

A Study of a Health Enterprise Information System

Executive Summary

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Introduction

Health reform is pressuring hospitals, health systems, and physician groups to demonstrate value, not just generate volume and that IT improvement has to be seen as part of that drive. To meet this challenge, all members of the care team will need to break down silos and collaborate more closely than ever before. Building trust with IT services is essential, but at the same time this will not occur without IT staff becoming committed to primarily clinical objectives. Success will require the enthusiastic engagement of physicians through the use of sophisticated CIS in quality improvement — and not just on isolated projects. This next level of interdependence and collaboration — known as clinical integration — is vital to any enterprise seeking improved quality, patient safety, and value. This study analyses the deployment of Firstnet in Emergency Departments from the viewpoints of ED Directors, systems analysts and software engineers and observes that the support needed by the EDs comes up well short of what is needed and that the shortfall is attributable to both the Health Support Services of NSW Health and the technology itself. If this situation is not rectified then the promise of the gains of the IT Age for clinical care will be well and truly squandered.

This document consists of a study, in 9 sections, into the deployment of the Firstnet software in the Departments of Emergency Medicine in New South Wales, Australia. The first section was published in October 2009 and later reissued in November 2009 (Part 1). Seven sections (Parts 2-8) cover work completed in the second half of 2010 and are published here. The ninth and final section captures the context in which this study was completed. It is a summary of five years research into the design and construction of clinical information systems and was published as a conference paper in November 2010¹.

The titles of the 9 sections are:

1. A Critical Essay on the Deployment of an ED Clinical Information System - Systemic Failure or Bad Luck?
2. Discussions with ED Directors: Are we on the right track?
3. Discussions with Software Performance Experts.
4. Conceptual Data Modeling.
5. Database Relational Schema and Data Tables.
6. Coalescing the Analyses of the ER Diagrams, Relational Schemata and Data Tables.
7. The Integrated Assessment.

¹ Patrick, J. Budd, P. Ockham's Razor of Design. Proceedings of the 1st ACM International Health Informatics Symposium, Washington DC. Nov 2010. <http://portal.acm.org/citation.cfm?id=1882998&CFID=116605072&CFTOKEN=43603995>

8. Future HIT Regulation Proposals.

9. Ockham's Razor of Design: An Heuristic for Guiding Design and Development of a Clinical Information Systems Generator.

The 9 separate sections of the study have created some departures from normal editorial practice. Firstly, there is a certain amount of repetition between sections to reduce the level of dependency for the reader to have to read each part consecutively. Second, a literature review of the many topics broached in the study has not been included. This has been deliberate as the focus of the work is to present the experiential practice and real world evidence as the primary artifact of this study.

The primary objective of this study is to present in detail the evidence of the analyses provided in the text, hence it has been divided into a number of separate sections. It achieves this objective in a number of ways.

Firstly, the study includes the direct evidence provided by ED Directors by attaching the full record of discussions in appendices.

Secondly, the layout includes the details of discussions with software performance experts who reveal their perceptions of the difficulties in using the Cerner software and weaknesses in its development approaches. It also captures the primary evidence of the technology design showing diagrams and screenshots of the topics introduced by the discussants.

Thirdly, there are a number of different topics in this study that have not been presented in a single study previously. Together in this study are: discussions with the users, and the analysis of the architecture and internal processing mechanisms of the technology, with the stories of the users to detect if the underlying software design has contributed to the user difficulties.

Fourthly, it presents a set of proposals for regulations that would assist health software purchasers to have more confidence in the quality of the software and that it would more likely be fit-for-purpose.

Fifthly, it offers a proposal for a new type of technology that will in principle solve many of the problems of current enterprise wide software solutions while engaging in the benefits of best-of-breed systems.

A summary of the analyses across the 9 sections of the study demonstrates that the difficulties expressed in Part 1 which covered the first roll-out of the FirstNet technology continued unabated in 2010. The systematic coverage of the experiences of 7 ED Directors shows they are frustrated with the poor performance of the software and its lack of appropriate support for their work practices throughout most aspects of their department's work. They are also frustrated at the loss of reporting functionalities they had in the pre-Firstnet technology that directly reduces the quality of patient care. This function enabled the

Directors to monitor many aspects of the performance of their department and in the review of patient cases. As one Director said:

"The system causes constant frustration and contempt which cannot die down or escape. You can't escape and can't accept it as it is so constant a reminder of its inefficiencies."

The discussion with Directors raised the issues of best-of-breed technologies compared to enterprise wide technology and this is discussed in depth as a demonstrable case for the failure of enterprise wide strategies.

The original study with the Directors received a boost when a team of software performance experts came forward with their experiences in supporting Cerner customers to improve their installations. They shared their experience drawn from assisting many installations overseas on how Cerner applies their technology for their clients (Part 3). The insights provide a unique opportunity to assess software not only from user experiences but also from a software engineering performance perspective.

The software performance experts also provided technical information from a variety of sites where they had worked. This included entity-relationship diagrams, database schema and data tables, which enabled for the first time a detailed analysis of the consistency of conceptual design with logical design with data processing (Parts 4 & 5). This enables a process of checking for weaknesses in stages of the development process and studying the extent to which weaknesses were removed or embedded by the software engineering processes. It is evident that the weaknesses in many cases persisted through the data processing stages so much so that entity integrity and referential integrity were not consistently defined in the conceptual model and appeared not to be fully preserved in the data tables.

The combined analysis of the technology itself raises a serious proposal that organisations need to do a risk assessment of the weaknesses identified in the system and determine the unintended consequences they have for patient safety, outcomes, productivity, and efficiency objectives (Part 6).

The integration of the Directors' commentaries and the technology assessment suggests that many of their issues are foretold by the software experts' analyses. The system's weaknesses can explain a reasonable number of their issues. However there are other issues relating to the strategies for deploying the system that suggest the Health Support Service of NSW Health is greatly wanting in an understanding of systems behaviour and applying appropriate professional IT skills and methods (Parts 1, 2 & 7).

The study draws together the first 7 parts to produce two recommendations. Firstly, a set of appropriate regulations needs to be developed that improves the product quality of the manufacturers so that the clients would be more secure in the nature of the product they are buying (Part 8). Secondly, a new way of thinking is needed about the nature of clinical information systems and how they will serve a complex community with many diverse needs and the software engineering methods that need to go hand-in-hand with development of this new technology (Parts 2 & 9).

Abstracts of Each Section

Part 1.

This essay is about the effectiveness and impact of Cerner FirstNet in NSW hospitals. The need for a systemic study became clear during work that was being undertaken at a number of NSW hospitals when clinicians and administrators constantly expressed their dissatisfaction even hostility to FirstNet, to the point of often refusing to use it. As such, this essay aims at unravelling issues that are obscure and not normally associated so that a clearer picture of relationships and their interactions can be evaluated.

Part 2.

Discussions were held with the Directors of 7 Emergency Departments in New South Wales (NSW) public hospitals assessing the impact of the introduction of the Firstnet information system into their Departments. All but one of the Directors has found that the system has had a deleterious impact on their department's clinical work. The range of problems reported indicate that whilst the software is not fit-for-purpose, many of the problems are created or exacerbated by attitudes of the NSW Health IT support, Health Support Services (HSS). In most departments it was reported that staff have developed significant strategies for minimising and circumventing the use of the system. The Directors are frustrated by the lack of a reporting functionality that disables their ability to monitor their own department's performance. Most Directors report an increase in the time required to deal with patients and therefore a deterioration in access block times. This has been masked by changes in the way this time has been redefined by NSW Health. Overall, most perceive that in moving from their previous information system EDIS to Firstnet they and their patients have suffered. Most Directors are resigned to the fact that no improvements will be made to the current performance of the system due to its inherent inadequacies and the attitude of HSS. A consequence of the ED Directors critique leads inevitably to the debate on the merits of enterprise wide systems versus best-of-breed systems. Emerging from these issues are criteria for a new technology for creating clinical information systems.

Part 3.

Evaluation of Clinical Information Systems (CIS) is usually performed by questionnaires administered to users to assess their level of satisfaction and usability of the system. In the modern enterprise system there is a layer of configuration of the system that requires a great deal of effort to engineer the customer's solution, which has not received scrutiny from researchers. Insight into the critical weaknesses and the consequences of the "configuration programming" of the Cerner Millennium software is provided through discussions with software quality and performance engineers whose job is to remedy the inefficiencies and concomitant insecurities created therein. The difficulties in maintaining Cerner sites for their customers are captured in the issues they have identified as weaknesses in the processing methods for creating a working CIS system.

Part 4.

A set of 6 entity-relationship diagrams representing subsystems of the Cerner Millennium products are analysed for design strengths and weaknesses. The results demonstrate that about 25% of the structures in the diagrams have points of weakness that could lead to errors in database design and programming errors. They also effect the correct storage and retrieval of patient data in a working clinical information system. There is one seemingly serious design weakness where two different important entities, PERSON and PRSNL are given the same primary key, person_id, in the diagrams, yet a putative primary key attribute for PRSNL, prsnl_id, can found throughout the diagrams in foreign key roles and as a compound in other attribute names. The consequences of these weaknesses such as failure to adhere to Entity Integrity and Referential integrity rules are explored.

Part 5.

Ten tables of the relational schema from the Cerner Millenium product are analysed for weaknesses in design and implementation. The design is further assessed by considering the full content of 3 data tables and screenshots of the contents of the 10 tables. The potential consequences of the design weaknesses are described and discussed in terms of their risk for process productivity and institutional outcomes, and maintaining the protection of patient records from unauthorised interference.

Part 6.

Consistent weaknesses in sections of the Millenium clinical information System (CIS) are revealed in the combined study of the ERD, logical schema and the data tables. PK values are not always defined unambiguously at the design level and data tables reveal inconsistencies in declarations and data validation. There is evidence that keys are managed by software within the application rather than by the in-built functions available in the database management system leading to less confidence in data integrity.

Part 7.

Comments from the NSW ED directors combined with the weaknesses identified in the technology, and the commentary of the software performance experts are analysed in an integrated assessment. The aim is to identify the comments which could help in redesigning the system going forward. Drawing all these elements together demonstrates that the range of the problems experienced by the Directors could be due to a combination of factors all exacerbated by the underlying weaknesses. The experts descriptions of the software and the configuration processes suggest this was predictable. User organisations need to make enterprise risk assessments of the software for their patients' safety and outcome and the work processes of their staff, for their current installations or before future purchases.

Part 8.

The regulation of information systems has been resisted by the industry until recently when the American Medical informatics Association called for its introduction in 2010. This paper suggests topics for legislation that emerge from this study. Proposal for regulations about the development of systems includes the exhaustive testing of variable configurations, provision of mechanisms for forensic analysis of program code and a log of the staff who have made changes, provision of bug and error logs with public reporting of their remediation, and validation of primary key and foreign key integrity. Proposals about regulations for the management of data include preserving data in the form in which it is captured, data loading be defined by a formal process and validation strategy with reporting of error rates, validation of data imported from external organisations. The need for effective engagement of users in specification and human factors assessment is also proposed. A Proposal about the removal of the “learned intermediary” defence for software manufacturers is also advocated.

Part 9.

This paper presents a rationale, created from first principles, for the design criteria for the architecture of clinical information systems. The criteria are developed according to the heuristic axiom of Ockham’s Razor, presented here for the first time and operationalised in the form of three principles; Generalization, Minimalization and Coverage. The minimal set of characteristics of the application is defined as – the context, roles of physician, the nature of the data, the business processes, the change management program, and the criteria for success. This set of characteristics is developed to demonstrate how they define the details of a proposed architecture, which can be used to create not a clinical information system (CIS) but a generator of clinical information systems. The generator creates CISs that have the characteristics of complete user control of the design of all input and output presentations and workflow with real-time adaptability, ad hoc analytics with natural language processing of all free-text, all information automatically coded in a lingua franca terminology(s) of clinical choice, and native level interoperability between CISs An example of a CIS generated for the Trauma Service of an Australian hospital is described. The “generative” model is presented as a superset of the strategies for building best-of-breed and enterprise systems and thereby representing a new paradigm in Clinical Information System development. The parsimonious model is demonstrated by creating CISs requiring only 11 objects for designing the users interfaces along with their business logic.