MEDINFO 2004
M. Fieschi et al. (Eds)
Amsterdam: IOS Press

Integration Models in Health Information Systems: Experiences from the PlugIT Project

Juha Mykkänen[a], Jari Porrasmaa[a], Mikko Korpela[a], Heidi Häkkinen[b], Marika Toivanen[c], Mika Tuomainen[d], Kristiina Häyrinen[b], Juha Rannanheimo[d]

[a]HIS R & D Unit, Computing Centre, University of Kuopio, Finland
[b]Shiftec, Department of Health Policy and Management, University of Kuopio, Finland
[c]Department of Computer Science, University of Kuopio, Finland
[d]School of Business and Administration, Savonia Polytechnic, Kuopio, Finland

Abstract

Different approaches are available for the integration of existing health information systems (HIS) in integration projects. Within the PlugIT project in Finland, we have found it necessary to design and implement integration in a collaborative, multidisciplinary and open way. In this paper, we use some generic integration models and relate them to the methods, solutions and experiences of the project. We summarize the results from nine integration teams, methods development and supporting surveys and studies, and discuss these experiences to provide some guidelines for the HIS integration projects in general.

Keywords:

Health information systems, Systems integration, Software design, Hospital information systems

Introduction

The integration of health information systems (HIS) is a combination of problems, where each organization has its own set of issues which must be dealt with. The integration of diverse data and systems is required in order to evolve HIS towards a more integrated health environment both for professionals and patients. Evolutionary and participatory software design processes are needed in order to achieve these goals [1].

Integration projects and standardization efforts in HIS have been mainly focused on the exchange of relevant data between the heterogeneous systems or interface definitions [2,3]. Integration standards, typically, leave many aspects of interoperability to be solved on a project-by-project basis [4]. The heterogeneity of the existing applications or legacy systems and the lack of unifying architectures or platforms for the integration are common in the HIS integration [3]. Many integration projects produce product-specific or organization-specific solutions, which can not be reused without a considerable amount of extra work and cost.

The objective of this study is to highlight issues and to give an overview of our approach for improving the reusability and moving towards interface-based and component-based HIS in a heterogeneous systems environment. We discuss the integration methods used and developed in the PlugIT project in Finland, introduce the most relevant experiences, and relate them to different models for integration solutions.

Materials & Methods

Classifying integration solutions and approaches

In this study, we adapt the categories of Enterprise Application Integration (EAI) solution models in [2]: information-, service-, process- and user-oriented integration. In general, one of the approaches is the most evident in one integration solution, but each integration problem can often be solved also by using different models.

The information-oriented integration approaches integration problems through information exchange, and databases and APIs that produce information are the primary points of integration. This approach has many advantages: source and target systems need only a few changes; state, logic and sequence do not need to be considered; and the approach is simple and widely used. The examples of information-oriented approaches in healthcare include the use of HL7, EDIFACT or DICOM messages and HL7 CDA documents. In advanced integration, semantics, data types and metadata management are also considered [5].

The process-oriented integration produces a layer of defined and centrally managed processes on top of existing processes. The goal is to combine relevant processes to support the flow of information and control logic between them. The solutions often include flexible middleware such as integration servers or distributed objects. The definition and understanding of the processes in the organization or the community are needed to produce process-oriented solutions. IHE integration profiles [6] are an example of process-oriented integration definition in healthcare.

The service-oriented integration allows applications to share common business logic or methods. This is accomplished by defining shared methods and by providing the infrastructure or middleware for such sharing. A common set of methods promotes reuse, reduces the need for replicating methods and data in several applications [2], and enables information-oriented and process-oriented integration by providing the required infrastructure. The Object Management Group (OMG) Healthcare specifications (*e.g.* PIDS, TQS) [7] and common services of the PICNIC project [5] are examples of service-oriented integration in healthcare. Service-oriented integration solutions, however,

often require changes in applications such as adaptation into the common infrastructure, which is often problematic especially in legacy systems.

The user-oriented integration (portal-oriented [2]) allows the user to gain a consistent view of a multitude of systems. This can be accomplished by using a unifying front-end system or by synchronizing the various applications on the user workstation. This approach focuses on the single-user aspects of the system, and the applications may not be directly integrated on data or service level. The examples of user-oriented integration solutions include healthcare portals and the CCOW context management standard from HL7 [8].

Another differentiator between integration approaches is whether to use a top-down or a bottom-up process for the definition of the integration solution. In the *top-down* approach, the starting point is an open standard or a readily-given specification, to which the solution must conform to. In the *bottom-up* approach, the solution is initiated from practical high-priority needs or a single bilateral or application-specific solution, which is generalized to make it more reusable and applicable in different situations.

The PlugIT project

The aim of the PlugIT project is to decrease the introduction threshold of healthcare applications by developing efficient, practical and open solutions for integration. This is pursued by collaboratively producing *open and reusable integration solution specifications and application interfaces* and by developing and selecting *methods and tools for specifying and implementing* application integration. The project involves four research groups, six hospital districts, two municipalities and 15 software companies in Finland.

We have used a collaborative process (see Figure 1, [9]) to produce integration specifications and approaches. In the tripartite collaboration, health service providers (health professionals and *e.g.* hospital IT departments), software vendors (also competitors), and a multidisciplinary research group (moderator) are involved in each identified integration domain. We also use a specific process for the solution specification phase [3]. In this phase, we consider existing applications, standards and new technologies, and the requirements and process improvement needs of the participants. The aim is to produce solutions for several *interoperability levels*, including interface technology, functionality, data contents, semantics and application architecture [4]. As a result, reusable specifications with distinct goals and audiences are produced on incremental *documentation levels*: requirements, platform-independent and technology-specific interfaces [9]. The specifications are evaluated and harmonized collaboratively, and implemented in pilot projects in existing application products. The integration process incorporates features from different integration models, including understanding and description of the processes in health environment and specification of information contents, application services and user interaction in the solutions.

Thirteen integration domains have been selected, prioritized and grouped during the project, and the work has been transferred to nine teams with responsibility of one or more integration domains. *Common core services* [10] include eight domains and separate teams for:

- *user* and *access* management,
- *patient* and *clinical information* access,
- *code sets* and *organizational structures*,
- *billing* interfaces, and
- *electronic patient record (EPR) archive* interface.

One visual integration team considers two domains: *clinical context integration on server and workstation* level [11] and *context-aware application invocations*. There are also two teams developing methods for specific subdomain requirements: *maternity care* service chain and *home care* work and interoperability improvement with *e.g.* mobile technologies [12]. One team also specifies a template of point-to-point component integration in specialized *order entry* (gastroscopy - pathology).

The main approach in the common core services is service-based. In the visual integration team, user-oriented integration solutions are specified. The order entry component team focuses on information sharing. The home care and maternity care teams are focused on providing clearer understanding of and requirements for the processes of these underspecified IS areas and related methods.

The specifications have been produced in several discussions, workshops and meetings with the participants. A joint group of teams has also been formed for the method and solution repository development and evaluation. In addition to the specified processes and documentation levels, several supporting assets for the specification work have been developed. These include *a study of current status* of software development process, tools, infrastructure and integration needs in Finnish healthcare applications, and studies of *component and service technology families* and tools for building and integrating HIS. Several reference implementations have been built to help the evaluation of standards and tools in relation to the participating products. We have also developed a framework for the evaluation and selection of various health-care specific and technology standards, and produced evaluations of them.

Some characteristics of the PlugIT project also affect the results. The project focuses on application "clusters" within healthcare organizations to provide *a more coherent application environment for the health professionals*. Thus, the distribution and network security issues are not as central as *e.g.* in regional integration. In addition, the aim is to produce reusable solutions *and* methods for future integration projects. Thus, the documentation and evaluation of these solutions are added to the total effort of the teams.

Results: summary of the integration teams

All the integration teams have produced open specifications. Some teams were to produce a set of subdomain requirements only, whereas others produced all the defined documentation levels. The speed and technology level of the produced open specifications depended heavily on whether they were initiated from the existing application-level needs or from the needs for understanding the processes and core activities in the domain.

Team-specific and group-specific experiences are summarized in Table 1. The integration teams are grouped based on their primary integration model. The top-down and bottom-up approaches were applied simultaneously in many teams. There were also differences in originators of the integration needs and the types of requirements. Different integration models produced different types of integration specifications. Though a common process, documentation levels and guidelines were used, they were applied differently according to the domain requirements. Standards in different teams reflected the underlying integration model of the standard. The choices, benefits and challenges in most cases follow those of the integration model: however, the difficulty of mediation between the top-down and bottom-up approaches is especially evident in challenges encountered. On the technology level, application adapters, services and web-based technologies were seen as the most significant areas of improvement in integration. Additional collective results are presented in the discussion section.

Discussion: Guidelines for integration projects

The experiences of using the collaborative and incremental integration process in the teams of the PlugIT project provide some basic rules for future integration projects.

Integration specification and implementation

Integration requirements must be the basis for the design decisions. The *knowledge of the integration domain* is imperative in the design of the solutions, as they change the existing work processes. It is useful to *identify the most urgent integration needs* from a set of requirements, and use an *incremental approach* to first satisfy these requirements. More requirements can be added on the subsequent versions and iterations of the process. In one visual integration domain, for example, only the synchronization of user and patient contexts were included in the first specification, and additional contexts and network security were added to the second version. We found that this approach supports *stepwise refinement* from the requirements to the solution specification and implementation, but requires prioritization and congruence with the scope of the first solution. Iteration, however, can not be easily planned in multilateral and open projects in a changing environment, and it did not occur as much and as quickly as was expected.

Open integration specification and pilot implementations should be distinguished, although they are interrelated. This prevents dependencies and waiting times between related projects. The step *from open specification to product-specific or site-specific implementation must provide some extra benefit* to the participants, who usually have other duties in addition to the integration project. A contract between the health service provider and system providers is often needed for this purpose. The *competitive edge* in products must be steadily protected.

Studies and comparisons of standards, technologies and their *effects on several interoperability levels* should be provided by the moderator, as *health service providers and application developers do not have the required time or other resources* to evaluate these aspects in detail. The *guidelines, examples and reference implementations* provided by moderators ease and accelerate the integration.

New technologies, tools and integration approaches *should be introduced cautiously* and justifiably, and *migration paths* should be defined for organizations and applications.

Standards and product-specific conventions

The experiences gained from studying and applying open standards point out several important points for integration projects. *Domain-specific standards* should be implemented with or be based on domain-independent technologies and infrastructure. Each standard covers only some aspects of the final solution. *The certification* of solutions against open specifications is necessary for validating them. In addition to standards, the functionality, architecture and technologies of the *existing applications* must be considered in order to produce realistic solutions with an acceptable introduction threshold. Standards and *standard families are seldom compatible* with each other or the existing applications. They differ in integration models and consequences beyond their main scope on several interoperability levels [3].

The *generalization* of bilateral solutions into open, reusable specifications (bottom-up) is pursued by discussing application roles or actors [6] instead of products. Analysis of the current status is separated from the design and implementation. Distinct specification levels allow the specification of same platform-independent interfaces using several interface technologies, and implementation of interfaces in several products. Solutions require the parallel consideration of standards (top-down) and conventions in existing systems (bottom-up). Open technologies and the separation of data and functionality in interfaces produce flexibility in solutions. The single most effective activity to ensure open integration solutions is the introduction of acceptance and harmonization (standardization) process.

Multilateral collaboration in integration projects

Almost all teams encountered challenges in multilateral communication and coordination. The nature of integration projects (openness and the lack of central management) calls for negotiation skills and agreements. The different *skillsets of the participants* (*e.g.* health professionals, IT experts) must be acknowledged, and common language, training and concept models developed. *Guidelines for the management of multilateral projects* (see Figure 1) are also needed. After *manager-level commitment*, the participants must achieve an *agreement on the requirements, resources and timetable* of the project. We used a model where *a neutral moderator* involves named experts from all the participating organizations. The *participants must be authorized* to agree on several solution details and be *committed to and available* for the project. Solution *deployment, maintenance and ownership* issues must be addressed early in the process. Pilots and implementations must *benefit all the participating organizations* (*e.g.* time-to-market, cost reduction, increased level of reuse, workflow and usability improvements).

We found the methods developed in the project applicable to both open and point-to-point integration. The balance between different integration models and between the top-down and bottom-up approaches requires special attention. The reusability

and openness goals often collide with the requirements for fast implementation and introduction. The would-be impact of the solutions on existing processes is not always evident, including situations where applications already contain the required features. For this reason, special attention should be paid to the understanding of the domain and process improvement. Our approach is best suited for service-oriented (interface- and component-based) solutions. We are specializing the methods for different integration models, and further developing the detailed guidelines for the integration phases. To a large extent, our approach is also applicable outside the healthcare domain.

Conclusions

It is practically impossible to find a single technological solution set that can be universally applied for HIS integration. Integration projects need to identify and combine various integration models to choose the right approach and the suitable set of standards, technologies and tools, and also address human and organizational factors. While information-oriented and document-oriented solutions remain common and suitable for many requirements, more "pluggable" solutions can be expected only when service- based and component-based solutions become common.

Acknowledgements

This paper is based on research in the PlugIT project (2001-2004), funded by the National Technology Agency TEKES grants no. 40664/01 and 40246/02, together with a consortium of software companies and hospitals. The authors thank all the team members and project participants.

References

[1] Giuse DA, Kuhn KA. Health information systems challenges: the Heidelberg conference and the future. *Int J Med Inf* 2003:69 (1):105-114.

[2] Linthicum D. Leveraging the heritage – Approaches to Integrating Established Information Systems. Intelligent EAI, April 15, 2003. CMP Media LLC, 2003.

[3] Mykkänen J, Porrasmaa J, Rannanheimo J, and Korpela M. A process for specifying integration for multi-tier applications in healthcare. *Int J Med Inf* 2003:70 (2-3):173-182.

[4] Herzum P and Sims O. *Business Component Factory*. New York: Wiley Computer Publishing, 2000.

[5] Bruun-Rasmussen M, Bernstein K, and Chronaki C. Collaboration – A new IT-service in the next generation of regional healthcare networks. *Int J Med Inf* 2003:70 (2-3):205-214.

[6] HIMSS, RSNA. Integrating the Healthcare Enterprise - IHE Technical Framework Volume I - Integration Profiles, Revision 5.3. HIMSS/RSNA; 2002.

[7] CORBAmed Roadmap. OMG Document CORBAmed/ 2000-05-01 Version 2.0 (draft). CORBAmed, 2000.

[8] Seliger R, and Royer B. HL7 Context Management "CCOW" Standard: Technology- and Subject-Independent Component Architecture, Version 1.4. Health Level Seven, 2002.

[9] Mykkänen J, Tikkanen T, Rannanheimo J, Eerola A, and Korpela M. Specification Levels and Collaborative Definition for the Integration of Health Information Systems. In: Baud R, Fieschi M, Le Beux P, Ruch P, eds. *The new navigators: from Professionals to Patients. Proceedings of MIE2003.* Amsterdam: IOS, 2003: pp. 304-9.

[10]Porrasmaa J, Mykkänen J, Savolainen S, Korpela M, Sormunen M, Riekkinen A, Jäntti M, Silvennoinen R, and Rannanheimo J. Common core service interfaces: applicability of international standards to existing healthcare software in Finland. Poster, *Medinfo 2004*, Accepted.

[11]Tuomainen M, Mykkänen J, Rannanheimo J, Komulainen A, and Korpela M. User-driven Clinical Context Management with Low Implementation Threshold. Poster, *Medinfo 2004*, Accepted.

[12]Toivanen M, Häkkinen H, Eerola A, Korpela M, and Mursu A. Gathering, Structuring and Describing Information Needs in Home Care: A Method for Requirements Exploration in a "Gray Area". *Medinfo 2004*, Accepted.

Address for correspondence

Juha Mykkänen
Computing Centre, HIS R & D Unit
University of Kuopio
P.O.B. 1627, Fin-70211 Kuopio, Finland
juha.mykkanen@uku.fi