* Paper reviewed according to DETYA standard 1999

Harmonising Health Information Models - a critical analysis of current practice

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Abstract

Sharing information is more than sharing just data. Not only must data content be understood, but its context as well. Information is pre-eminent in health care today and it must satisfy *universal health care requirements* of equity, continuity, coordination and independence over time and place to a far greater degree than in the past.

Conveying information across a domain as large as health care requires a deeper understanding of the nature of information. Information has levels of meaning corresponding to its specificity. Overall information as used for general purposes to convey intent uncluttered by detail. For specific operational purposes information must carry the fine-grained detail required to intimately coordinate and share service activities. The inevitable information gaps between intent and detail are filled by implicit meaning which becomes impossible to keep consistent over a large and dispersed organisation.

We have analysed information and data models from NSW Health using new information structure analysis methods based on *the consistent dependency principle*. As a result we can report useful advances in understanding the nature of information structure, and hence modelling and systems. This leads to an approach to harmonising information across levels of specificity.

The promise is improved compliance and inter-operability between systems; and improved satisfaction of the *universal health care requirements.*

Introduction: This paper is the result of analysing and enhancing information models produced for NSW Health from 1994 through to 1999. We gratefully acknowledge the assistance and cooperation of NSW Health. For all the complexity of modern medicine, information technology and social organisation, the core of a health system is both familiar and simple - it is the patient doctor relationship. Everything else in health is around this relationship - supporting it, monitoring it, servicing it. This paper is about harmonising health information. To assist this we display at the HIC Conference an enhanced suite of information models from NSW and Commonwealth health departments that are in the public domain or for which we have permission to have on restricted display. The suite shows the actual information structures that support health at different levels of specificity. The question is:- do the structures have *sufficient compliance* between them? Moreover, what does *sufficient compliance* entail? The models show the familiar doctor-patient relationship elaborated within the complexity that surrounds health care processes. . Unfortunately, there is only space for some general outlines of the models within this paper.

ISBN 0 9585370 8 9

What does harmonisation mean and why do it?: Organizations and industry-focussed groups frequently develop information models, data models, class diagrams, classification schemes etc to represent their information needs within various areas of interest or for particular purposes. Commonly these information structure representations are used as the basis for physical database schema.

Large development projects rely upon CASE Tools to manage data dictionaries and schemas. Frequently, in large projects, development teams are fragmented and need, periodically, to consolidate their work to a baseline schema, so that changes can be propagated to all groups. Obviously a very rigorous process is involved in consolidating to a baseline schema – programs operating on one database must be consistent in their use of the schema.

The same is not true however of “independent” projects and activities. A model/database developed for a PAS (Patient Admission System) system may not use the same structural elements (entities, relationships and attributes / tables) as those that are used by a UPI (Universal Patient Identifier) or an Ambulatory Care system/model, even though some items are common. These different systems are not constrained by the technical imperative of operating within or on one data-space. Only when they transfer/exchange information is there a need to understand and translate the structural elements to equivalent meanings, and to complicate the situation further, the translation may be to a different, common model or standard such as the HL7 RIM model.

As a result of their independence, there is no established “industrial” process by which independent models are checked for consistency, even where there is interdependence. Structural interdependence is only investigated either at the time of development – in efforts to use existing/corporate data standards (by inspection of data definitions and technical characteristics of the data (eg same datatypes/length)) or at the time interdependence is developed – that is when an interface is developed.

Harmony needs a simple structure: A grand harmony needs a familiar simple theme. A grand symphony is intricate in its detail, but familiar in its overall structure and theme.

We have de-constructed, abstracted and refined the NSW health Enterprise Information Model (EIM). To de-construct and then reconstruct we have had to invent new methods to analyse information structure. The determined reader is referred to several papers that connect the application of category theory to information and data structures. {Dampney and Johnson, 1995, 2000; Colomb et al, 2001).

Implicit content defies complete explicit compliance: In information structures, as in music and art, apparent harmony is gained without complete compliance with the rules. It is the implicit that causes us to infer and thereby complete our understanding. So understanding in general is only partially explicated.

It is implicit information, the often obvious information that is not represented, that hinders explicit and complete compliance between information models. We observed that in the NSW Health Enterprise Information Model (NSW Health, 1996). depending on the level of specificity, there are implicit information structures that are not represented. At the more detailed *physical* levels of specificity these implicit information structures include: -

- the context of role, organisation, intent, and purpose;

- classification schemes; and
- information/computation artefacts such as those required to support intensive, heuristic and commercially sensitive processes such as rostering and scheduling.

At more general, abstract, levels of specificity the implicit information structures include:-
- entities (such as a booking of an appointment) that are omitted because they can be implicit (such as in a walk-in bulk-billing medical centre)
- representation of knowledge incompletely codified in classification schemes
- implicit relationships such as between medical observation and medical diagnosis where such detail is too expensive, subjective or private to explicate for sharing purposes.

This implies that compliance between models must have an appropriate abstracting mechanism.
Sharing information on a grand scale - an overview

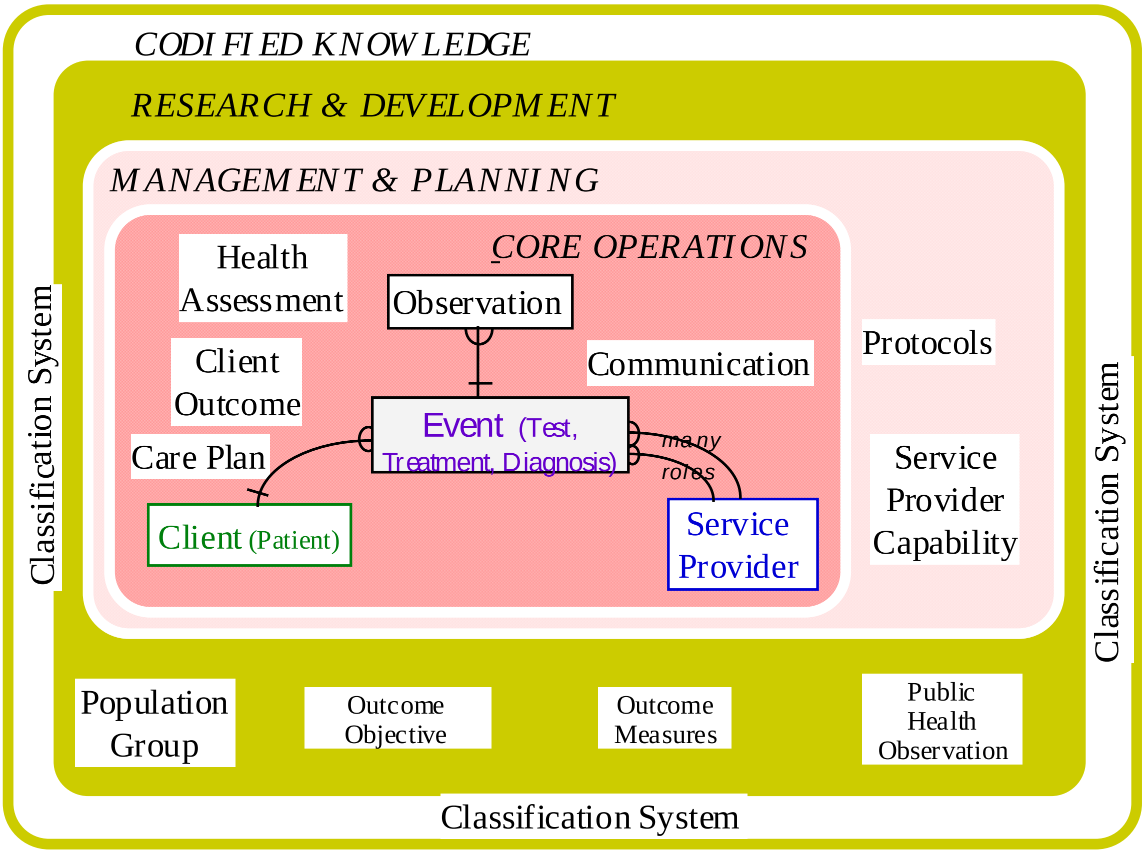

Figure 1. The kernel, management, development and classification of health care.

Sharing information on health care across a large hospital, a State, or a Nation is extraordinarily challenging. Sharing resources of any kind is difficult, but sharing the way we perceive our world is evocative and sometimes confronting. Perception is essential but intangible. It is, nonetheless, the means we have to gather information. When perceptions clash problems arise.

We share information because a society gains value beyond its individuals by shared activity, allocating responsibility and coordinated actions. And information is the vital medium for this.

An obvious view of the nation's health care information is its central focus on patient health care by health care service providers. This core information, our analysis showed, is wrapped within the layers of management & planning, research & development, and classification (knowledge codified to information) that are required to guide, improve and resource health care (figure 1).

The question then is - *what level of detail is required to portray the information structures effectively?*

The National Health Information Model (AIHW, 2001) is a case in point. As it evolved from version 1 to version 2, it dropped most of the relationships within it to focus on its essential goal - a common information classification framework independent of jurisdiction, medical specialisation and operational business rules. Its purpose became clearer and is reflected in the generalisation enabled by omitting relationships. The model is a basis for the Commonwealth (national) government to fund the various Australian State governments for the health care of their residents. So we can conclude that purpose impacts specificity.

Harmonising Information Models for resourcing, for planning and for operation: To do one should plan, and to plan one must have resources. Where more than a few people are involved these processes need information system support. To coordinate doing, planning and resourcing over an organisation, requires shared information.

Shared information is more than just data; it is agreed common understanding of what the data means within the particular context considered.

This simple imperative distinguishes information modelling from data classification. The need for data classification is simple - in a literate society one knows that to search for books and facts requires overarching classification and common definition.

Data alone is not sufficiently defined by a classification scheme for operational purposes. While classification for planning and resourcing purposes should be independent of specific events (specific context), operational activity in contrast requires explicit associations. For example, booking a patient with particular conditions for a particular medical procedure at a particular operating theatre requires exact association. As systems increase their reach, range and use in everyday coordinated activity associations must become increasingly explicit.

Classification and explicit context: The problem is that as associations are made more explicit, information models become more detailed. As information systems embrace the enterprise as a whole, intention is lost in the complex maze of relationships that appear. Abstracted enterprise information models may attempt to balance the explicit and the intention, but the tension in endemic and the balance is susceptible to change.

More specific explicit information models are required to support particular health care activity, but wider classification and more generalised association is required to document intent consistently across all of health care.

With the emerging policies of continuing and coordinated health care, information models are required which document both explicit detail and general intent across all of health.

The challenge of comprehensive information modelling: As a consequence information models at different levels of specificity have emerged, and these need to be "harmonised" so they work together

This problem is not peculiar to health, it is evident in airline reservation systems, insurance systems, and others such as integrated supply systems that service the general infrastructure of a developed society. The particular challenge in health is that its information systems are not amenable to a gross production line approach.

The challenge in health care is that individual need, both patient and doctor, and organisational imperatives must be accommodated. Common context and meaning is required for people to share information, and common purpose is needed for people to gladly share. Sharing information requires interpreting data in the same way according to the same information structures implied by the same rules and purpose. Information structures as represented in systems need to be in harmony with each other.

From a scientific perspective our understanding of information structure is primitive. This is so despite emerging science distilled from research and practice in information modelling, database schemas, data warehouses, (statistical) data analysis, natural language and artificial intelligence.

From a practice perspective, the information systems that support coordinated health care must exchange semantically consistent data to support health care services, epidemiological control and resource allocation. This requirement intensifies as health care becomes more complex, more diverse and more distributed in keeping with equity in health services, population movement, and advances in medical science and in technology generally.

Harmonising information models through common information structures: We focus on the information structures because a system is governed and fundamentally specified by its structure. We have found that category theory[1] is applicable to describing the way we structure and thus construct and conceptualise reality. Specifically the category theory (CT) construct of *commuting diagrams* supports the *principle of consistent dependency*[2] which empirical evidence shows is central to information structures (Dampney 1995). We have applied these principles to developing new methods for analysing information structures.

The NSW Health Enterprise Information Model (EIM) is an overview of health information. It is comprehensive, intensive and challenging. Its purpose is to support planning, managing and *delivering* $7 billion of health care services annually in New South Wales. In contrast, the NHIM is aimed at monitoring population well being and funding needs.

The challenge of information exchange is illustrated by the HL7 standards. HL7 is aimed at message exchange between disparate systems, and as a consequence we believe of this disparity, the number of different types of HL7 messages and their variations is increasing very rapidly.

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[1] Category Theory is a universal algebra and a candidate for describing the foundations of mathematics.

[2] *Consistent dependency* is expressed by a *commuting diagram*. For example in figure 3, all the composite functions from Payment to Specialist are equal. Given a Payment it is to the same specialist whether via Health care service or via Agreement.

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The NSW Health suite of models

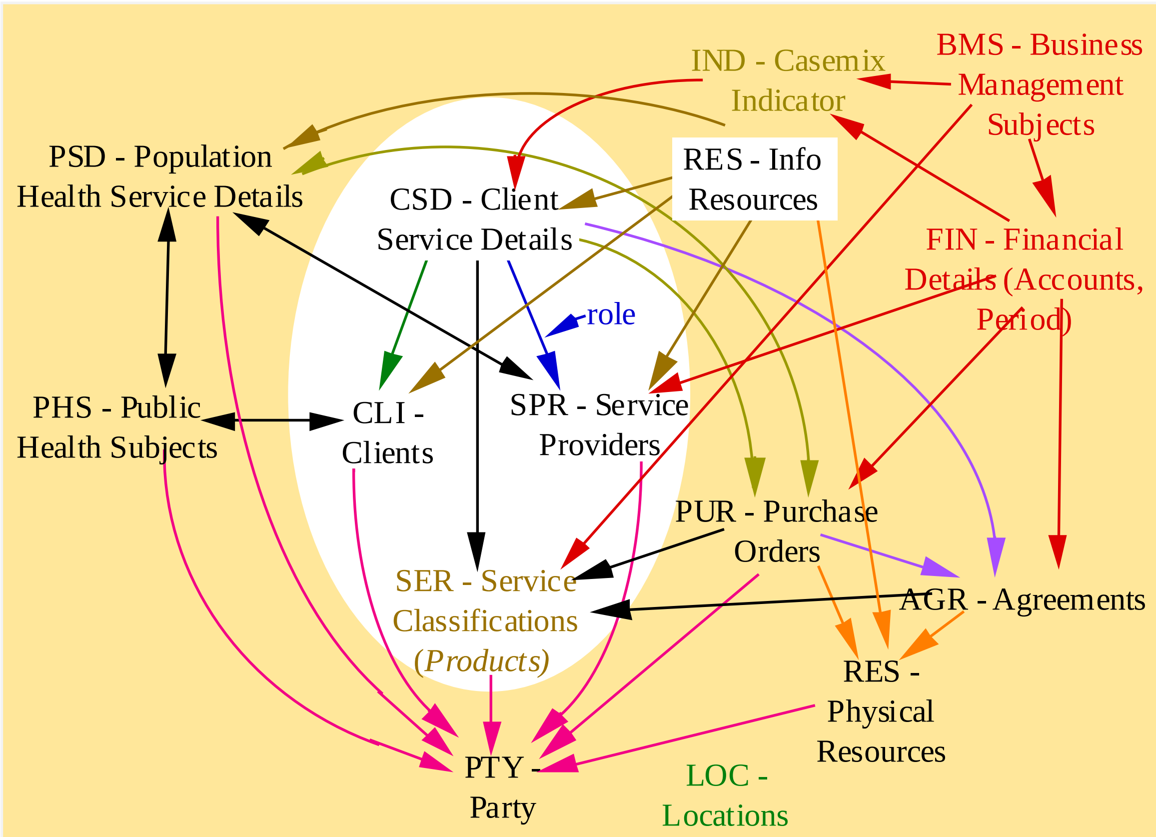

Figure 2. The subject areas of the NSW Health Enterprise Information Model. The arrows roughly represent many-to-one relationships where the arrow head is at the "one" end.

We reveal the analysis by elaborating the NSW Health EIM (displayed at the HIC conference). The re-arrangement of the EIM based on *dependency*[3] is much easier to comprehend. This is because alignment of dependencies, expressed as a lattice, defines context of meaning for each entity.

The advantage of this re-arrangement is suggested in figure 2, which is an abstraction of the EIM based on its subject areas. Of course it is still complicated, but the reader should focus on the core and then consider step by step the surrounding subject areas.

This executive overview shows the function of epidemiology (PSD), financial management (FIN), and health care service classification (SER) around core health care operations.

Health information structures are shown to be an intricate, complex elaboration and monitoring of the relationship between doctor and patient. This is hardly surprising, but the elaboration itself reveals much about health and health information.

[3] At the conceptual level, an entity B depends on an entity A, if the existence of an instance of B requires that an existence of an instance of A. At the physical representation level (within a relational database system) a table representing the entities B has a foreign key which must correspond in value of the primary key of the table representing the entity A. For example in figure 3 a payment depends on a Health care Service and a .

Fibering - compliance between information structures at different levels of specificity: Consider health care services for patients (with care plans coordinated by a GP) carried out by specialist facilities that can provide the service class needed. A health care service is paid by health care funds in accordance with an agreement with the specialist facility for that service class.

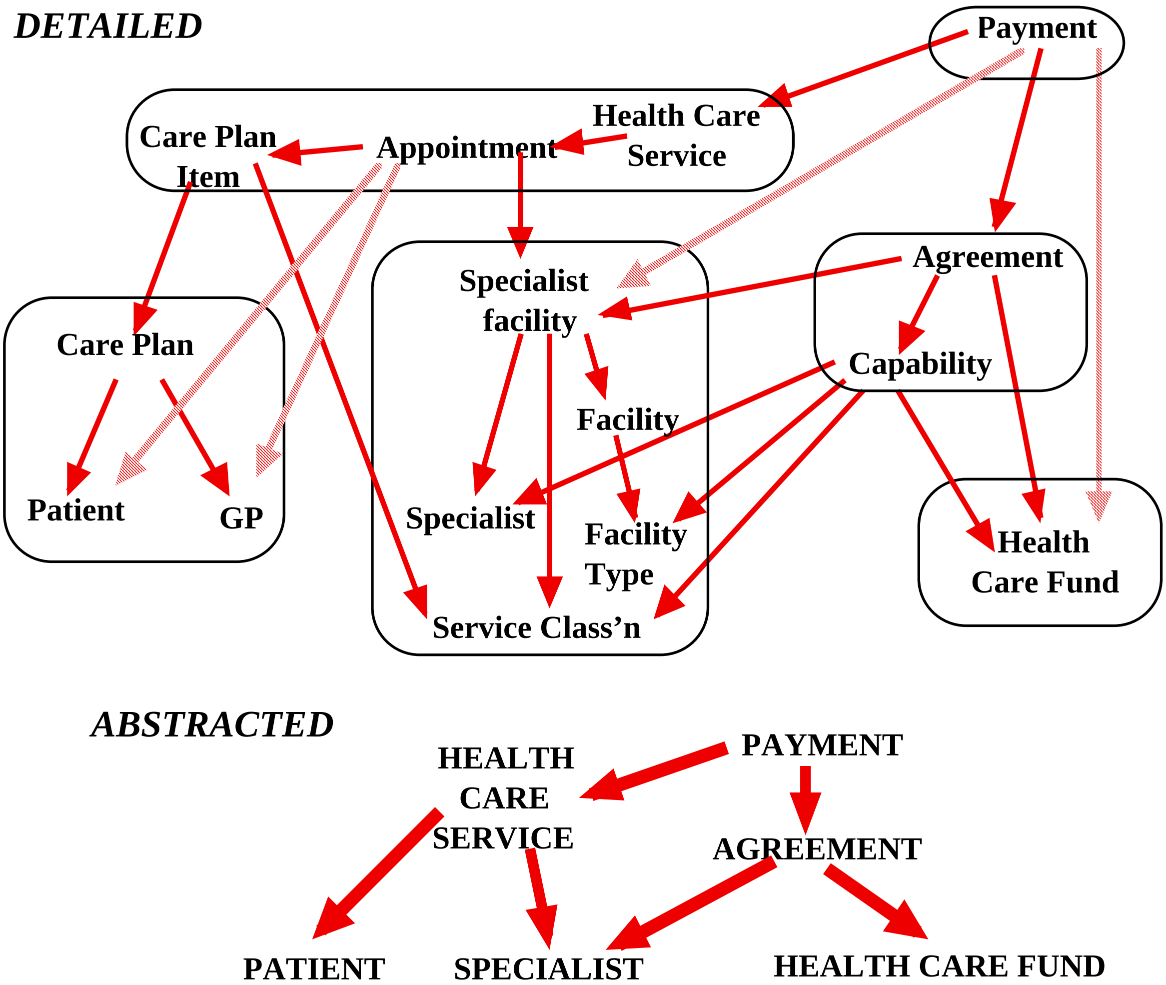

Figure 3. Information models detailed and abstracted levels of specificity for health care services. See text for details. This figure also contains several commuting diagrams, which express consistent dependency (see earlier footnote). Dashed arrows are some of the composite functions.

This is modelled at two levels in figure 3. The arrows are mathematical functions, which represent many-to-one relationships between entities in the detailed model (functors between composite entities in the abstracted model.). The detailed model complies with the abstracted model in the figure via the mappings from the encircled clusters of entities to the composite entities. This correspondence satisfies a category theory construct called *fibration*, which preserves consistent dependency between entities.

In every day terms we can think of the abstracted SPECIALIST as consisting of not only the *specialist* person but also the *facilities* and *classifications* needed to define the relationships that can be more easily represented and understood in detail.

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We can now harmonise between models at different levels. Two kinds of comparison are needed to check compliance: -

- C*onsistent data content*. Ensuring the data definitions used within different models *are consistent in content*. Achieved by use/compliance with a corporate data dictionary

- *Consistent data context as defined by information structure appropriately refined or abstracted Ensuring* that the structural arrangement of data (organised into entities) and their relationships are consistent between systems/models.

Conclusion: The benefits of harmonisation of content (data definition) and context (information structure) against a corporate standard is realised when**:**
- *Interfacing different system (via message flow, procedure calls or shared data)*. Equivalence in source and target systems is identifiable.
- *Acquiring products.* Comparison of the compliance of the structural elements of competing products to a corporate standard provides one method to assess overall suitability.
- *Developing applications*. Reference to a corporate standard, and re-use of a (partial) corporate model, can reduce development effort.
- *Coordination of large-scale disparate projects*. By providing a basis for understanding or recognizing the similarities and differences that exist in the structural components.

As illustrated in this paper, methods based on consistent dependency can be applied to the compliance/harmonisation processes at the structural level. These methods are objective, rigorous and amenable to mathematical processes

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