other international standards.

SNOMED CT provides the core general terminology for the electronic health record (EHR) and contains more than 311,000 active concepts with unique meanings and formal logic-based definitions organized into hierarchies. When implemented in software applications, SNOMED CT can be used to represent clinically relevant information consistently, reliably and comprehensively as an integral part of producing electronic health records.

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