

The Federated Electronic Health Record (FEHR): *Getting Beyond HL7*

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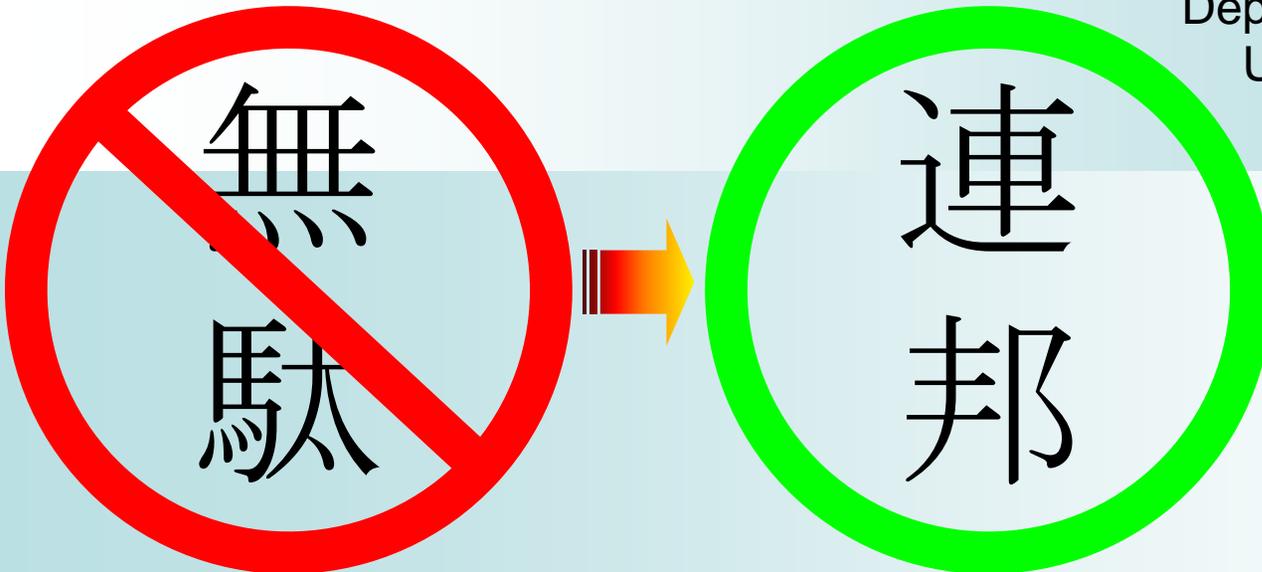
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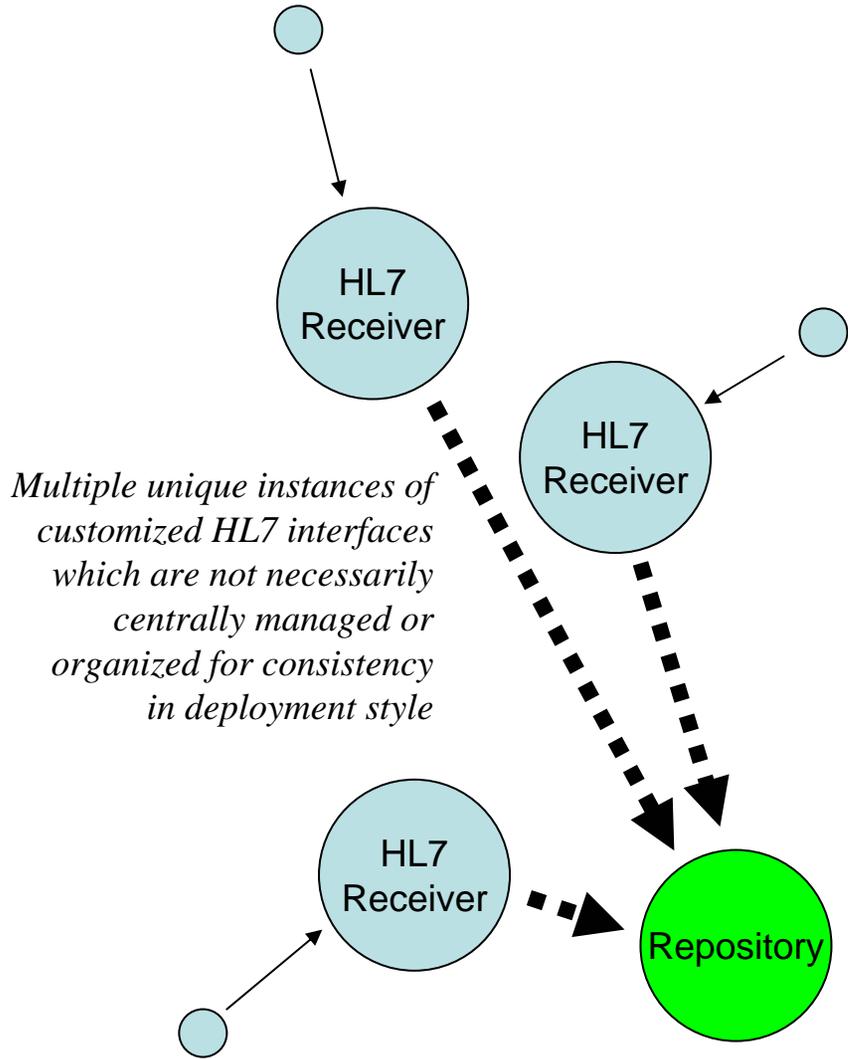


Overview

- Concepts are meant to be taken as thought-provoking and not dogmatic
- Comparison of current interface deployment strategies vs. those which are possible by use of newer information model approaches
- Review of the promise of Federated Topologies
- Examination of the role (if any) of Lean/Six Sigma approaches in the rational deployment of LIS/HIS interfaces and data dissemination.
- Review of the underlying data model technologies which will enable possible federated architectures

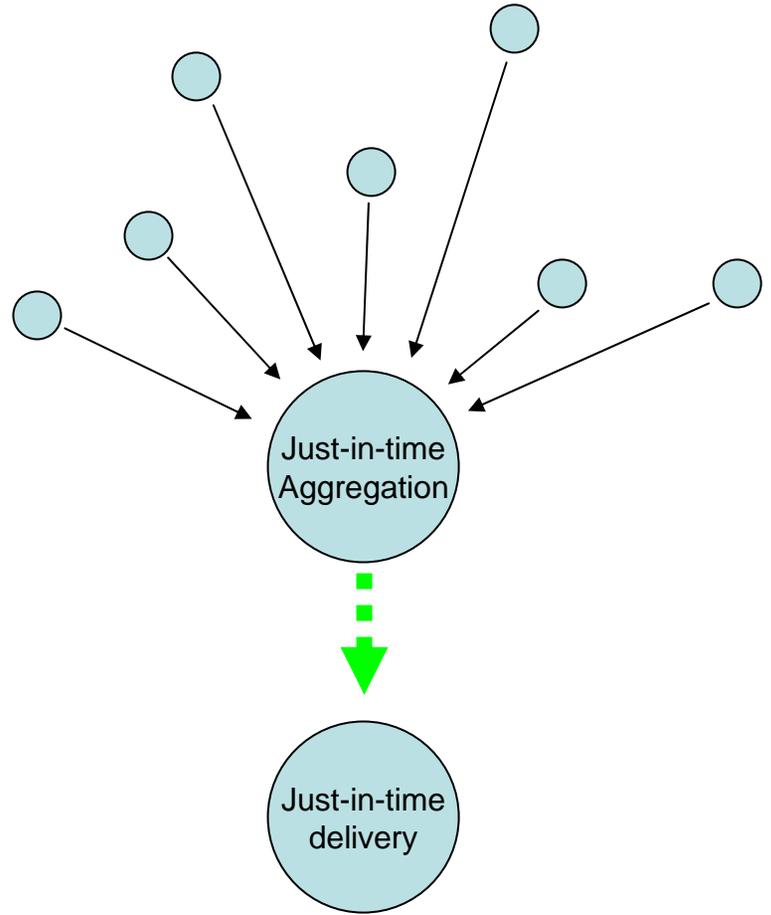
Trends with Central Hospital I.T. Strategic Planning

- Realization that central repositories designed for clinical decision support are increasingly difficult to support.
- Realization that ancillary departments (LIS, RIS, OR, ED, etc.) are optimally empowered to control both content *and display* of their data.
- Identification of monolithic repositories as being ideal for research support and not necessarily for clinical support.



Multiple unique instances of customized HL7 interfaces which are not necessarily centrally managed or organized for consistency in deployment style

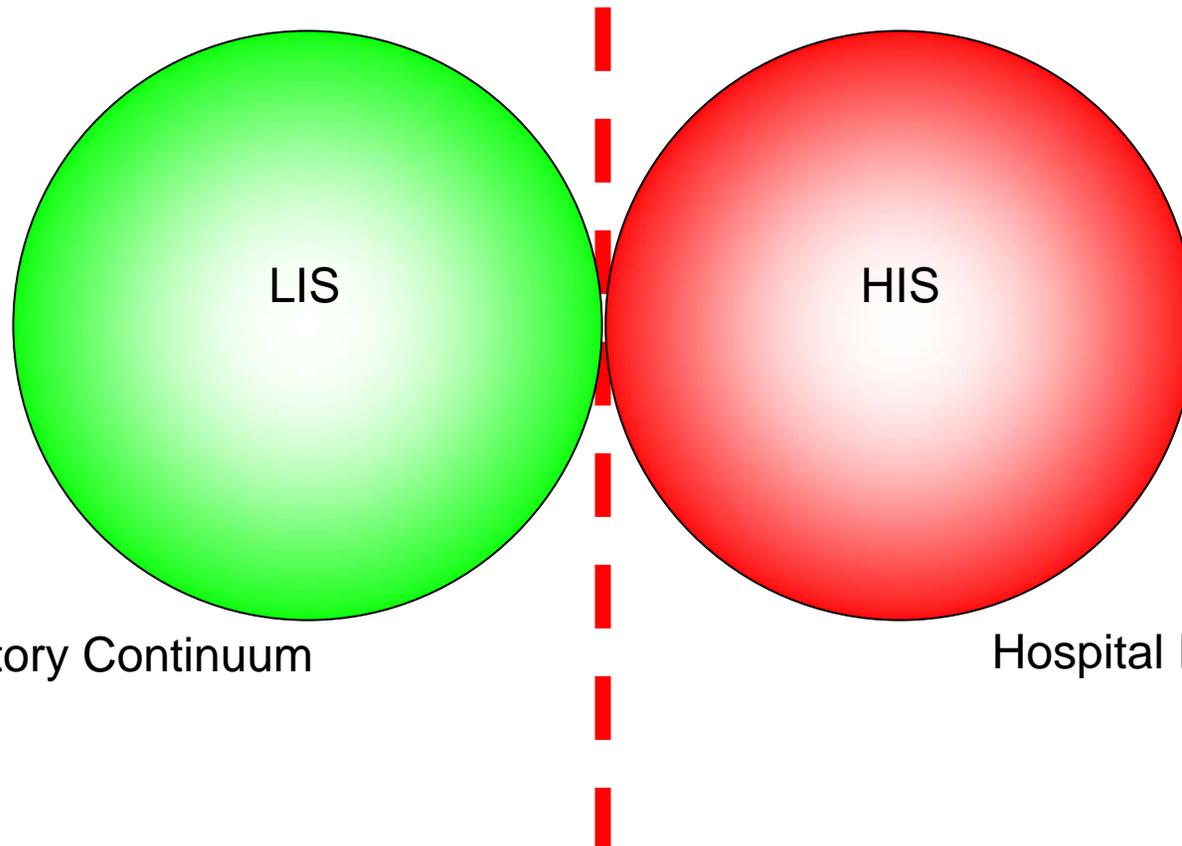
Present State



Future State

The Imbalance of Infrastructure to Required Support

Ideal Oversight Model



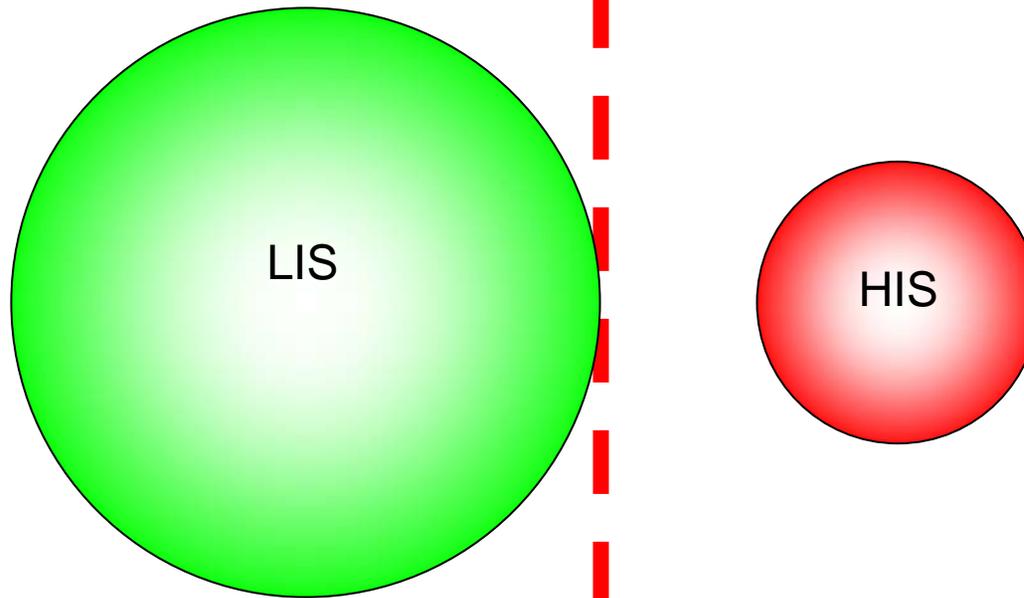
Clinical Laboratory Continuum

Hospital I.T. Continuum

Demarcation of Intended Scope of Influence/oversight

The Imbalance of Infrastructure to Required Support

Diminishing Central IT Expertise

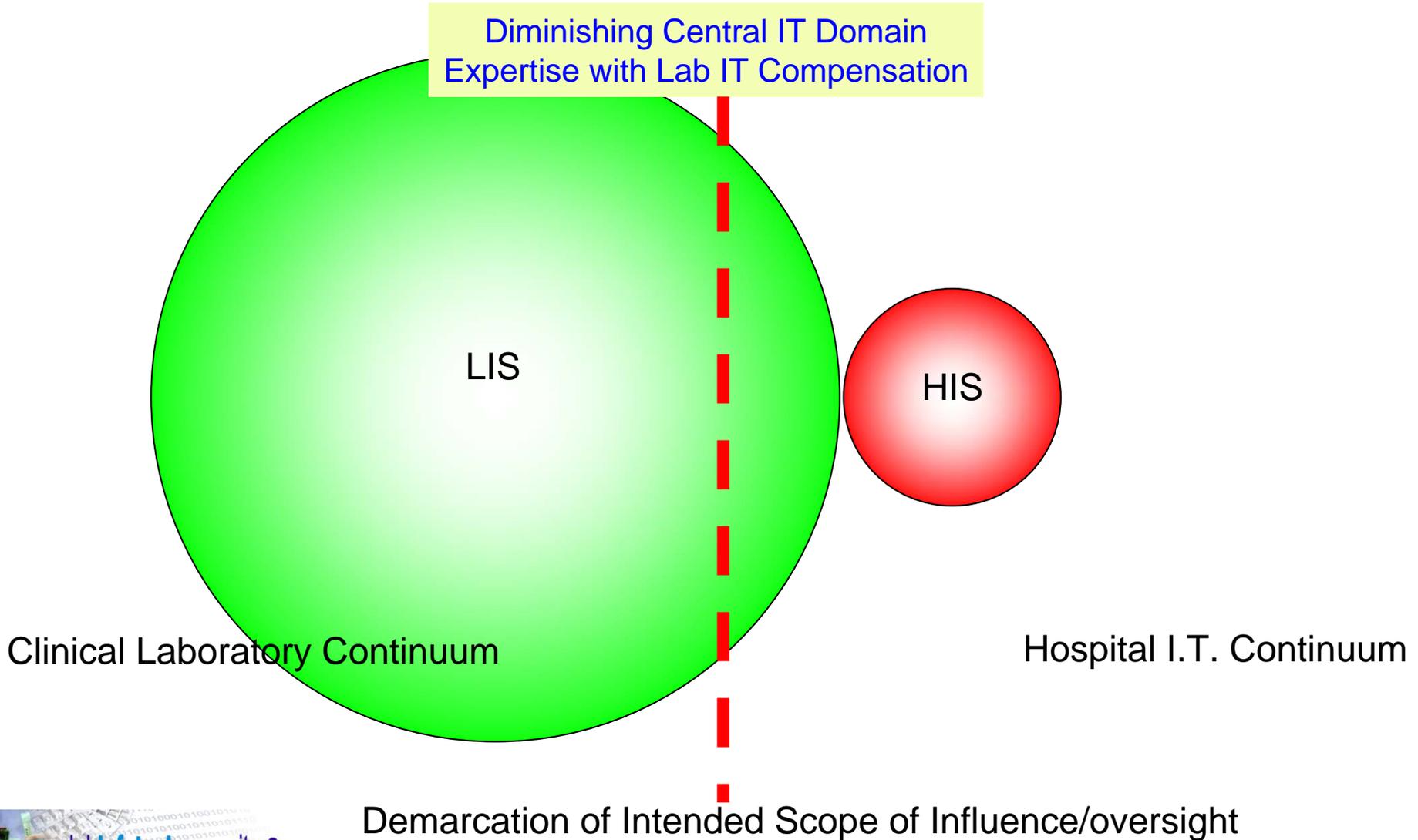


Clinical Laboratory Continuum

Hospital I.T. Continuum

Demarcation of Intended Scope of Influence/oversight

The Imbalance of Infrastructure to Required Support



Present State

- Effort expended to interface instruments to the LIS and the LIS to the HIS represent an increasing percentage of overall operational effort of the generally fixed Lab IT resource.
- Hospital migration of HIS platforms can impose a sudden and daunting resource requirement on lab IT resources to design, implement and test the myriad of extant interfaces required by such a new system
- The current language of interface HL7 2.x represents a formalized exchange construct that requires precisely constructed specification of the sender/receiver pair to create a functional data channel; this is labor-intensive and requires specialized programming expertise.

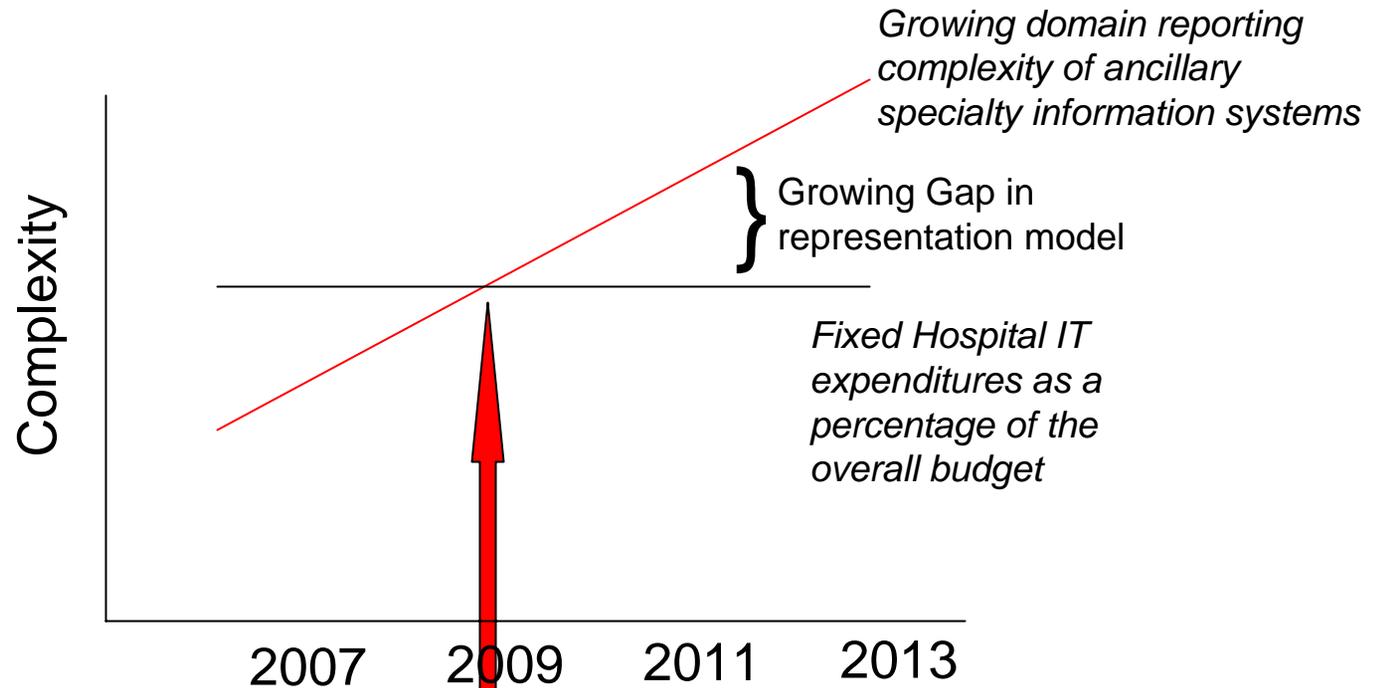
Future State

- Use of standards that reduce error, maintenance/rework, complexity, data duplication and multiple (and often complex) interdependencies.
- Use of empowering technologies:
 - ? HL7 3.x, ?HL7 2.x with use of XML
 - Stand-alone XML schema definitions standards
 - Framework systems of knowledge representation
 - Adoption of Lean/Six Six Sigma philosophies to the LIS/HIS production continuum

Some Estimates of Effort

- Typical LIS implementation
 - 10+ instrument interfaces
 - 2 HIS interfaces
- 40 programmer hours/interface/year as a conservative support metric
- 800+ hours effort/site-year
- ~Millions of programmer hours of interface maintenance and customization effort annually.

The Pending Imbalance...



LIS Data Model complexity exceeds HIS receiver capabilities

Taking a “Postmodern” View of Data Warehousing...

- While stand-alone repositories are effective for clinical research extraction applications, they represent an exponentially growing area of complexity for operational support of conventional clinical reporting needs.
- Specifically, the re-work associated with recapitulating domain data management practices in a single central instantiation represents a challenge for even large central IT department.

Emergence of Lean and Six-Sigma Approaches in LIS Deployment

- There are seven categories of waste (Muda): when applied to the LIS/HIS production environment continuum, these categories form the following interesting parallels to the conventional production setting:
 - **Overproduction**: carrying out more computational effort than is required to effectively deliver information to the consumer
 - **Conveyance**: imposing more interface transfer steps than what should be required
 - **Waiting**: delays in reporting associated with cascaded and single-threaded interfaces.
 - **Motion**: Added complexity of multiple interfaces caused data to be moved incremental iterations, increasing the chance for data corruption over each successive step.
 - **Rework**: being forced to re-specify and retest downstream interfaces when local processes are modified (e.g. a new addendum method within-Lab requires validation of the new addendum functionality at the HIS level)
 - **Over-processing**: extra effort associated with denormalized data models and the effort to ensure that all copies are kept in sync with the single source of truth (SSOT), if it even exists. This imparts risk that one or more copies of the data will become unsynchronized with the SSOT.
 - **Inventory**: added institutional data storage infrastructure associated with denormalized data models and storing of the exact same data elements in multiple locations





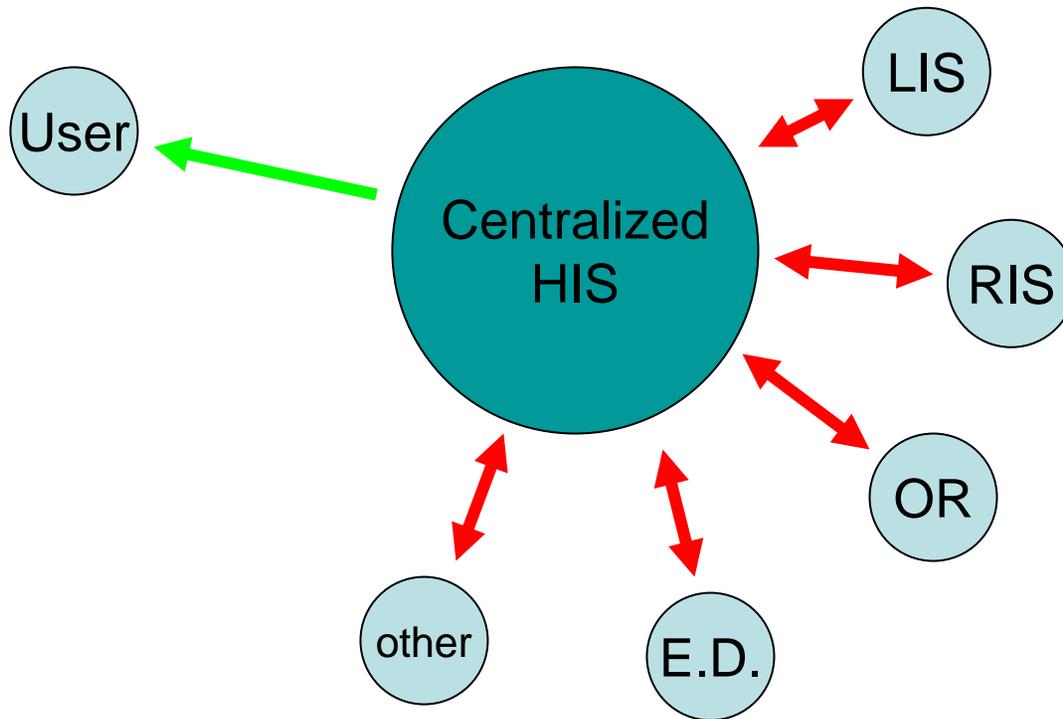
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The Promise of Federation

- Recognize that central IT departments have increasing demands and often diminishing composite resources to meet such demands
- Recognize that ancillary departments are usually the *most qualified* domain experts in terms of appropriate stewardship of data.
- Recognize that it takes less effort and imparts less risk to store every data element once and no more than just once (affirming the use of SSOT principles)
- Reduce time-consuming rework associated with cascaded interface changes, in the setting of evolution in both workflow and data model practices.

What is Federation?

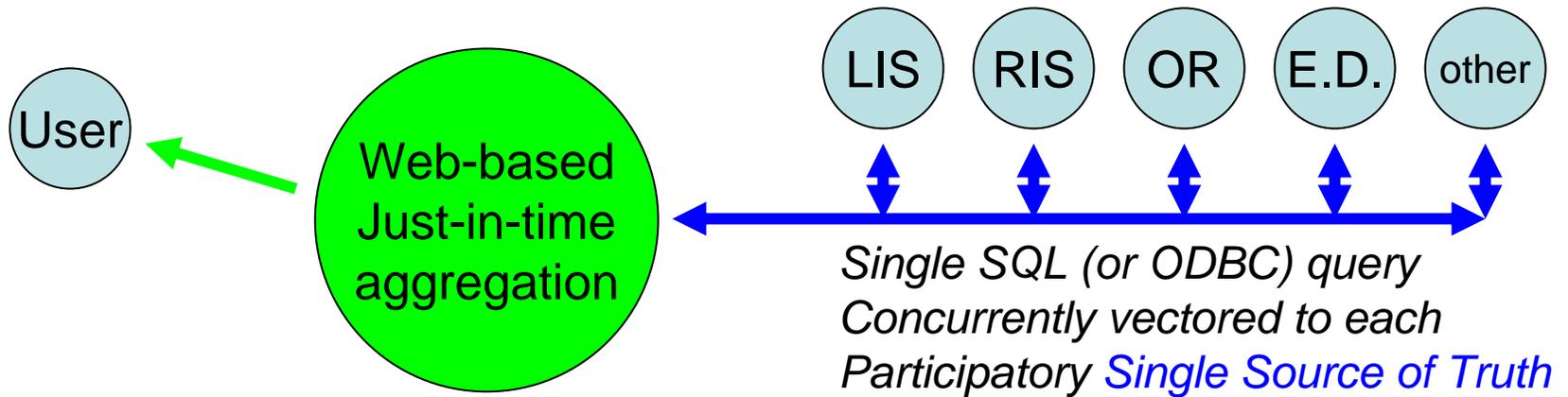
Conventional Data Model



■ Conventional HL7 interface

What is Federation?

Potential Revised Data Model

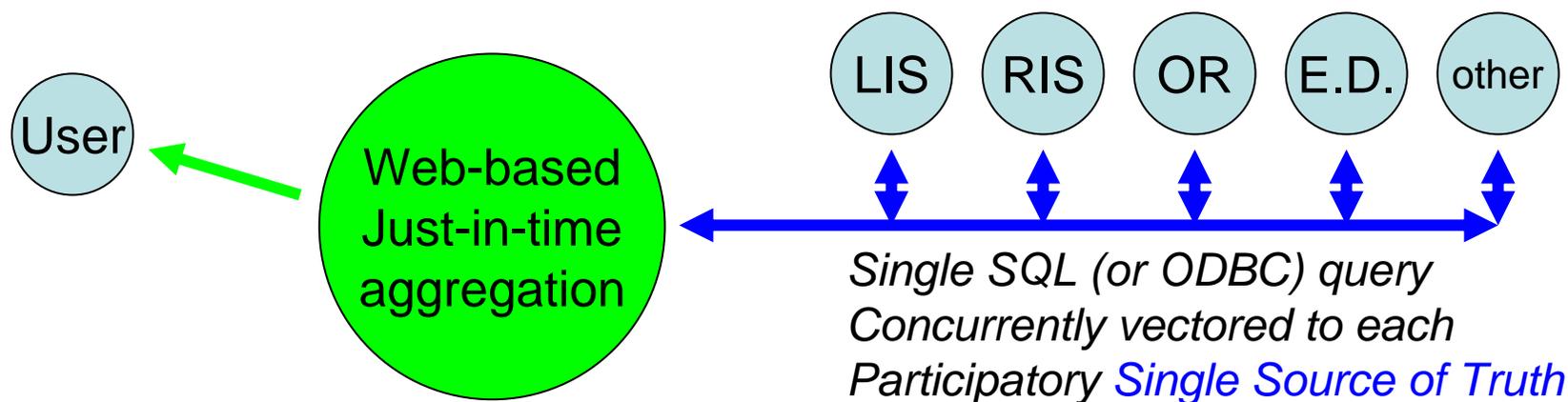


SSOT shifted to the appropriate domain-specific stewards of data from the HIS domain

■ Participatory SQL servers

What is Federation?

Potential Revised Data Model



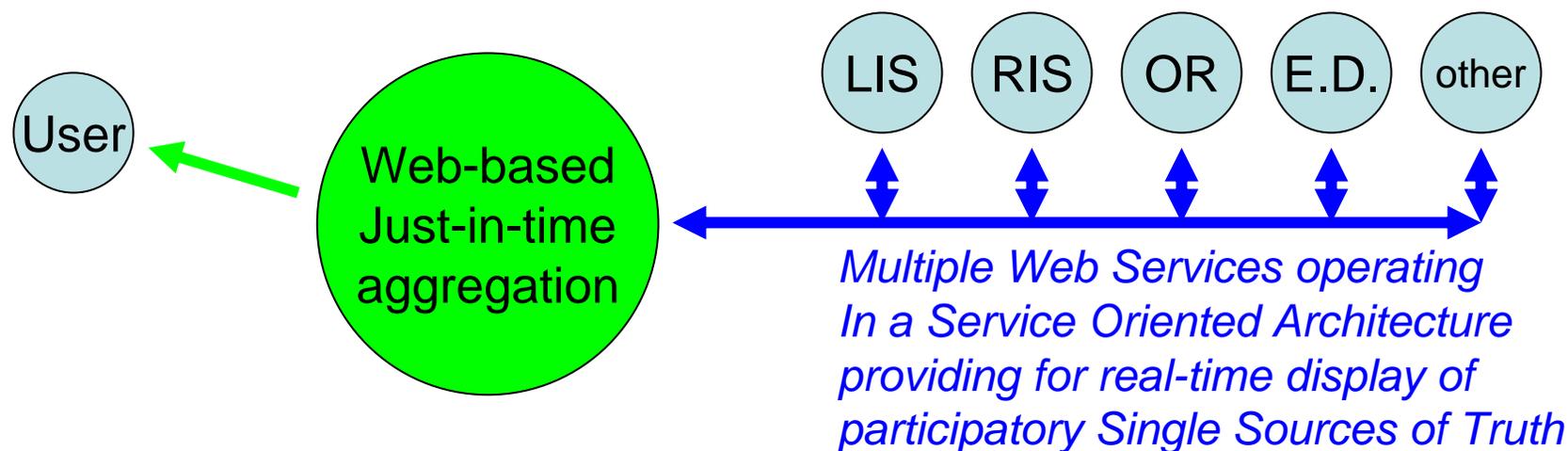
Consequences of shifting to a SQL-based SSOT model:

- Data only represented once in overall enterprise model
- Reduction in number of interfaces requiring support
- Potential to transfer classes information other than text
- Reduction in support responsibilities of central hospital IT.

■ Participatory SQL servers

What is Federation?

Potential Revised Data Model



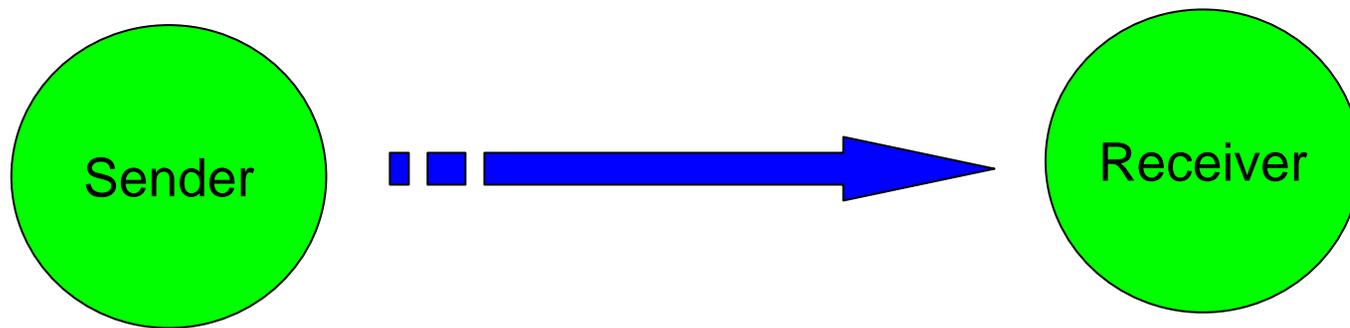
- Consequences of shifting to a Web-based SSOT model:
- Simplified transfer and display of complex data types
 - Simplified exchange of information via Web-based standards, supporting intra- and inter- institutional needs

■ Participatory SOA-Web servers

What is beyond HL7?

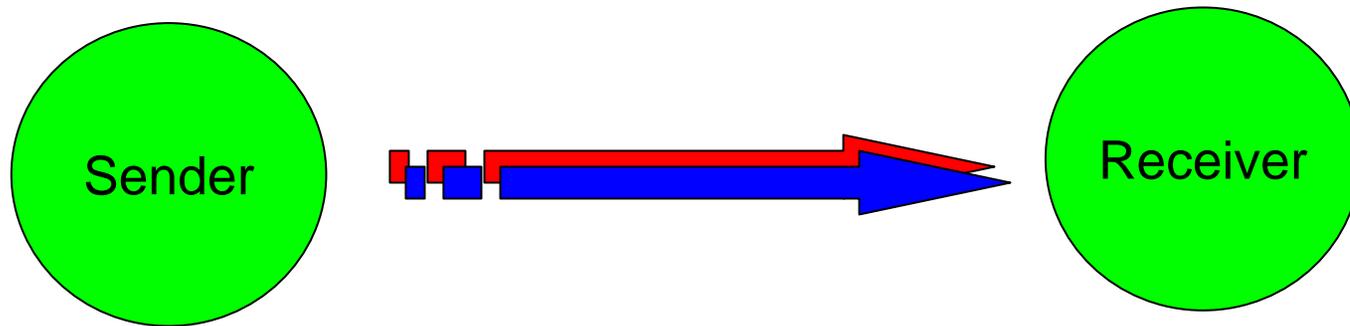
- Zero-Knowledge message exchange
- HL7 (XML)
- True Federation
 - Transact-SQL
 - ODBC
- ISO-11179
- RDF

HL7-based message exchange



- Dependence upon:
 - Precise pre-coordination of expected data fields, formatting and specific sequence of data elements between sender and receiver
 - That each interface must be precisely specified and implemented on both ends
 - That when an internal change in workflow will results in substantive data model changes, there is the requirement to amend the interface on both ends

Zero Knowledge-based message exchange



- Differences:
 - Data elements are transferred along with a message specification layer
 - No *a priori* knowledge of either message content or format required at the receiver
 - In essence, the message is both self-contained and self-defined.
 - Due to use of data element standardization, (ISO-11179), each term is fully defined and recognizable by the receiver, without pre-coordinated effort

Tools to Empower the Creation of Zero-Knowledge Interfaces

- Informatics metadata construct Toolset
 - ISO-11179
 - XML (.XSD)
 - RDF
 - DAML
 - OWL
 - Dublin Core
 - W3C Compliance



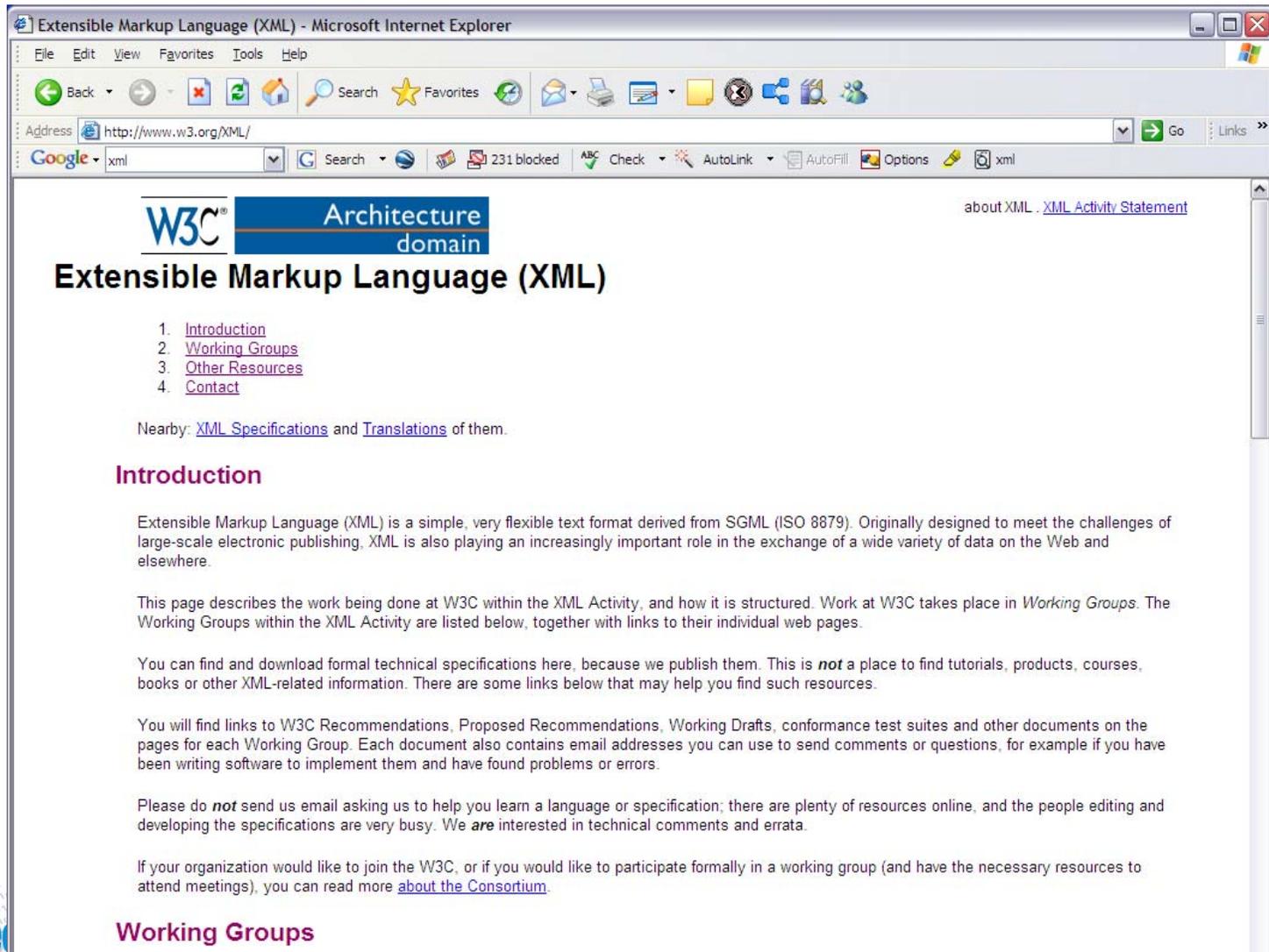
ISO/IEC 11179

- Recognized world-wide
- Allows representation of data elements via markup language (XML) where markup definitions are consistently specified and

ISO-11179 Subparts

Parts	Description
11179-1	Part 1: Framework , introduces and discusses fundamental ideas of data elements, value domains, data element concepts, conceptual domains, and classification schemes essential to the understanding of this set of standards and provides the context for associating the individual parts of ISO/IEC 11179.
11179-2	Part 2: Classification , provides a conceptual model for managing classification schemes. There are many structures used to organize classification schemes and there are many subject matter areas that classification schemes describe. So, this Part also provides a two-faceted classification for classification schemes themselves.
11179-3	Part 3: Registry Metamodel and Basic Attributes , specifies a conceptual model for a metadata registry. It is limited to a set of basic attributes for data elements, data element concepts, value domains, conceptual domains, classification schemes, and other related classes, called administered items. The basic attributes specified for data elements in ISO/IEC 11179-3:1994 are provided in this revision.
11179-4	Part 4: Formulation of Data Definitions , provides guidance on how to develop unambiguous data definitions. A number of specific rules and guidelines are presented in ISO/IEC 11179-4 that specify exactly how a data definition should be formed. A precise, well-formed definition is one of the most critical requirements for shared understanding of an administered item; well-formed definitions are imperative for the exchange of information. Only if every user has a common and exact understanding of the data item can it be exchanged trouble-free.
11179-5	Part 5: Naming and Identification Principles , provides guidance for the identification of administered items. Identification is a broad term for designating, or identifying, a particular data item. Identification can be accomplished in various ways, depending upon the use of the identifier. Identification includes the assignment of numerical identifiers that have no inherent meanings to humans; icons (graphic symbols to which meaning has been assigned); and names with embedded meaning, usually for human understanding, that are associated with the data item's definition and value domain.
11179-6	Part 6: Registration , provides instruction on how a registration applicant may register a data item with a central Registration Authority and the allocation of unique identifiers for each data item. Maintenance of administered items already registered is also specified in this document.

XML



The screenshot shows a Microsoft Internet Explorer browser window with the title "Extensible Markup Language (XML) - Microsoft Internet Explorer". The address bar contains "http://www.w3.org/XML/". The page content includes the W3C logo and the text "Architecture domain". The main heading is "Extensible Markup Language (XML)". A list of links is provided: 1. [Introduction](#), 2. [Working Groups](#), 3. [Other Resources](#), and 4. [Contact](#). Below the list, it says "Nearby: [XML Specifications](#) and [Translations](#) of them." The "Introduction" section follows, explaining that XML is a simple, flexible text format derived from SGML (ISO 8879) and is used for large-scale electronic publishing and data exchange. It also describes the work being done at W3C within the XML Activity, mentioning Working Groups and their individual web pages. The text states that formal technical specifications are available for download, but this page is not for tutorials, products, courses, or books. It also mentions that links to W3C Recommendations, Proposed Recommendations, Working Drafts, and conformance test suites are available for each Working Group. A note asks users not to email for help learning a language or specification, but to use online resources and contact the editors. Finally, it offers information on how to join the W3C or participate in a working group.

W3C[®] Architecture domain

about XML - [XML Activity Statement](#)

Extensible Markup Language (XML)

1. [Introduction](#)
2. [Working Groups](#)
3. [Other Resources](#)
4. [Contact](#)

Nearby: [XML Specifications](#) and [Translations](#) of them.

Introduction

Extensible Markup Language (XML) is a simple, very flexible text format derived from SGML (ISO 8879). Originally designed to meet the challenges of large-scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the Web and elsewhere.

This page describes the work being done at W3C within the XML Activity, and how it is structured. Work at W3C takes place in *Working Groups*. The Working Groups within the XML Activity are listed below, together with links to their individual web pages.

You can find and download formal technical specifications here, because we publish them. This is **not** a place to find tutorials, products, courses, books or other XML-related information. There are some links below that may help you find such resources.

You will find links to W3C Recommendations, Proposed Recommendations, Working Drafts, conformance test suites and other documents on the pages for each Working Group. Each document also contains email addresses you can use to send comments or questions, for example if you have been writing software to implement them and have found problems or errors.

Please do **not** send us email asking us to help you learn a language or specification; there are plenty of resources online, and the people editing and developing the specifications are very busy. We **are** interested in technical comments and errata.

If your organization would like to join the W3C, or if you would like to participate formally in a working group (and have the necessary resources to attend meetings), you can read more [about the Consortium](#).

Working Groups



```

- <dnaChange level="Intragenic" type="Deletion">
  <name>35delG</name>
</dnaChange>
- <!-- Defines the change to the amino acid sequence.
      Types are: Frame Shift, Missense, Nonsense, Silent, Substitution, Deletion

      REQUIRED sub-elements:
      name

-->
- <aminoAcidChange type="Frame Shift">
  <name />
</aminoAcidChange>
- <!-- Pointer to the reference system with additional details
-->
<variantReference referenceSystemId="HPCGG GVAD" variantId="45873" />
- <!-- Genomic location of variant
-->
- <genomicLocation>
  <chromosome>13</chromosome>
  <chromosomeRegion>13q12</chromosomeRegion>
  <gene>GJB2</gene>
  <geneRegion>Exon 1</geneRegion>
</genomicLocation>
- <!-- Class of this variant: Pathogenic, Presumed Pathogenic, Novel Presumed Pathogenic, Novel Unknown,
      Novel Presumed Benign, Presumed Benign, Benign, Resistant, Responsive,
      Polymorphism, Unclassified, Unknown
-->
<interpretationCode code="Pathogenic" />
- <!-- Allele state of the variant: Homozygous, Heterozygous, Hemizygous, Homoplasmic, Heteroplasmic
-->
<allelicStateCode code="Homozygous" />
- <!-- Clinical significance of the variant: Incidental, Non-incidental

```

-->

<interpretationCode code="Pathogenic" />

- <!-- Allele state of the variant: Homozygous, Heterozygous, Hemizygous, Homoplasmic, Heteroplasmic

-->

<allelicStateCode code="Homozygous" />

- <!-- Clinical significance of the variant: Incidental, Non-incidenta

-->

<significanceCode code="Non-incidenta

</sequenceVariant>

- <sequenceVariant>

- <dnaChange level="Intragenic" type="Substitution">

<name>269T>C</name>

</dnaChange>

- <aminoAcidChange type="Missense">

<name>L90P</name>

</aminoAcidChange>

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- <genomicLocation>

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<chromosomeRegion>13q12</chromosomeRegion>

<gene>GJB2</gene>

<geneRegion>Exon 2</geneRegion>

</genomicLocation>

<interpretationCode code="Pathogenic" />

<allelicStateCode code="Heterozygous" />

<significanceCode code="Non-incidenta

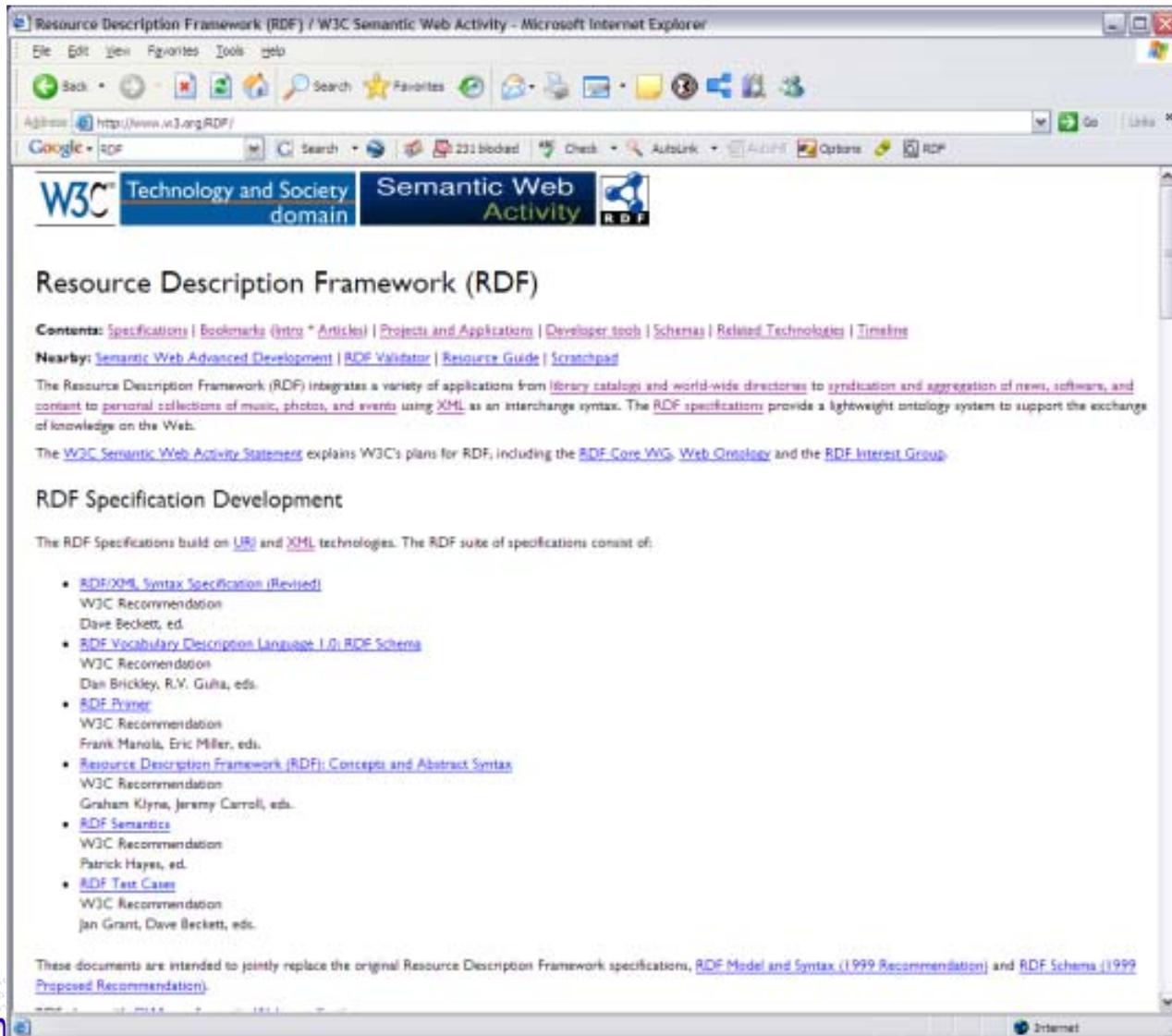
</sequenceVariant>

</variants>

</fulfillment>

</geneticTestOrder>

RDF



The screenshot shows a Microsoft Internet Explorer browser window displaying the W3C Semantic Web Activity page for RDF. The address bar shows the URL <http://www.w3.org/RDF/>. The page features a header with the W3C logo and the text "Technology and Society domain" and "Semantic Web Activity". The main heading is "Resource Description Framework (RDF)". Below the heading, there are sections for "Contents" and "Nearby" with various links. A paragraph describes RDF as a framework for integrating applications from library catalogs to personal collections. Another paragraph mentions the W3C Semantic Web Activity Statement and its associated groups. A section titled "RDF Specification Development" lists several W3C Recommendations and Proposed Recommendations, including RDF/XML, RDF Vocabulary Description Language, RDF Primer, RDF Concepts and Abstract Syntax, RDF Semantics, and RDF Test Cases. At the bottom, a note states that these documents are intended to replace the original 1999 specifications.

Resource Description Framework (RDF) / W3C Semantic Web Activity - Microsoft Internet Explorer

Address: <http://www.w3.org/RDF/>

W3C Technology and Society domain Semantic Web Activity

Resource Description Framework (RDF)

Contents: [Specifications](#) | [Bookmarks \(Intro * Articles\)](#) | [Projects and Applications](#) | [Developer tools](#) | [Schemas](#) | [Related Technologies](#) | [Timeline](#)

Nearby: [Semantic Web Advanced Development](#) | [RDF Validator](#) | [Resource Guide](#) | [Scratchpad](#)

The Resource Description Framework (RDF) integrates a variety of applications from [library catalogs and world-wide directories](#) to [syndication and aggregation of news, software, and content](#) to [personal collections of music, photos, and events](#) using XML as an interchange syntax. The [RDF specifications](#) provide a lightweight ontology system to support the exchange of knowledge on the Web.

The [W3C Semantic Web Activity Statement](#) explains W3C's plans for RDF, including the [RDF Core WG](#), [Web Ontology](#) and the [RDF Interest Group](#).

RDF Specification Development

The RDF Specifications build on [URI](#) and [XML](#) technologies. The RDF suite of specifications consist of:

- [RDF/XML Syntax Specification \(Revised\)](#)
W3C Recommendation
Dave Beckett, ed.
- [RDF Vocabulary Description Language 1.0: RDF Schema](#)
W3C Recommendation
Dan Brickley, R.V. Guha, eds.
- [RDF Primer](#)
W3C Recommendation
Frank Manola, Eric Miller, eds.
- [Resource Description Framework \(RDF\): Concepts and Abstract Syntax](#)
W3C Recommendation
Graham Klyne, Jeremy Carroll, eds.
- [RDF Semantics](#)
W3C Recommendation
Patrick Hayes, ed.
- [RDF Test Cases](#)
W3C Recommendation
Jan Grant, Dave Beckett, eds.

These documents are intended to jointly replace the original Resource Description Framework specifications, [RDF Model and Syntax \(1999 Recommendation\)](#) and [RDF Schema \(1999 Proposed Recommendation\)](#).

labinfotechsum

DAML

DAML.org - Microsoft Internet Explorer

Address: <http://www.daml.org/>

DAML

The DARPA Agent Markup Language Homepage

The DARPA Agent Markup Language (DAML) Program officially began in August 2000. The goal of the DAML effort is to develop a language and tools to facilitate the concept of the Semantic Web. [Michael Pagels](#) is the DARPA Program Manager for DAML. The DAML program will end in early 2006.

Why Use DAML?

A set of [Roadmaps](#) have been tailored for different user communities to help them access and use the contents of this site more efficiently. The Roadmaps should be particularly useful for new visitors to the DAML web site.

Site Links

- [About DAML](#)
- [New User Roadmap](#)
- [daml-help reading list](#)
- [Announcements](#)
- [HotDAML Newsletters](#)
- [DAML in the News](#)
- [Upcoming Events](#)
- [Downloads](#)
- [DAML Briefings](#)
- [DAML Publications](#)
- [Related Links](#)
- [Site Map](#)
- [Search the Site](#)
- [Past DAML Meetings](#)
- [DAML Researchers](#)
- [DAML Language \(DAML-OL\)](#)
- [DAML Services \(DAML-S\)](#)
- [DAML Query \(DQL\)](#)
- [DAML Rules](#)
- [DAML Time Ontology](#)
- [DAML Ontology Library](#)
- [DAML Creator](#)

Recent Announcements

2006-01-13: [Michael Pagels](#) has been named to succeed Bob Popp as DAML Program Manager.

2005-11-07: W3C has [announced](#) the creation of the [Rule Interchange Format \(RIF\) Working Group](#).

2005-09-09: The [Semantic Web Services Framework](#) has been acknowledged as a [Member Submission](#) by W3C.

2005-05-27: [Bob Popp](#) has been [named](#) to succeed Mark Genovesi as DAML Program Manager.

2005-04-19: Briefings presented at the [Semantic Web Applications for National Security \(SWANS\)](#) conference are now available.

2005-04-11: [SWEL FOI](#) has been acknowledged as a [Member Submission](#) by W3C.

[...all announcements](#)

Done Internet

OWL

W3C Recommendation

W3C

OWL Web Ontology Language Overview

W3C Recommendation 10 February 2004

This version:
<http://www.w3.org/TR/2004/REC-owl-features-20040210/>

Latest version:
<http://www.w3.org/TR/owl-features/>

Previous version:
<http://www.w3.org/TR/2003/PR-owl-features-20031214/>

Editors:
Deborah L. McGuinness (Knowledge Systems Laboratory, Stanford University) dmg@ksi.stanford.edu
Frank van Harmelen (Vrije Universiteit, Amsterdam) Frank.van.Harmelen@cs.vu.nl

Please refer to the [errata](#) for this document, which may include some normative corrections.

See also [translations](#)

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Abstract

The OWL Web Ontology Language is designed for use by applications that need to process the content of information instead of just presenting information to humans. OWL facilitates greater machine interpretability of Web content than that supported by XML, RDF, and RDF Schema (RDF-S) by providing additional vocabulary along with a formal semantics. OWL has three increasingly-expressive sublanguages: OWL Lite, OWL DL, and OWL Full.

This document is written for readers who want a first impression of the capabilities of OWL. It provides an introduction to OWL by informally describing the features of each of the sublanguages of OWL. Some knowledge of [RDF Schema](#) is useful for understanding this document, but not essential. After this document, interested readers may turn to the [OWL Guide](#) for more detailed descriptions and extensive examples on the features of OWL. The normative formal definition of OWL can be found in the [OWL Semantics and Abstract Syntax](#).

Status of this document

Dublin Core

The screenshot shows the Dublin Core Metadata Initiative (DCMI) website as viewed in Microsoft Internet Explorer. The browser's address bar shows the URL <http://dublincore.org/>. The website features a prominent orange header with the DCMI logo and the tagline "Making it easier to find information." Navigation links include "ABOUT THE INITIATIVE", "DOCUMENTS", "GROUPS", "RESOURCES", "DCMI NEWS", "TOOLS AND SOFTWARE", "PROJECTS", and "AskDCMI". A search bar is located in the top right corner.

The main content area is divided into several sections:

- Overview:** A brief description of the DCMI as an open forum for developing interoperable online metadata standards.
- Ready Reference:** A list of links for "DCMI Metadata Terms", "DCMI Element Set (ISO Standard 15926)", "DCMI Abstract Model", "Encoding Guidelines", "Schemas", and "User Guide".
- DCMI Registry:** A link to "DCMI Registry".
- Resources:** A list of links for "Documents", "Conference Papers", "Translations", "Projects", "Tools and Software", "Training", "Glossary", and "Bibliography".
- Affiliates:** A list of member organizations, including Helsinki University Library, UK's JISC, Singapore's National Library Board, New Zealand's National Library of New Zealand, and Korea's National Library of Korea.

The central focus is the **DC-2006: International Conference on Dublin Core and Metadata Applications**, held in Manzanillo, Colima, Mexico, from 3-6 October 2006. A green banner highlights this event. Below the banner, there are two "Document Announcements":

- Meeting Announcements:** Further details on the DC-2006 program, registration, and sponsorship, dated 2006-08-07.
- Document Announcements:** Follow-up for public comment on DC-XML and DC-RDF, dated 2006-07-05.

At the bottom of the page, there is a "News Archive" with links for "General", "Document", "Event", "Tools & Software", "Meeting & Presentation", and "All". The page is dated "Last updated: 7 August 2006" and "Next update: 28 August 2006".

Putting it all together:

- Federation enables:
 - Consolidation of optimal use of standards for pre-coordinated message exchange.
 - Reduced domain-expertise at the central IT level
 - Simplified application support → less hours spent every year on interface support
 - Elimination of the need for any customization whatsoever at the receiver site, made possible by ISO-11179, XML and RDF
 - Supports **Best-of-Breed** deployment
 - Approaching the vision of plug and play interoperability in both intramural and extramural settings (*a first step towards working RHIOs*)

An Example Standard that Embraces Federation

- Laboratory Digital Imaging Project (www.ldip.org)
 - A message Exchange Specification, based on XML and RDF (W3C compliant architecture).
 - True zero-knowledge functionality.
 - Use of ISO-11179.
 - Participation from major stakeholders in industry, academia and community practice.
 - Based upon XML and RDF Open source tool sets
 - Designed to be upwards compatible with DICOM

The screenshot shows a web browser window titled "Laboratory Digital Imaging Project - Association for Pathology Informatics - Microsoft Internet Explorer". The address bar shows "http://www.ldip.org/". The page content includes the API logo, the title "Association for Pathology Informatics Laboratory Digital Imaging Project", and a list of specific goals for LDIP. A sidebar on the left contains navigation links, and a "Quick Links" box on the right features logos for GE and McKesson.

Association for Pathology Informatics
Laboratory Digital Imaging Project

Laboratory Digital Imaging Project

The Association for Pathology Informatics Laboratory Digital Imaging Project (LDIP) was developed in 2004 under the direction of the **Association for Pathology Informatics (API)**, a division of the **American Society for Investigative Pathology (ASIP)** to develop and promote the use of pathology images to improve patient care and improve the quality of research in pathology by the development of standards relating to the interchange of various types of images.

Specific goals for LDIP include:

- (1) developing a set of definitions to clarify the uses of imaging in pathology and laboratory medicine;
- (2) developing an educational plan that will promote the uses of imaging and will provide educational forums for pathologists, informaticians and vendors to discuss new and developing imaging technologies;
- (3) establishing an open access, voluntary use specification that will permit images generated in pathology and in clinical laboratories to be widely shared across different applications, databases, and operating systems for the purpose of enhancing image annotation, integration, archiving, publication, and analysis;
- (4) encouraging LIS, lab/web portal, telepathology, and digital camera vendors to offer and deploy efficient and effective imaging systems that will lead to improved patient care;
- (5) assessing the value and roles of images in communicating the results of clinically useful laboratory tests, particularly in the area of multiplex testing;
- (6) exploring the uses of imaging as a pathology research tool that will lead to improved treatment and prevention of disease; and
- (7) encouraging and facilitating the publication of scientific studies and publications that document and enhance the value of images in pathology and the lab industry.

Quick Links
LDIP Membership
Support Levels & Benefits
Apply for Membership in LDIP
Corporate Members
Platinum
GE
Imagination at work
GOLD
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