

ON INFORMATION SYSTEM INTEGRATION IN HOSPITALS: A QUANTITATIVE SURVEY

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Abstract

Communication among information systems in hospitals is essential for smooth IT supported processes in medical treatment. This work deals with the practical relevance of integration concepts in hospitals and their technological and organizational challenges. The quantitative online survey among hospital IT managers in Germany, Austria and Switzerland showed that inefficient point-to-point integration architectures are still present but might be replaced by modern middleware products in central enterprise application integration and distributed service-oriented architecture approaches.

Keywords – Hospital information system, System integration architectures, Quantitative survey, Communication server

1. Introduction and motivation

Information technology (IT) is playing an important role in medicine and eHealth. Information systems (IS) are a valuable key to success in management of data and information flood in hospitals [1]. The high number of IS that are present in clinical departments of hospitals at the moment seconds that trend. These extremely specific so-called “best-of-breed” IS inherently construct a heterogeneous IT system landscape within an organization. A study conducted 2010 by the German Bundesverband Gesundheits-IT [2] yields that hospitals are increasingly complementing rather than substituting their existing IT systems. As a result, heterogeneity of their system landscapes will continue to be on the rise.

Integration of independent systems enables point-of-care treatment by providing consistent information throughout the healthcare enterprise and avoids media breaks in documentation processes. Additionally it has been a proven concept to protect the investments in IT of an organization by keeping legacy systems alongside new technologies [4, 9]. These goals are achieved by using a variety of integration methods and architectures such as simple point-to-point coupling (PTP), or more sophisticated architectures like enterprise application integration (EAI) and service-oriented architectures (SOA) [11]. PTP may be useful when a limited amount of applications or systems have to be integrated. It does not involve any kind of mediation platform (middleware or communication server) but each system implements communication connections by itself. If one has n systems, this may result in a complex network of inflexible communication channels, requiring $n(n-1)$ interfaces to be implemented when fully connected. EAI and SOA approaches exploit middleware which provides centralized, scalable and extensible communication

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capabilities among heterogeneous systems. The main difference between them is that EAI follows a central (hub/spoke architecture) and SOA a distributed approach (bus architecture) [8]. A lot of integration strategies and models are available to choose from [5, 10], each suited for a very specific integration problem. The vast potential of systems integration is revealed if they are used in combination. Mostly there is not the “one-and-only” middleware tool which solves integration problems in an organization [8]. Similar to the previously mentioned supplementation of existing IT systems, integration software may be used simultaneously in order to tackle an organization’s integration problems. One has to bear in mind that not only technical feasibility but also restructuring of workflows is essential for successful integration and requires expertise [10, 11]. The great variety of theoretic concepts questions their practical relevance in hospitals which was one major objective of this work.

There has been similar research on middleware and its requirements for health care scenarios, where Lange [6] provided a taxonomy and a requirements catalogue for communication servers in hospitals. The author created a model of a communication server by analyzing middleware products and conducting a survey among its vendors but did not include modern technologies like e.g. SOA. This work was motivated by the goal of providing a decision basis for hospital IT managers pro or contra a specific integration solution (i.e. a communication server). In [3] Engels et al. created a reference architecture of an integration platform. They revealed technical services used in different integration models based on the three-tier architecture of software (data layer, business layer, presentation layer). Their work is mainly focussing on establishing SOA in an enterprise rather than presenting the interconnection and interactions of components within the platform.

2. Research design and methods

Starting at the theoretical basis, we scanned literature and revealed relevant integration models and methods for coupling heterogeneous IS and applications in general. In order to evaluate their practical relevance for hospitals in particular, we decided to conduct a survey among hospital staff who provides sufficient authority and knowledge for answering both technological and organizational questions regarding their integration solutions. We chose the target group to be IT managers rather than administrative directors or chief information officers because we needed data closely related to daily IT routine.

Among the study objectives we discriminated between technological (TECH) and organizational (ORG) ones using two different categories of questions. Questions regarding IS and their integration into the hospital IT landscape as well as data and communication standards and integration products used were summarized in TECH. IS in clinical departments may be subsystems of other, superior systems (e.g. outpatient clinic management system as subsystem of the hospital information system HIS) or standalone (e.g. a self-developed or third party product). We wanted to know which systems are tendentially standalone, part of other systems or not used and on which levels of the three-tier architecture coupling of systems takes place primarily. Another goal was to find out whether they use a central EAI or a distributed SOA integration approach or whether there is even a tendency towards monoliths. Moreover, the current percentage occupied by PTP architectures among others has been of interest. ORG questions dealt with the general conditions when using integration solutions. These comprise the motivation for choosing a specific solution or product, potential problems and obstacles, customer satisfaction as well as its supportability. Integrating the Healthcare Enterprise (IHE) recommends certain standards (e.g. HL7 and DICOM) in their technical frameworks and profiles for specific clinical workflows. This survey should reveal whether these recommendations are included in IT strategies of the hospitals – as long as they have an IT strategy – or not. Open-source software (OSS) may be a good cost-effective alternative to commercial products. Considering the perpetual cost pressure on hospitals and their contemporary

increasing dependency on IT systems, we surveyed the attitude of IT managers towards open-source products in their productive environment.

In the aftermath of a risk analysis and a pre-test loop for quality assurance we initially invited IT managers of 479 hospitals in Germany, Austria and Switzerland via e-mail. A reminder was sent to everyone five days before the deadline except to those who opted out or already completed the questionnaire. All replies were clustered into categories (see *Table 1*) using a constant criterion common to the selected health care systems, the quantity of inpatient beds. This has been done under the assumption that the number of inpatient beds positively correlates with the size of the hospital for the purpose of detecting distinctions between the various sizes. We used anonymous online questionnaires due to the advantages of this method over paper-based ones, reported by [12]. The survey has been created and represented using the open-source tool “limesurvey”.

3. Results

After a survey time of two weeks we had 67 complete responses (response rate: 14%), see *Table 1*.

Table 1: This table illustrates the responses in four clusters using the common criterion “inpatient beds” (n=67)

Cluster	Quantity of inpatient beds	Response quantity abs.(#)	Response quantity rel.(%)
1	< 200	11	16,4
2	200 - 499	31	46,3
3	500 - 799	12	17,9
4	≥ 800	13	19,4

24 further incomplete responses were not included into analysis. Of all responses, about 60% came from German hospitals, 27% from Austria and 13% from Switzerland. Regardless of the kind of installation (standalone, module/subsystem etc.) all participants reported the usage of a specific software product for administrative tasks (HIS). Outpatient clinic management system, medical documentation IS (MIS), nursing and care unit management system, and OP management system are the most frequently mentioned ($\geq 50\%$) subsystems of an HIS. One might expect that some important subsystems like the Picture Archiving and Communications System (PACS), Laboratory IS (LIS), Radiology IS (RIS) and electronic food ordering system might already also mostly be integrated in an overlying IS, but to our surprise the before mentioned are reported to be mostly not part of an overlying IS. However, a trend towards more modularized than monolithic system landscapes can be observed. About 50% use Enterprise Resource Planning (ERP) systems which mostly incorporates modules for finance and accounting, controlling, inventory management followed by Human Resources and facility management system. More than 60% are already using business intelligence/data warehouse systems for cost-control and economical optimization tasks.

From the as-is analysis of integration architectures it appears that central EAI concepts are established primarily. In the questionnaire, we also asked about future plans about the structure of the hospital IT systems. Compared to this target state the majority of participants reported that isolated systems should be decreased in every hospital size cluster (see blue arrows in *Figure 1*). *Figure 2* illustrates an all-cluster overview of integration types of IS and modalities. It can be seen that the focus is clearly set on using EAI and a central integration approach (communication server). It can be observed that SOA concepts are hardly present. PTP coupling is still common, but is sought to be decreased in all clusters (see *Figure 1*). The most common and also most flexible integration model is “functional integration”, located on the business layer of software, followed by data and presentation integration. Most widespread commercial products have been reported to be

messaging solutions with SOA capabilities (1. Oracle eGate/JCAPS, 2. SIEMENS OPENLink, 3. SAP PI/XI). If participants use SOA middleware (e.g. Oracle SOA Suite), there was at least one classical messaging product complementing their integration solution. DICOM and HL7v2.x outbalance proprietary data and communication standards, though, proprietary formats are used in more than one third of participating hospitals.

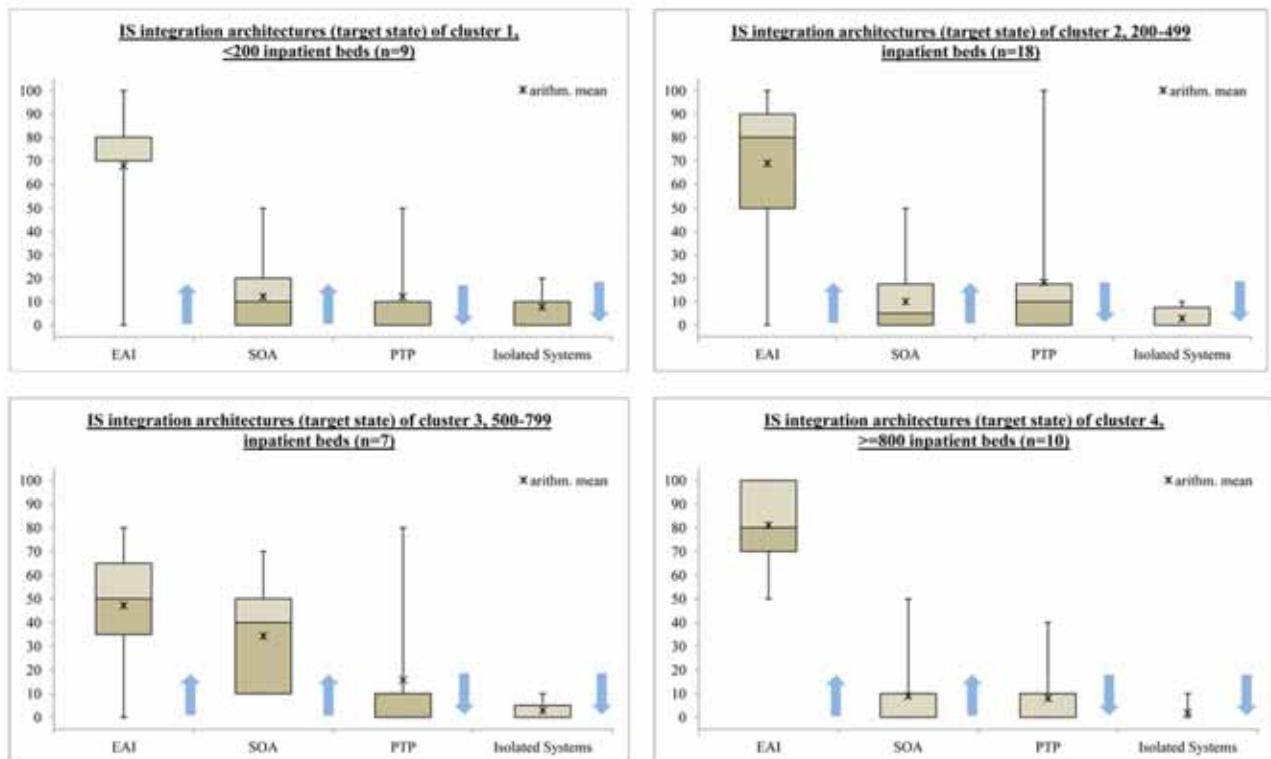


Figure 1: This figure illustrates the target states of each cluster regarding their integration architectures. The blue arrows indicate the intended change according to the current state. An arrow pointing upwards means that the majority of participants would like to increase the adoption of a specific concept, one pointing downwards means that the majority would like to decrease the adoption of a specific concept in their hospitals

More than 60% stated that the functionality of the product and references of other hospitals were significant for its choice. Scientific resources of information on solutions remain unexploited. A quite above-average satisfaction ($>60\%$) can be observed, too. Common problems, especially in clusters 3 and 4, were insufficient interface monitoring capabilities and a high vendor dependency. For system administrators it is essential to have tools for automated reporting as well as interface and performance surveillance. A solution to this issue may be exchanging current integration products, which is considered by about 40% of hospitals in cluster 3 within the next two years. IT strategies exist in more than 60% (highest rate in cluster 4) and about one third of them include recommendations of the IHE. More than 50% in clusters 2 and 3 would use OSS in their productive environment, hospitals in clusters 1 and 4 remain undecided.

3. 1. Reference model of a communication platform in hospitals

Using these study results, an analysis of four middleware products as well as preexisting work published in [6] we were able to develop a reference model for communication platforms in hospitals. This model and also a more detailed analysis of the survey results can be found in [7]. The reference communication platform consists of ten functional components summarizing 70 requirements in a catalogue for both SOA and EAI integration approaches.

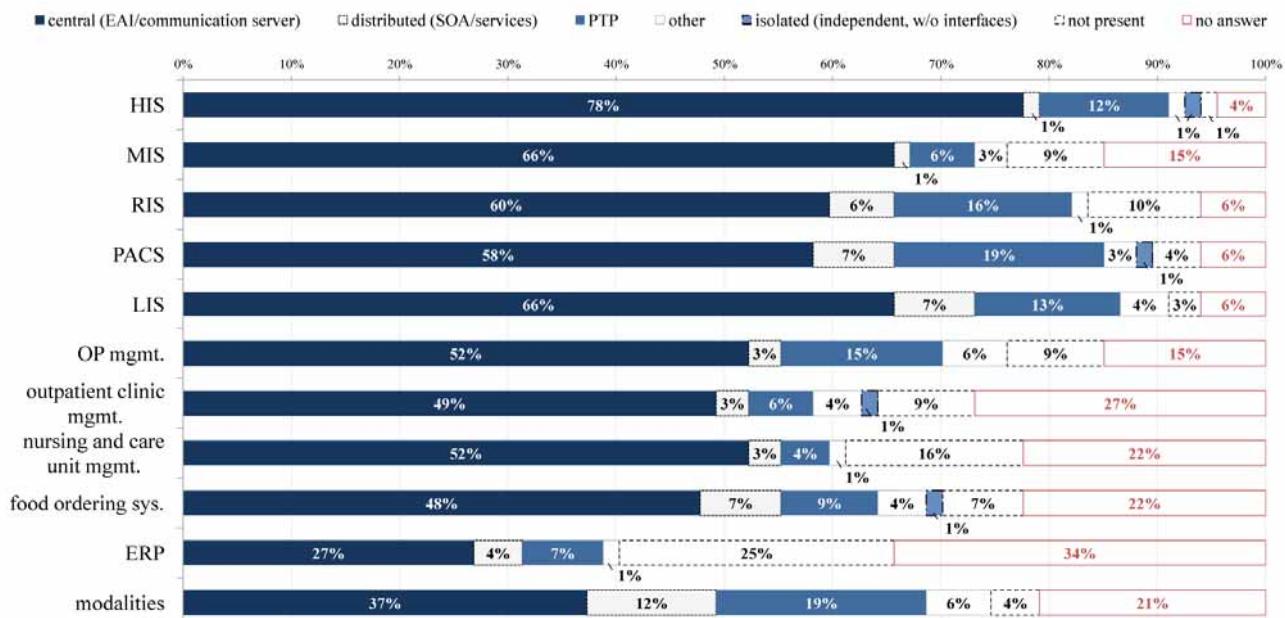


Figure 2: This figure shows the integration types (horizontal) over different types of information systems and modalities (vertical) among all hospital sizes (n=67). A central concept of integration (EAI) is customary

4. Discussion and conclusion

We designed multi-dimensional questions in order to keep the length of the questionnaire at bay. The survey tool exhibits some limitations such as that one is not able to implement more complex logic into the questionnaire than simple if-then-rules for questions (e.g. IF questionA.answer1=true THEN showQuestionB ELSE hideQuestionB). Due to that we had to dismiss certain replies (e.g. where the total percentage exceeds 100%). The amount of PTP and isolated systems may be explained by the fact that technologies and products are evolving but their efficient use lacks in practice. Our results yielded that for smaller institutions using a limited number of systems (proprietary) PTP coupling may be a cost-effective alternative rather than buying a full-featured integration server. But due to the small number of replies, the sub-group analysis performed in *Figure 1* cannot be generalized without limitations.

A high vendor dependency may be explained by too complex products which are not maintainable without regular special training. Outsourcing is considered to be one alternative strategy to maintain integration solutions in daily routine. The larger the hospital, the more internal maintenance can be observed (>60% in cluster 3 and 4). Strategic orientation of an IT organization regarding the recommendations of IHE requires conformance statements of software systems for certain profiles. This is an important step towards homogenization and standardization of health data exchange and integrated care within and across hospital boundaries.

5. Acknowledgements

The authors would like to thank the German software vendor MEIERHOFER in Munich for their cooperation by providing the address data and supporting the development of the questionnaire.

6. References

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