Chapter 2
Why Interoperability is Hard

2.1 What is Interoperability?

The term interoperability means different things to different people. For example, the *HIMSS Dictionary of Healthcare Information Technology Terms, Acronyms and Organizations* lists 17 definitions, from the strictly technical factor to social, political, and organizational factors (HIMSS 2006).

A widely used definition is:

> Interoperability is ability of two or more systems or components to exchange information and to use the information that has been exchanged. (Institute of Electrical and Electronics Engineers 1990)

The HL7 EHR Interoperability Work Group has developed a framework, which covers three different points of view (Gibbons et al. 2007):

- Technical interoperability
- Semantic interoperability
- Process interoperability

These concepts are interdependent, and all three are needed to deliver significant business benefits.

Technical interoperability moves data from system A to system B, neutralizing the effects of distance. It is domain-independent. It does not know or care about the meaning of what is exchanged. One of the foundations of technical interoperability is Claude Shannon's information theory, which proved that it is possible to achieve 100% reliable communication over a noisy channel (Shannon 1948).

Semantic interoperability ensures that system A and system B understand the data in the same way. It allows computers to understand, interpret, and use data without ambiguity. This is specific to domain and context and usually involves the use of codes and identifiers. Semantic interoperability is at the core of what we usually mean by healthcare interoperability.

Process interoperability coordinates work processes, enabling the business processes at the organizations that house system A and system B to work together. Process interoperability is achieved when human beings share a common under-

T. Benson, *Principles of Health Interoperability HL7 and SNOMED*, HI,
DOI 10.1007/978-1-84882-803-2_2, © Springer-Verlag London Limited 2010

standing, so that business systems interoperate and work processes are coordinated. They obtain benefits only when they use the new system in their day-to-day work; if it is not used as intended, for whatever reason, it is a failure. The importance of reengineering work processes to take full advantage of electronic systems has long been recognized, but the lessons have not been well-learnt.

The more we know about the three types of interoperability, the less likely we are to underestimate what is required to make health systems interoperable.

2.2 Benefits

The benefits of joined-up health care, to provide the right information at the right time and place, are predicated on deploying and using standards that enable computer systems to exchange information in a way that is safe, secure, and reliable.

The problem with standards is not that there are so many to choose from, but that we have not deployed those we have and that there is no regulator to make deployment happen. Standards that are not deployed are a waste of time and effort.

The center of the star at the right of the figure below indicates a single specification being used for linking the six domains (Fig. 2.1). This replaces the 15 separate specifications shown on the left-hand side.

The benefits increase exponentially and more parties are involved, because the number of interfaces needed to connect N systems increases using the formula $(N^2-N)/2$. Without using a standard in this way, linking two nodes needs only a single interface, which can easily be agreed by people sitting around a table; linking six nodes requires 15 interfaces; but linking 100 nodes requires 4,950 interfaces (Fig. 2.2).

Examples of functions needing interoperability cover a wide range:

- Requests for investigations such as laboratory tests and radiology
- Prescriptions for medication and other therapy in hospitals and in the community
- Orders for nursing care, equipment, meals, and patient transport
- Investigation reports from laboratories, radiology, and other diagnostic departments

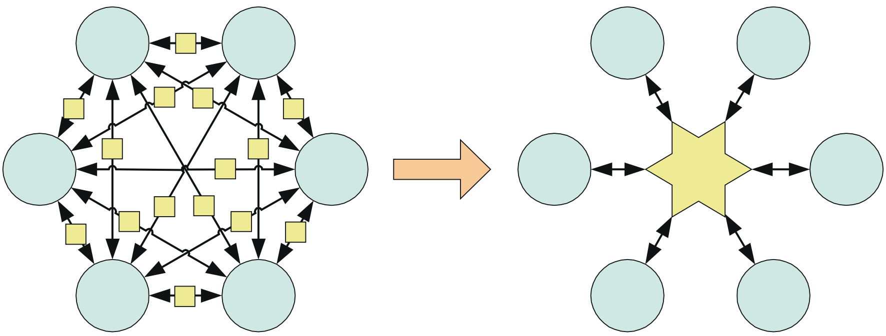

Fig. 2.1 The benefits of one standard

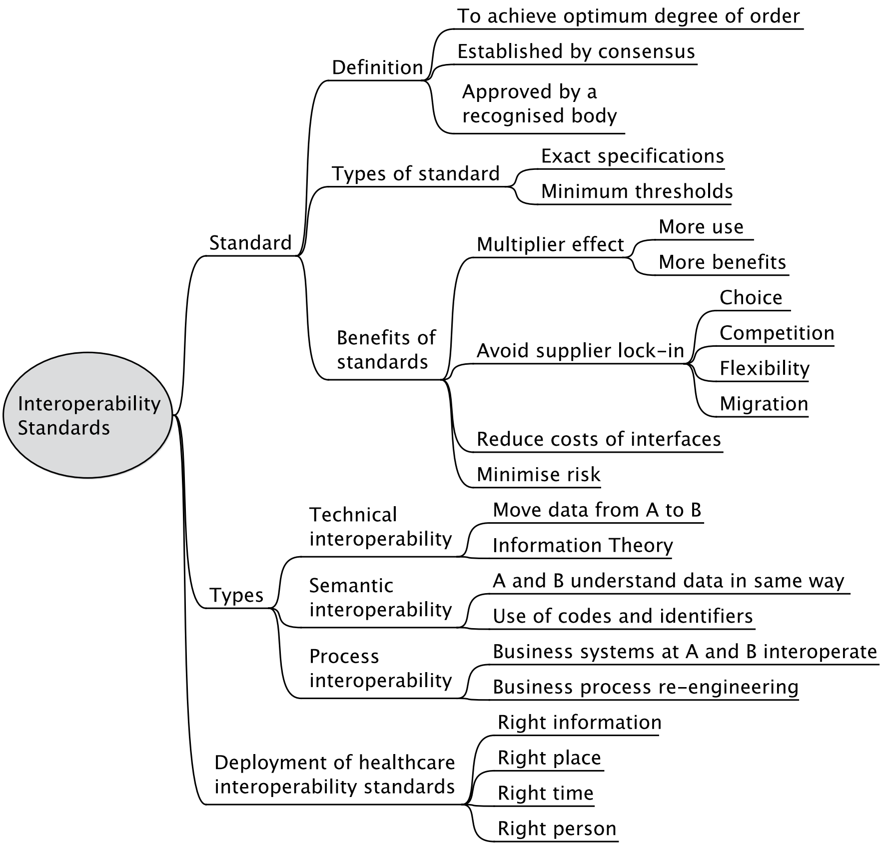

Fig. 2.2 Interoperability standards

- Administrative data such as patient registration and identification, clinic appointments, admissions, discharges, and transfers (ADT)
- Letters and memos from one clinician to another, including referral, clinic and discharge letters and opinions exchanged between hospital specialists, GPs, and community services
- Transfer and merging of electronic medical records between GPs and within and between hospitals and community services
- Information used for management, audit, and monitoring
- Commissioning, billing, and accountancy data

The numbers of transactions in healthcare systems can be vast. For example, in 2007 a single system (the EHR system) at one large hospital (the Mayo Clinic in Rochester, MN) processed 660 million HL7 messages or about two million messages a day.[1]

[1] Anthony J., Personal Communication.

2.3 Need for a Lingua Franca

Problems begin because each computer system stores data internally in a different way. This means that to communicate, data has to be translated from one format or internal language into another. The solution is often achieved by translating to an intermediate *lingua franca* (such as a version of HL7) that is understood by each party.

There are two translations in any interchange; first from the native language of System A to the lingua franca; second, from the lingua franca to the native language of System B.

When we talk about a language we mean both the syntax, grammar or information structure of the language and its semantics, vocabulary, or terminology.

The Rosetta stone from ancient Egypt, now in the British Museum, provides an analogy. The Rosetta stone contains the same proclamation in three languages, used by the priests (Hieroglyphic), the court (Greek), and the people (Demotic). In our context, the three languages could be those used by a sending system, the receiving system and a common lingua franca used for information interchange, such as HL7. The meaning of a message is precisely the same in each language but the notation is quite different.

The inscribers of the Rosetta stone only needed to perform their translation once, but in computer interoperability, each and every message has to be translated from one format to another without error. The choice of interchange language is not sufficient to ensure interoperability. Each transaction needs to be defined in unambiguous detail as part of a complete, consistent, coherent, and computer-readable set of specifications for interoperability between the machines to minimize any possibility of error.

2.4 Electronic Health Records

Clinical information is complex, but before exploring the variety let us look at ways in which clinical information is similar.

In their seminal paper, Rector, Nowlan, and Kay (Rector et al. 1991) describe how an electronic health record (EHR) is best thought of as a collection of statements, which is a faithful record of what clinicians have heard, seen, thought, and done. The EHR is not a collection of facts, but a set of observations about a particular patient, which have been made by clinicians, each at a specific time and place for some purpose.

Because each clinical statement is an observation, it is quite possible for two statements about the same event to disagree with each other, but this can be resolved if the context or provenance of each statement (who stated it, when, and where) is recorded. As with a work of art, a statement without provenance is of doubtful validity.

The ISO 13606 Reference Model for electronic health record communication sets out a useful hierarchy of clinical information in the context of exchanging clinical information between parties.[2]

- Extract: The top-level container of all or part of the electronic health record (EHR) of a single subject of care (patient) is known as the EHR Extract.
- Composition: The EHR is made up of Compositions. The Composition is a key concept; it is the set of information committed to one EHR by a clinician relating to a specific clinical encounter. Progress notes, laboratory test reports, discharge summaries, clinical assessments, and referral letters are all examples of Compositions.
- Folder: Compositions may be grouped together into Folders and sub-Folders. Folders may be used as containers for various purposes, grouping together the records by episode, care team, clinical specialty, condition, or time period.
- Entry: Each Composition comprises a number of Entries, also known as Clinical Statements. An Entry is the information recorded in the EHR as a result of a single clinical action, observation, interpretation, or intention. It may be thought of as a line in the record. Examples include the entries about a symptom, a laboratory result, a diagnosis, or a prescribed drug.
- Section: Entries may be grouped together in Sections. A Section is a grouping of related data within a Composition usually under a heading such as Presenting History, Allergies, Examination, Diagnosis, Medication, and Plans. Sections may have subsections.
- Element: The leaf node of the EHR hierarchy is an Element, which is a single data value, such as systolic blood pressure, a drug name, or body weight.
- Cluster: Related Elements may sometimes be grouped into Clusters. For example, systolic and diastolic blood pressures are separate Elements, but may be grouped into a Cluster (e.g., 140/90), which represents one Item in an Entry (Fig. 2.3).

Each clinical specialty has its own way of working. The grand vision of joined-up health care is predicated on the notion that patient records can be shared electronically between clinicians from different specialties. Historically, this has been largely wishful thinking. There have been few successes and many failures. Yet, this is the promise of President Obama's HITECH Act and was a specific but largely unrealized objective of the NHS National Program for IT, which was established in 2002. Every success has depended on the certified use of agreed standards.

First, we must recognize that it is difficult to share information between different computer applications even within the same specialty. This is because each computer application stores data in a different way and may use different internal codes. The GP2GP project in England illustrates the point. Patients in England have a lifelong

[2] ISO 13606-1:2008. Health Informatics – Electronic health record communication – Part 1: Reference Model

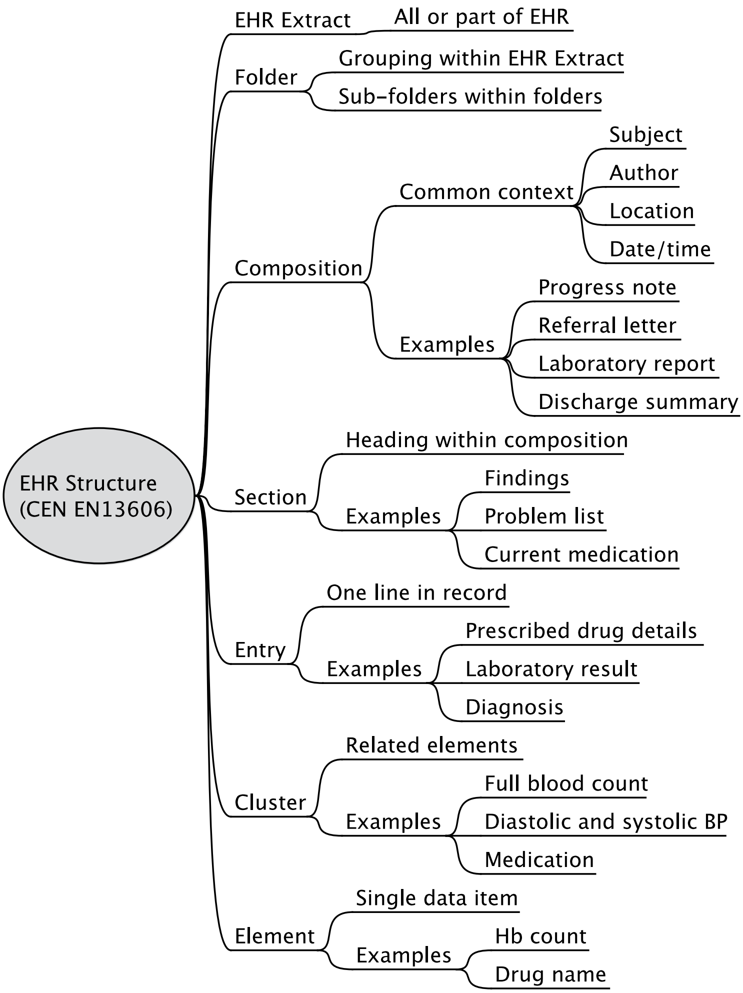

Fig. 2.3 CEN EN13606 EHR Structure

medical record, which follows them when they move from one GP to another. In an ideal world, each patient's records would be sent electronically from their old practice to the new in a manner that minimizes risk and avoids the need to reenter information.

The GP2GP project set out to do just that, although the project's leaders recognized that it could a poisoned chalice.[15] The work has been every bit as difficult as predicted and each record has to be carefully quality-checked before transmission and on receipt; but after 7 years work it is a qualified success story, but not the Holy Grail.

Even within the same specialty, the information about an outpatient visit differs greatly from that about an elective surgical operation or inpatient discharge summary following an emergency admission.

For example, consider the following types of document. At one level each of these could be regarded as a discharge summary, written from a hospital to a GP, summarizing the outcome of a visit or episode of care. At another level each is very different.

- An elderly patient discharged home after a fracture
- Mother and baby following birth
- A family after a course of counseling by a psychologist
- Consultation report from an ophthalmologist notifying a proposed operation for cataract
- Letter to GP notifying that a patient has been diagnosed with cancer
- Discharge from hospital following coronary artery bypass grafts
  Postmortem report

Each of these is a composition which relates to a discharge event, but the information contents are extremely diverse.

Similarly, people sometimes talk about clinical laboratory reports as if they were homogeneous, but the content of each type of clinical laboratory report is quite different, as is the work done in each type of laboratory. Histopathology examines cells with a microscope; microbiology grows bacteria to identify them; haematologists count blood cells; and clinical chemistry measures chemical concentrations by measuring the intensity of color changes when chemical are added. The only commonality is that they all work with specimens extracted from patients. Yet, the specimen workflow is not fixed; sometimes the requester supplies the sample, sometimes the sample is taken by the laboratory, and sometimes the patient is required to be present in person.

2.5 Analysis is Paramount

Much of the hard work involved in interoperability lies in teasing out the hundreds or thousands of different use cases. Information technology analysts, and those who pay them, tend to focus on the high-volume transactions, which are common across all specialties and prefer not to deal with the specific needs of the smaller specialties. Yet, the common stuff is not usually the most important clinically. The value of any piece of information is, like a piece of art, often related to its rarity.

Even apparently simple concepts such as name and address become complex on closer inspection and in spite of years of effort, there are still no satisfactory international standards for name and address. Even the order in which names and addresses are written varies substantially between countries.

One person may have several names and several addresses, which they can change at will. For example, a woman may use both her maiden and married names in different contexts. One person may use several addresses (home, work, previous, holiday, etc.) and each address may also be associated with different people, such as family members, friends, or colleagues.

The naming rules for addresses are complex in themselves. For purposes of addressing, buildings have names or numbers or both; they can be subdivided into units, apartments, or rooms. Multiple factors identify the physical location of each building, including its street, locality (village, part of a town or district), town or city, state (county or region), country, and postal code, as well as supplemental data such as map-grid references and instructions on how to find the house.

One way to simplify the problem is to distinguish clearly between information that needs to be processed by computer and that which needs to be read and understood by human users. Computer processing is essential when data elements need to be identified, matched, retrieved, or counted. This type of information must be structured, complete, unambiguous, and validated. These are relatively few but important.

Human readers, responsible for any aspect of the care of an individual patient, need information in a format that they can understand. This does not have to be highly structured, although it needs to be easy to read and accompanied by supporting contextual data such as who wrote it, when, and where, and for what purpose. Humans are good at judging the significance of small discrepancies, but digital computers are unforgiving of a single unexpected bit.

2.6 Complex Specifications Create Errors

Building a single link to exchange data between two computers is relatively straightforward. Everyone sits around a table and works out what they are going to do. This approach works for very small projects, where each person is co-located, but it does not scale. One alternative approach is to develop rigorous implementation guidelines, but these are often complex and voluminous. For example, in the NHS Pathology Message Implementation Project (PMIP), which was a successful national project to send clinical chemistry and hematology laboratory test reports to GPs in England, the implementation guidelines consisted of 185 separate Word documents, running to almost one million words. The endeavor to be rigorous leads to errors caused by the sheer length and complexity of the specifications.

A different sort of problem arises when the domain experts (such as doctors, nurses, and managers) are unable to fully understand these specifications due to the complexity of language or simply the time it takes to read them. As a consequence, these specifications may not be reviewed or checked at the specification stage as thoroughly as is required.

Errors multiply according to the:

- Probability of misunderstanding any part of the specification, which depends on difficulty of language and domain and technical knowledge of participants (people with high levels of both technical and domain knowledge are rare).
- The length of specification: In a long specification, exactly the same idea may be presented in different ways in two places, but each may be understood differently. If large blocks of information are replicated in different sections, with small but important differences, these differences may be missed.

- Number of options permitted.
- Number of times different implementations to be made: Each implementation involves mapping or translating the specification into the local implementation language.

Misunderstanding inevitably leads to error; errors increase costs and reduce quality, create delays, and hit profits and reputation.

Successful specifications avoid errors by limiting scope, being easy to understand, relatively short, and simple, with few if any options.

Many problems are caused by inadequate thought and preparation by both users and suppliers. If time is running out, it is all too easy to be vague in a specification or offer the implementer a choice of options depending on the local context.

2.7 Users and Suppliers are both Guilty

Often, both users and suppliers genuinely believe that they are in full agreement until the moment when users try to use the final product. Problems lie on both sides.

Users do not fully understand what they want, let alone what other parties can or cannot provide; they do not commit enough time or effort up-front to fully review written requirements specifications; they then will not commit to these, and insist on new features after the schedule and budget have been fixed. Most users are technically unsophisticated, do not understand the development life cycle, and are simply unable to perform the sort of scrutiny which is demanded of them. This is one of the reasons why users need a far higher level of education in health informatics than has been provided in the past.

Suppliers are equally guilty. They often try to shoehorn the users' requirements to fit their existing systems or patterns, believing that it will be quicker, cheaper, and lower-risk to reuse what already exists, while failing to grasp that the user will never be happy with it and really needs something else. Suppliers may also lack the specialized domain knowledge to fully understand the user's business processes at the required level of detail. This is one other reason why most suppliers focus attention on the high-volume aspects of health informatics, because they do not have the domain knowledge to deal with the idiosyncrasies of each and every specialty.

2.8 Shared Meaning

Shared meaning between computers requires shared understanding between all of the human participants.

An analogy is the purchase of a new kitchen. The kitchen designer prepares a plan of the new kitchen. This plan is checked, reviewed, and signed off by the customer and is the basis of the contract. All of the details that are important to the user (sizes, color, etc.) are specified precisely and agreed with the customer in a way that is also understood by the manufacturer (implementer). This plan uses a precise technical notation, which provides a means of communicating precisely the user's needs to the implementer (manufacturer), in a form that can be understood by both. Manufacture only begins after the customer has agreed the specification.

Manufacture uses a different but related set of plans, which specify the exact materials and products to be used down to the precise specification of every last screw.

The challenge in interoperability is harder; it is to ensure understanding horizontally across business processes, which may be in different organizations (between domain expert and domain expert) and vertically within computer systems suppliers, between users and developers who speak different dialects (Fig. 2.4).

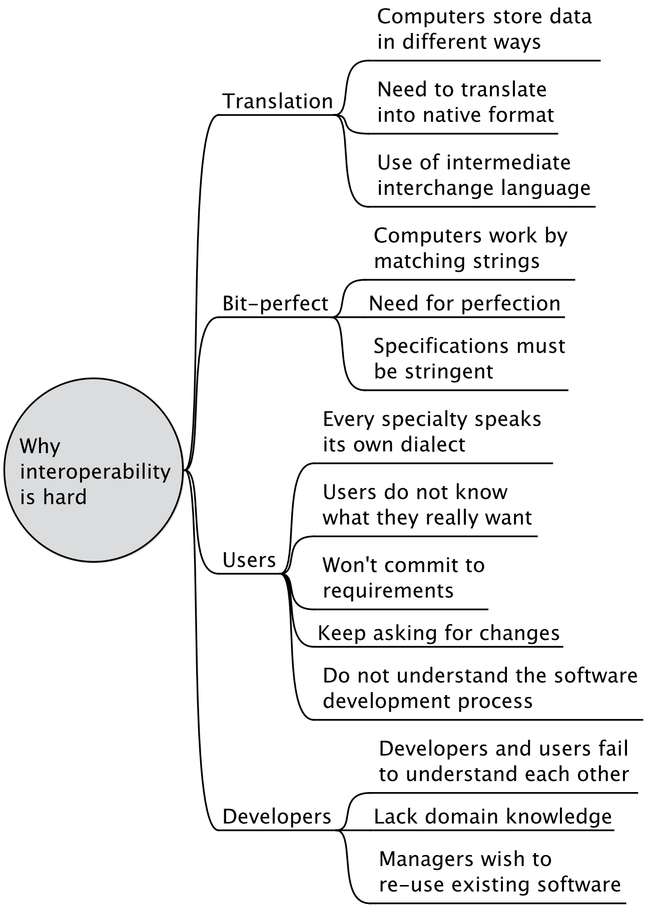

Fig. 2.4 Why interoperability is hard