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How Should Interfaces Specify Application Behaviors?

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Introduction

A distinguishing feature of healthcare informatics in the 21st century has been the recognition that a patient-centric multi-enterprise health record is not only desirable but essential to the provision of safe, appropriate care.

Systems exchange information both to document healthcare activities in comprehensive records, and to share information necessary for current patient care, either locally or remotely. A local inpatient care system may accumulate test information from a remote laboratory system for the purpose of integrating it with local information in a flowsheet that is part of the patient health record. Based on the information received, a clinician using the same local system may immediately request further testing from the remote laboratory system, or may use the flowsheet information to inform a medication decision that will result in the placement of one or more orders to a local or remote pharmacy system.

However, it is not enough for patient care systems to agree on what they *know*: they must also agree on what they *do*. Interface specifications must address the expectations and responsibilities of both senders and receivers. Such requirements necessitate a quantum leap from legacy interface specifications through the middle 1990s, which typically confined themselves to the behavior of their own applications in providing data to other systems with which they might happen to be interfaced. Present-day interoperability architectures, both within and across enterprises, need to be able to constrain application behavior as well as interface contents.

Methods and results

Standards and the interoperable clinical record

The development of the concept of the interoperable health record is in part a logical extension of the application of such interface standards as LIS05-A (formerly ASTM E1238) [1] for transmission of clinical observations, Health Level Seven (HL7) [2] for dissemination of patient administrative and clinical information across single-enterprise systems, and DICOM [3] for the transmission of imaging information. It also owes its existence to the efforts of researchers such as Hammond [4] in distinguishing the *flow* of information from the information *stores* (both intra-enterprise and inter-enterprise).

However, there are a number of specific legal, ethical, policy, and operational requirements that have been developed by healthcare systems and that are not fully addressed by existing standards. These requirements apply both to manual operations and to information systems in the institution. Therefore, they must be supported by commercial systems that are interfaced to the institution's internal systems. For example:

- Privacy issues
- Patient safety issues (including patient identification issues, synchronization of systems, correction of errors, acknowledgement of messages from other systems)
- Health information management rules
- Data custody requirements and the role of "system(s) of record"

Early commercial interfaces

A typical method of interfacing clinical systems from the 1970s into the 1990s was for a system to advertise that it would make certain information available, such as testing results or billing transactions, to other systems that might happen to be interested in the data. The sending system (generator) could include the interface as part of its general data production requirements. This approach was successfully adopted both by vendors of systems using proprietary interfaces, as well as by some early commercial adopters of the ASTM E1238 standard.

HL7-based and DICOM-based interfaces

Early HL7 messaging definitions – those developed for Versions 2.0 through 2.4 of the HL7 Standard between 1987 and the late 1990s – standardized the elements communicated in interfaces, while continuing to apply minimal constraints to application behavior. Such minimal constraint has been axiomatic even into the 21st century.

HL7 added a conformance mechanism in Version 2.5 [5] that provides a template for interface specification. This template includes a dynamic definition that incorporates an interaction model as well as acknowledgment responsi-

bilities. While the template does not explicitly provide for the specification of application behaviors, these could conceivably be enumerated as an extension of the dynamic definition. This approach has been followed by the U.S. Veterans Health Administration's VistA Imaging Team to specify interfaces from its in-house-developed, open-source VistA software to commercial Picture Archiving and Communication Systems (PACS).

DICOM Conformance Statements (DCS) [6] are required documents (by the DICOM standard) that are designed to unambiguously define a product's specific DICOM features. VA uses the DCS as a primary communications tool in understanding a vendor's product. The DCS is used to compare system integration possibilities and, most importantly from the point of view of the current discussion, to perform validation conformance testing before use in the VA.

Each DCS includes a sequence of real-world activities to define interactions between its vendor and others. For example, the Storage Commitment transaction, as defined by the DICOM standard, allows a local system to request that a remote system commit to the safekeeping of one or more images, thus releasing the responsibility for storage from the local system. Each vendor states in its DCS how this functionality is implemented on its product.

IHE-based interfaces

The Integrating the Healthcare Enterprise (IHE) Initiative and the IHE Technical Frameworks, besides providing contexts for the constraint of messages using standards such as HL7 and DICOM, can assist in determining system behavior.

An IHE radiology transaction definition typically incorporates one or more DICOM or HL7 messages and defines the trigger events, message semantics and expected actions. The "expected actions" section generally includes the behavior that is expected of the receiver of the message. [7]

Specifying and testing behaviors of applications in VistA Imaging interfaces

The next step toward interoperability using IHE-based profiles is to incorporate context-specific requirements into interface specifications. "Context" in this case may refer to a single department or to a nationwide medical enterprise such as VA.

VA has requirements that apply to all of their systems, whether internally developed or commercially procured. These include specific requirements for patient identification, privacy, records custody, and patient safety. Commercial system interface specifications published by VistA Imaging incorporate these requirements as extensions to the behavioral conditions imposed by standards and by IHE.

Testing and lessons learned

Having developed interface profiles based on user input, organizational policies, and regulatory requirements, VA published its interface specifications and a testing summary on a public web page [8]. PACS vendors access this page to find what is required of their systems in communicating with the VistA Radiology and VistA Imaging PACS modules. As vendors develop new products, they contact the VistA Imaging Team to schedule testing of their interfaces.

Our experience over 18 months of testing has been that commercial products are not always prepared to meet the behavioral requirements as stated in our specifications. Evaluation of interface test results, feedback from vendors, and internal reviews have resulted in clarifications to the interface specification, such as the enumeration of table values for error acknowledgment codes.

Discussion and conclusion

It is not only desirable and possible, but also essential, to specify application behaviors as part of interoperability requirements. Such requirements, although presented here in the context of the VistA Imaging software, are not specific to the VA. All interoperating medical institutions will share many of the same needs. Some institutions may have more well-defined application requirements, perhaps due to more experience with clinical information systems. Thus, every vendor will need to meet the needs of a variety of healthcare systems. These needs can be met by enumerating behavioral constraints in addition to what is provided for in the HL7 and DICOM Standards and the IHE Technical Frameworks.

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