The Aging of a Clinical Information System

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Abstract

The senescence of a clinical information system is more likely to have administrative than technical bases. Supporting this claim is a case study of one aging oncology information system. The case study is qualitative, as behooves the subject matter. Content analysis of several documents suggests that the change in job description of the data coordinator led to a workflow breakdown. Next, twenty-two individuals were interviewed. Notes from the interviews were coded, and the resulting patterns led to

- partial support for the workflow breakdown conjecture,
- refutation of the hypothesis that users disliked the character-based, human-computer interface,
- support of the conjecture that political rather than technical factors drive the usage patterns of the system, and
- evidence that 'political' activity will determine the future of the information system.

A stakeholder matrix is proposed that addresses administrative concerns. Also, the issue of the uniqueness of any oncology clinical information system is linked to the plans for this legacy system.

Keywords: clinical information system; software life cycle; legacy; oncology; retirement; workflow management; human-computer interface; stakeholder matrix; administration; politics

1 Introduction

Lemaitre et al [1] said: "Legacy systems are crucial for organizations …. But they become obsolete with aging …. Managing their evolution is a key issue in software engineering." A legacy oncology information system for patient care (hereafter referred to as OS) will be examined. The administrators for OS worry that OS is outdated and do not know to what extent to invest in software revisions to OS or in replacements for OS. They are uncertain as to how to assess the utility of a legacy system, and since the workflow of the cancer center is intimately connected to OS, the administrators are worried about disruption to workflow. Because of the political sensitivity of the issues surrounding OS's current state, references that would uniquely identify it have been removed from this manuscript.

OS was developed many years ago at the Cancer Center, and since then has been the dominant information system in the Cancer Center. In OS's early years computer systems for comprehensive support of clinical care were novel, and OS was a major success. However, maintaining a 'home-grown' system for one institution is expensive, and in health care the trend is towards acquiring commercial systems rather than tailoring in-house systems [2]. The Cancer Center faces pressure to replace OS with commercial systems. Issues relevant to the aging of OS include

- workflow,
- the software life cycle, and
- legacy systems,

and these issues are addressed next.

The majority of health care information system implementations are failures [3]. The advice provided decades earlier by Barnett [4] remains applicable today, namely, the system must be:

- carefully attuned to the needs of its users,
- fit gracefully into the workflow of those who are expected to use it, and
- show clear benefits to its usage.

The perspective of workflow has become increasingly important over the last few decades [5].

A survey of 216 hospitals reveals that most hospitals follow the traditional systems development life cycle [6]. The traditional software life cycle defined in ISO 12207 begins with requirements capture and ends with retirement [7], but research virtually ignores the retirement phase. In fact, some health care information systems experts do not include 'retirement' or 'senescence' in the description of the life cycle [8].

Each phase of the software life cycle is substantially impacted by a large variety of factors [9], and as the software process moves into the retirement phase the complexity of factors that impinge on the process is great and the process tends to leave the domain of the engineer [10].

A search on MEDLINE in January 2004 with the phrase "legacy information systems" retrieved 115 articles. Many are about designing new systems that integrate fragmented legacy systems [11], tools for integrating across legacy applications [12, 13] or using standards-based solutions [14, 15]. One assessment of a legacy system noted the importance of subjective or qualitative methods versus objective or quantitative methods [16]:

> Health care information systems (IS) cannot be treated purely from the objectivist perspective … the perception of health care IS will always involve an element of aesthetics, politics and sociology … The provision of an evaluation framework which takes account of these factors is important in the move towards professionalism in medical informatics.

The relevance of qualitative methods to complex problems involving human organizations is well documented [17]. The next section describes a qualitative content analysis of existing documents about OS. After that, the results of interviews with stakeholders are presented.

2 Content Analysis

Based on the qualitative analysis of multiple documents, insight will be gained as to the evolution of OS. These documents including the following five:

- A 100,000-word document written in the 1980s that describes OS (call this DOC1),
- A 50,000-word user manual from the 1990s (DOC2),
- A functional review (about 10,000 words) of OS done in 2002 (call this DOC3),
- A 10,000-word audit of OS done in 2002 (call this DOC4), and
- A 500-word job description for a data coordinator written in 2003 (call this DOC5).

DOC1 describes the administrative and technical genesis of OS, its functionality, and user acceptance. OS was developed to meet the vision of a new kind of clinical information system that would support doctors in decision-making by storing and displaying data trends. The assessment of OS in DOC1 was positive. Given the

technical constraints of the 1980s, output to users was only on paper and professional data coordinators did all data entry.

The data coordinator

- had a comprehensive knowledge of the capabilities and limitations of the OS applications and
- was knowledgeable and experienced in medicine and health care delivery.

Furthermore, the data coordinators attended daily rounds and were active participants in the care giving team. With this background, the data coordinator was well situated to

- enter clinically meaningful data about the patient into OS,
- provide reports for the clinicians that took advantage of the best retrieval and formatting capabilities of OS, and
- work with the OS programming staff to add functionalitym, if OS was not currently supporting the type of data retrieval or report that the clinician should have..

By assuming these responsibilities, the data coordinator eliminated the need for any other member of the clinical team to enter data into OS. The physicians and nurses typically operated in read-only mode.

In successful organizational systems, a 'socio-technical' facilitator role is considered vital [18]. The socio-technical facilitator is knowledgeable in both the human and computer aspects of the organization and works with people to help them take advantage of the computer. Based on DOC1, the socio-technical facilitator role for OS was played by the data coordinator. If subsequently the users of OS became alienated from OS, then one can hypothesize that a breakdown in the role of the data coordinators occurred.

The functionality of OS described in DOC2, DOC3, and DOC4 is in many ways the same as in DOC1. However, positive comments about the utility and cost-effectiveness of OS that were in DOC1 are missing in these newer documents. Screens are still character based, but the role of the data coordinator has markedly changed. The data coordinator no longer does rounds with the physicians nor is expected to have any medical training. A data coordinator with the outpatient unit spends most of her day typing laboratory values from outside laboratories into OS. The data coordinators are no longer socio-technical facilitators.

Why did the data coordinator become a data entry clerk? OS was originally funded by a grant through the physician side of the cancer center. Subsequently, the maintenance costs of OS were covered by funds from the administrative side of the health system which is responsible for billing for hospital services (not physician services) and for paying all staff other than physicians. The activity of a data entry clerk leads to bills to send to the health insurance companies that generate more income than the salary of the data entry clerk. However, the benefits of the salary for data coordinators do not as directly correspond to income that the administrative side of the health care system sees. This salary/income relationship may have driven the change in the data coordinator position. At the same time that the management of the hospital was changing the role of the data coordinator, in the broader environment data entry was ‘less and less’ done by data entry clerks and ‘more and more’ captured by the computer system at the point of data generation.

3 Interviews

To gain further insight about the challenges and opportunities with OS, interviews were conducted. Twenty-two people were interviewed. Each person was significant for his or her role in the organization. Most of the people who were interviewed filled roles that are indicated in italics in Figure 1.

The interviews were loosely structured. Generally, an effort was made to understand for each interviewee

- how OS was used,
- what was liked and disliked about OS,
- how OS had changed over time, and
- what changes in OS should occur next.

No recording was done during the interviews, but after each interview the interviewer made extensive notes about what the interviewee had said.

After all the interviews were completed, the data was coded. Approximately 200 logical propositions, such as the proposition "ROLE data coordinator FUNCTION rounding wards TIME past", were constructed from the coded data.

The interviews confirmed what was detected in the content analysis of OS documents. Namely, the data coordinators stopped rounding wards and stopped helping physicians with their research needs. In the interviews (and consistent with the earlier 'content analysis') the change in data coordinator role was attributed to the change in funding of OS and the financial pressure to increase billing. However, the data coordinator role change was not seen by any interviewees as a reversible change.

Several administrators said that the primary problem with OS is that its interface is outdated. However, only one person who used OS to do his or her daily tasks was dissatisfied with the interface. New clerks trained in the use of OS immediately adapted and had essentially no complaints about the system interface.

An intriguing pattern in the interview data was the distribution of OS usage across administrative units:

- In the inpatient unit, OS is almost never used.
- In the radiation oncology unit and in the satellite, ambulatory medical unit, OS is used for scheduling and to store and retrieve some laboratory values.
- In the central, ambulatory, medical oncology unit, OS is used extensively.

Many roles (including physician, nurse, receptionist, referral clerk, and phlebotomist) in diverse ambulatory settings (medical specialty or radiation specialty and central or satellite location) use the OS scheduling function. Pharmacists at the central location use no functions of OS, whereas pharmacists at the satellite medical oncology clinic depend almost entirely on OS for computer support.

How are 'Role', 'Location', 'Administrative Unit', and 'OS Usage' related? Retracing the history, one sees a pattern:

- Early in its history OS included pharmacy functionality and was used throughout the cancer center pharmacy units. Administrators favoring the hospital pharmacy information system subsequently lobbied successfully to have OS in the central oncology pharmacy units replaced with the hospital pharmacy system. However, the satellite oncology unit retained its autonomy and continues to use OS for its pharmacy information system.

- At one time, when retaining inpatient nurses was particularly critical to the central administrators, they purchased a new, commercial system to support inpatient nursing and replace OS.

This historical interpretation shows that negotiations among administrators can strongly influence the pattern of usage of an information system.

Fortunately, this study had access to people who created OS, as well as the current leadership. The propositions distilled from their interviews are recast here:

- The founding medical creator of OS said that the past vision was clear but the current vision is unclear, and a healthy future for OS depends on a clear vision. As regards the pragmatics of getting a relevant vision accepted and OS maintained adequately, the medical creator said that the leadership of OS should return to the physician-oriented roots of OS and gain the financial support of the physician side of the health system.
- The founding technical creator of OS said that OS was unique and served the cancer center better than any commercial system could. However, he added that repeatedly there is a struggle between the central (health system) administrators and the departmental (oncology center) administrators for control of vision and resources. He said that the future of OS depends on the Director of OS being able to keep OS within the control of the oncology center and not under the control of the health system.
- The Director of Ambulatory Nursing said that OS is good and should be retained but its interface improved. She also said that the administrative 'give and take' across

the various stakeholders in the health system would determine the future of OS and that currently OS was losing resources.

- The Cancer Center Chief Administrator said that maintaining OS has become too costly (about $2 million per year) and that software from the hospital or elsewhere should replace OS wherever practical.
- The OS Programming Director said that technically OS well serves the Cancer Center and can be improved as needed, but that the future of OS is a political matter and that OS supporters are currently losing the political battles.

The majority of interviewed leaders said that politics (in the sense of intrigue or maneuvering within an organization) would determine the future of OS. Politics is also known to influence decisions about technical issues in other health care environments [19].

4 Discussion

A few studies in requirements engineering reveal the importance of political activities in software development. For instance, Bergman et al [20] say: "Large-scale system requirements are constructed through a political decision process…." The challenges to successful software requirements development may apply also to the retirement phase of the software life cycle. In other words, political struggles in the organization will influence the future of a large, legacy system.

The Bergman et al case study [20] was done at the National Aeronautics and Space Administration's Jet Propulsion Laboratory (JPL), and JPL has special characteristics not necessarily present at a health center. In particular, at JPL promotion from the technical

to the project level or from the project level to the organizational level requires expertise at the preceding level. In other words, everyone at the project or organizational level was previously a technical expert. Such omnipresent technical expertise puts negotiation at a certain common level. However, the project and organizational individuals with influence over the retirement of OS are not necessarily technically expert. The absence of a common technical base would put increased reliance on political factors for determining the fate of a software system.

A stakeholder matrix is next recommended that might help an analyst collect non-technical information about the likely future of an information system. A traditional stakeholder matrix [21] would have stakeholders on one axis and topics on the other axis, as follows:

- stakeholders: physicians, nurses, ancillary staff, administrators, and system developers and
- topics: direct effects on patient care, impact on the health care process, usability, integration, and cost effectiveness.

To modify this matrix in accord with the experience at OS, different questions are recommended for two kinds of roles. For roles that perform largely routine tasks or have little or no supervisory responsibility, such as a receptionist, the people filling the roles may tend to have a narrow view of the issues. Questions to them would be largely restricted to topics regarding their own performance of tasks on the system, and the analyst would more or less be soliciting functional requirements. For leaders the questions would be more far reaching and would address for the system:

- history,

- vision,
- resources,
- politics, and
- next steps.

A systematic method of documenting and communicating the leaders' responses to the interview questions might become part of the health system's process for developing a consensus about what to do with its legacy information system.

While one might accept that decisions about the retirement of a cancer center information system are political, an unresolved question is hauntingly relevant: Does a cancer center need cancer-specific software? If the answer is no, then the arguments for replacing OS with generic parts are strengthened. Addressing the question entails considering these complicating factors:

- A cancer center may be a stand-alone organization that must have its own information system or may be part of a larger organization that provides a system.
- Generic health information software that accesses a database with cancer-specific data may function no differently than software built specifically for cancer.

Several interviewees were asked whether they thought a cancer center that was part of a large health care system needed unique clinical software. They said that while dealing with repeated patient visits and complex treatments is important for a cancer center, treating other life-threatening, chronic diseases requires the same kind of information system. However, the interviewees also said that no existing systems are adequate. Future research might delineate the extent to which a given medical specialty has special information system requirements.

5 Conclusions

An oncology clinical information system (called here OS) that was developed decades ago at a cancer center is in trouble. The senior administrators of the cancer center and the health system are questioning whether to continue to invest in upgrading OS or to retire as much of the system as possible and instead use 'off-the-shelf' software. However, these administrators are unclear as to what to do next. This research was part of the solution to the problem of what to do next.

A content analysis of existing documents about OS revealed a historical sequence of events that is hypothesized to be a key to some of the malcontent over the current performance of OS:

- OS was initially funded by the physician-side of the health system and focused on serving physicians by supporting data trending.
- Subsequent financial support for OS came from the non-physician side of the health system which demanded a focus on non-physician billing.
- Data coordinators were a key component of the staff initially and did rounds daily with physicians, as they helped physicians provide pertinent data to OS and retrieve the data trends that the physicians wanted. (This role could be called a social-technical facilitator role).
- Through time the role of the data coordinators was changed to that of data entry clerks and no other role was assigned their 'social-technical facilitator' functions.

The evolution of the role of the data coordinator from a socio-technical facilitator to a data entry clerk was confirmed in interviews. However, no one is again prepared to finance data coordinators as socio-technical facilitators.

The interviewed leadership said that vision and politics would determine OS's future. The traditional stakeholder matrix for the software life cycle might have missed this important observation. Two stakeholder matrices are proposed:

- One for non-supervisory staff is designed to collect functional requirements and
- One for leaders is designed to support organization-wide decisions about the system.

The leader's matrix asks about history, vision, resources, and politics. This study of a legacy, oncology clinical information system has highlighted that vision and politics play an important role in shaping decisions about whether to modify or replace a legacy system.

6 Figures

Figure 1: Role Hierarchy. The hierarchical relation is ‘reports-to’. The people who were interviewed filled roles that are indicated in italics. At least one level of detail is omitted; for instance, ambulatory care occurs at two, geographically-separated locations and nurses and clerks at both locations were interviewed.

Chief Executive Cancer Center
- *Chief Administrator*
- *Director OS*
  - *Programming Director*
    - *Programmer*
  - *Chief Data Coordinator*
- Medical Director
  - *Medical Director, Ambulatory*
    - *Nurse Director, Ambulatory*
      - *Ambulatory Nurse*
      - *Phlebotomist*
      - *Referral clerk*
      - *Registration clerk*
    - *Physician*
    - Medical Director, Inpatient
      - *Inpatient Nurse*
- *Pharmacist*

CIO Health System
- *Director Clinical Systems*

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