A framework for data and context integration in the modular digital OR

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Abstract

Today, OR planning is supported by different clinical information systems. However, relevant patient information is distributed and spread over separate heterogeneous information systems (HIS, RIS, PACS), where each requires its own login and user interaction scheme. Furthermore, transfer of different planning data objects into the OR is currently not accomplished in a consistent electronic manner. This work proposes a framework, which integrates heterogeneous clinical information systems using a portal application with single-sign on and single-patient-lookup functionality. OR planning data can be composed into a digital planning record, which is seamlessly transferred to the modular integrated OR system. Data acquired or generated during surgery is automatically labeled with the electronic patient context, thus ensuring simple and consistent OR documentation.

Contents

1 Problem

Although there are communication standards such as HL7 and DICOM for the exchange of patient data, the majority of planning tools, clinical IT systems, and systems for computer assisted surgery (CAS) are not networked to support a uniform and consistent electronic data flow along the perioperative process. In today's hospitals there are different clinical information systems (HIS, RIS, PACS) from different

vendors with separate user interface designs and interaction concepts. Each of these systems requires a separate login and lookup of patient data. For the transfer of planning data into the operating room (OR) as well as to document intraoperatively acquired data, exchangeable media, paper printed images, or handwritten records are used. Beside the logistical aspects, the manual entering of patient information into imaging modalities or assistance systems requires a certain amount of time, is highly prone to error and could result in inconsistent data in clinical repositories.

Integrated clinical desktop sessions have been already defined by the HL7 Clinical Context Object Working Group (CCOW) [1]. Using HL7 CCOW multiple clinical information system clients can be simultaneously controlled using a portal software on the client computer. The portal software enables single-sign-on preventing the need to manually logon in every information system. Furthermore, the patient context is maintained over all information systems (single-patient-lockup), e.g. changing the patient within PACS results in an automatic change of the patient within HIS or RIS. Currently HL7 CCOW is implemented in a few HIS/PACS solutions but not widely established. There are no free toolkits available to implement CCOW compliant applications and the CCOW standard is rather complex, which results in high development efforts [2].

The goal of this work is to define a framework, which realizes uniform access to heterogeneous clinical information systems using single-sign-on as well as software tools, which support the planning workflow. Transfer of intervention related data from OR planning to surgical intervention and postoperative documentation should be consistent under a common electronic patient context. The surgeon should be able to integrate all relevant planning data into a multidimensional digital planning record. This planning record should be seamlessly transferred to the integrated operating room, where all information is presented for review at the central surgical cockpit. Intraoperatively acquired data should be assigned with the electronic patient context to ensure consistent OR documentation.

2 Methods

The proposed framework extends the basic principles of HL7 CCOW (Single-Sign-On and Single-Patient-Lockup) to facilitate an integrated planning process, which realizes a consistent and uniform data transfer between applications for intervention planning and components of the modular digital OR.

2.1 OR Database

The framework supports the electronic data exchange between medical systems at different phases along the perioperative process. Therefore a database is used, which stores all relevant information and provides interfaces to access the data clinic-wide within the intranet. Several requirements for a database management system (DBMS) have been defined and five open source products selected for evaluation: PostgreSQL, MySQL, MaxDB, Ingres and Firebird. According to the defined criteria, PostgreSQL has been selected as best suited for the implementation. The required data objects have been identified and a database schema created. The database doesn't store data, which is already stored in other information systems such as HIS or PACS, but rather stores hyperlinks to these data records. Furthermore, the database stores new data objects for the digital operating room such as surgical checklists, planning notes, screenshots, as well as user and device profiles.

2.2 Planning software: MetaPlan

The application MetaPlan has been developed, which supports and extends the OR planning process. The clinical user logs in into MetaPlan once, which retrieves the user's profile from the OR database. The user profile contains the login data (PGP encrypted) to all clinical information systems, the users role and domain specific assignments to planning applications.

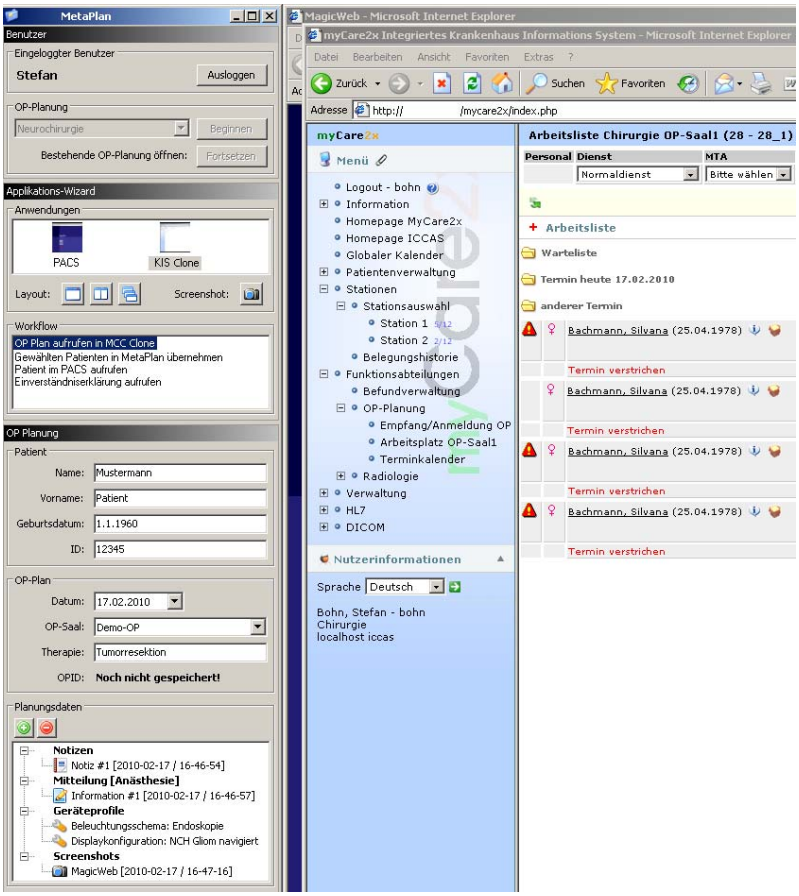

Figure 1: MetaPlan (Sidebar left) realizes the electronic patient context for the OR planning and automates the access to planning softwares and information systems (right). A digital planning record (lower left) with relevant data (screenshots etc.) can be created.

MetaPlan acts as sidebar at the desktop and interacts with the proprietary clinical information system clients. After login, MetaPlan automatically opens the clinical information system clients and arranges these windows at the desktop (Fig. 1). Often recurring functions (e.g. 1st open OR schedule, 2nd lookup patient in HIS, 3rd lookup same patient in PACS etc.) are modeled as planning workflows and stored in the OR database. The clinical user can click on items in the planning workflow and MetaPlan automatically executes the corresponding commands within the particular clinical information systems. Automation of programmed command sequences and access to data within client windows is facilitated using AutoIt [3], a scripting-system for application automation. A script- and profile editor has been developed, which supports the administration of user profiles and application scripts within the OR database.

MetaPlan is compatible with any Microsoft Windows based planning application and clinical information system client. MetaPlan doesn't change the interaction with the particular planning software's but rather provides a uniform framework, which supports the user by automating often recurring and tedious user interface interactions. Furthermore, MetaPlan provides additional functionality, such as grabbing screenshots from planning applications and the creation of annotations. The clinical user can add notes,

drawings, checklists and user specific files. All together the planning items and the electronic patient context form the digital OR planning record, which finally is stored into the OR database.

2.3 OR Integration

A modular OR integration framework, which is based on open standards has been designed (Fig. 2). The IT infrastructure models medical devices and CAS systems as independent components within a service-oriented architecture [4]. Communication between modules within the network are based on standard protocols for session management, data exchange, remote method invocation, time synchronization, as well as systems monitoring. The core components of the integration architecture realize fundamental functionality for an integrated OR such as central user interface, systems monitoring, remote configuration, logging as well as interfaces to clinical information systems. MetaPlan is integrated as a module within this integration architecture and communicates with the OR database over the network infrastructure.

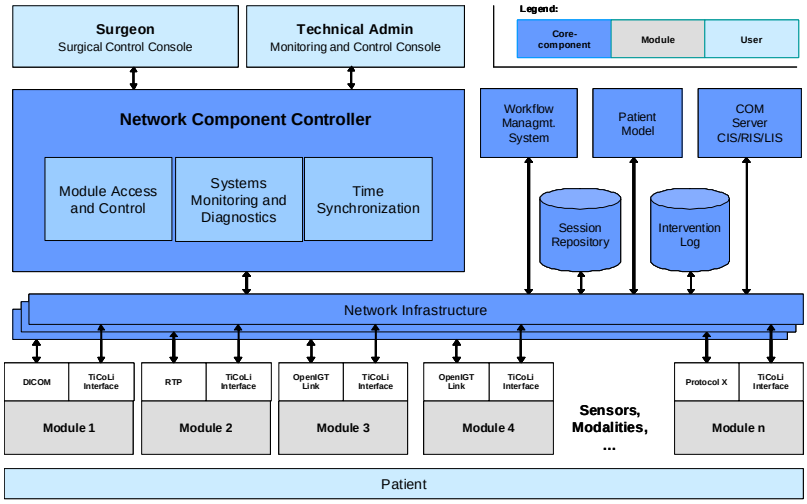

Figure 2: OR integration architecture.

The central surgical cockpit within the OR retrieves the preoperatively generated digital planning record and displays the multidimensional planning data for review close to the surgical situs prior to surgery. Data acquired or generated during intervention, such as screenshots from the integrated video routing and documentation system, are labeled with the electronic patient context and stored within the OR database. After surgery, all acquired data are displayed for review and the surgeon can select or annotate items, which are stored for OR documentation within the PACS system.

3 Results

The proposed framework realizes data and context integration between OR planning, intraoperative application, and postoperative documentation within the integrated modular OR system.

MetaPlan integrates heterogeneous planning software and clinical information systems under a common framework. Access to existing proprietary planning applications is facilitated using single-login. Often recurring user interactions are automatically executed using application automation. Different data items (e.g. screenshots, notes, surgical checklists, device profiles) can be integrated into a digital OR planning record, thus avoiding transport into the OR using exchangeable media or paper.

Figure 3: User interface at the central surgical cockpit in the digital OR. **Left**: List of all scheduled patients for the current day. **Middle**: Access to the digital planning record as well as control of the video routing system. **Right**: Review of data acquired during intervention and selection for OR documentation.

The major benefit for the clinical user is that the OR planning record is seamlessly transferred to the OR and directly accessible at the surgical cockpit close to the surgical situs (Fig. 3).

The proposed framework has been embedded into the modular OR infrastructure at ICCAS, integrated within our prototype lab (Fig. 4) and clinically evaluated in neurosurgical interventions. Thus, the modular OR system realizes integration of hardware and software components at different levels: 1) data integration, 2) function integration, 3) context integration, as well as 4) application and display integration.

Figure 4: Prototype integrated OR system in the ICCAS demonstrator lab.

4 Discussion

The proposed framework realizes a consistent electronic data flow between OR planning, integrated OR system, and OR documentation. Heterogeneous planning data can be integrated into a digital planning record, which is electronically transferred to the surgical cockpit. Furthermore, the electronic patient context is maintained over all phases of the perioperative process, avoiding manual entering of patient information into medical devices.

Functionality and user interfaces of existing planning applications and access to clinical information systems are not changed, but rather simplified using the MetaPlan application. The generic definition and modeling of planning workflows provides flexibility to adapt the overall framework to different clinical scenarios and software systems.

The clinical evaluation successfully demonstrated the practical feasibility of the OR integration system. Ergonomic centralized information display close to the surgical situs and access to planning or preoperative data supports the surgeon to better assess the current surgical situation.

References

[1] http://www.hl7.org/implement/standards/ccow.cfm, Version 02.03.2010

[2] BERGER R, BABA J (2007): “The realities of implementation of Clinical Context Object Workgroup (CCOW) standards for integration of vendor disparate clinical software in a large medical center”. International Journal of Medical Informatics. Volume 78, Number 6, p. 386-390. June 2009.

[3] http://www.autoitscript.com, Version 29.01.2010

[4] BOHN S, MICHAEL G, FRANKE S, VORUGANTI A, BURGERT O (2009): “An integrated OR system based on open standards”. The MIDAS Journal - Systems and Architectures for Computer Assisted Interventions; 12th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI), London 2009.