

# Modelling and implementing Electronic Health Records in Denmark.

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## Abstract

*The Danish Health IT strategy [1] points out that integration between electronic health records (EHR) systems has a high priority. A prerequisite for real integration and semantic interoperability is agreement of the data content and the information models. The National Board of Health is working on a common model for EHR, but it is not yet fully developed. At the same time several development and implementation projects are taking place at a regional level. These EHRs are built on information models from different vendors and are based on different integration platforms. The Danish EHR observatory, which has been monitoring the development of EHRs in Denmark since 1998, have analysed the challenges of using different information models and integration platforms. This paper also reports new tendencies in modelling and integration platforms globally and how this is reflected in the National development.*

## Keywords:

Electronic health records, information models, archetypes, paradigm shift, middleware

## 1. Introduction

In Denmark, the National Board of Health is developing a basic information model for electronic health records (EHR) [6]. Only some parts of the model, i.e. regarding medication and imaging, are developed in detail. EHR systems are currently developed and implemented in several counties in Denmark by different providers. The systems are based on different information models and different technology platforms.

This paper reports the analyses made by the Danish EHR-Observatory regarding the different models and implementation strategies in the three major projects in Denmark and the modelling work by the National Board of Health. It also reports major shifts in technologies and modelling techniques identified globally and compares these paradigm shifts with the development in Denmark.

The EHR projects discussed in this article are

- EHR development in Aarhus County based on a Domain Object Model (Aarhus-DOM)
- Distributed Health Care Environment in Copenhagen Hospital Corporation (DHE)
- Shared record project in Vejle and Viborg counties (SUP, Standardised Extraction of Patient data)

as well as the Basic EHR Model from the National Board of Health (G-EPJ)

The EHR-Observatory<sup>1</sup> has since 1998 has been monitoring the development of EHR in Denmark. The focus has been on implementation and dissemination issues and on questions related to integration of EHR-systems. The implementation and dissemination issues have been studied by analysing data on diffusion and diffusion rate of EHR-systems, experience among the different stakeholders, and factors that increase diffusion and use of EHR-systems. Questions related to integration challenges includes uncovering of differences and compatibilities between regional information models, analysing consequences of using incompatible information models and specification of the demand for a common frame of reference. The analysis of the data and the conclusions have been published in annual reports [7, 8], conference proceedings and journals [9].

## 2. Methods and materials

The information about the EHR projects, their information models and the implementation of these has been collected three ways.

Literature and web-sites about the projects themselves has been studied. The available documentation on the information models creating the basis for the EHR applications has been studied (documented in [7]). Furthermore, workshops have been organised with the projects, where representatives for the organisational and technical parts have been interviewed. In addition relevant standards and documentation from CEN, HL7 and OpenEHR have been used. From CEN the ENV 13606 [3] have been the main source, from HL7 parts of the Reference Information Model [4] have been used, and OpenEHR have provided material on archetypes [2, 5].

## 3. Results

Currently, fundamental changes in the ideas regarding development and implementation of EHR are taking place. The new paradigms are now massively disseminated from the few front-runners to a broader uptake. Since the changes are fundamental and are spreading quickly, we have chosen to see them as paradigm shifts. The combined modelling and technology paradigm shift creates the basis from moving from 1<sup>st</sup> generation EHR systems 2<sup>nd</sup> generation systems. The next generation EHR's will better support the new health care requirements with patient focused, shared care based on extensive re-use of information cross organisations. This implies secure communication of structured, standardised datasets and a flexible technological system platform.

### The modelling paradigm shift

The new modelling paradigm consists of a separation of the generic information modelling from the health care domain modelling. The consequence is that instead of working with large, static models describing the whole "health care related world", it is now possible to focus on smaller, dynamic models that can be adjusted to different needs. These models are defined a little differently by various groups and are called *Archetypes* or *Templates*.

We are using the term *archetype* and understand it as concept model for a certain domain based on constraints of a generic model. Such a "prototype model" can be the basis for a series of individual models. The use of archetypes for development of EHR's is among other described by Thomas Beale [2].

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<sup>1</sup> We have recently changed the name from EPR-Observatory to EHR-Observatory according to more contemporary terminology.

The archetypes are thus related to a two levels of models. A generic level of information modelling will only contain information on the basic parts of the record and how they are related, i.e. the record structure. The Electronic Health Care Record Architecture standard from the European Standardisation Organisation, CEN (ENV 13606), is such a generic standard. It defines the rules for how a *Folder* can contain *Compositions*, which can contain *Headed sections* containing *Data items* or *Clusters of Data Items*.

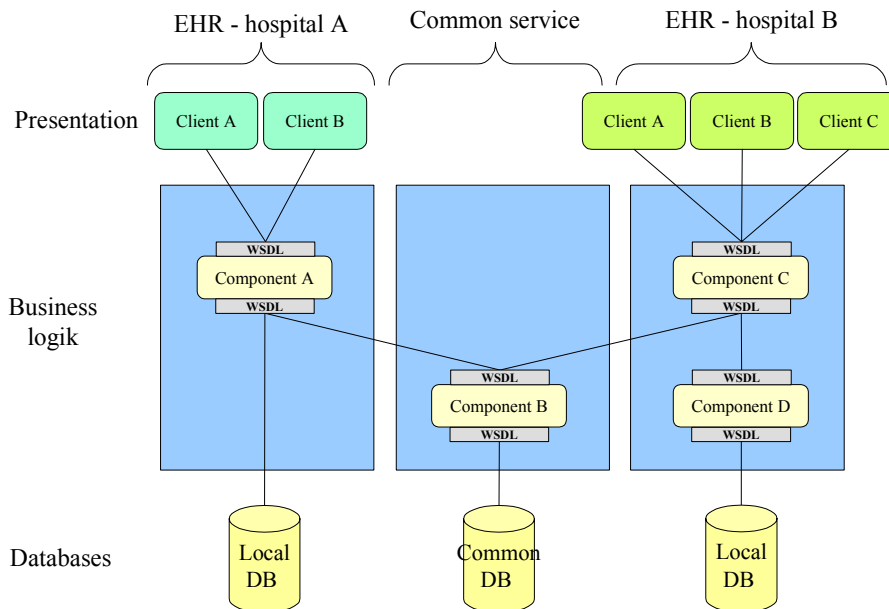
The structure of the health care related content is described on the next level on models. This domain information is described at the archetype level. This level defines the types of entities, acts, etc. that can be found in the record, i.e. blood pressure, medication or examination result. The actual value of a blood pressure (i.e. systolic blood pressure = 120 mmHg) is placed in a data item as a result of an examination result (blood pressure measurement), which is a specific type of an act.

The “blood pressure archetype” describes in detail how the content is structured. This is a part of the health care (domain specific) modelling work. One advantage with this kind of modelling is that the health care professionals can concentrate on modelling their domain without having to consider an overall model.

In the EHR development in Aarhus County based on a Domain Object Model (Aarhus-DOM), archetype-like models are used. These are called Act Description Definitions.

### The technology paradigm shift

The technology paradigm shift consists of a splitting up of the technical architecture in three layers. The presentation layer handles the user interfaces in the “client” applications, i.e. an Internet browser. The presentation layer does not communicate directly with the database layer. All interaction goes via the applications in the Business logic layer. (Fig 1.)



**Figure 1. EHR architecture with three layers and a component based middle layer**

One advantage with this middleware EHR architecture, which already has been used in modern Hospital Information Systems (HIS), is that each layer may be replaced separately. This gives the purchaser larger flexibility to choose different vendors for the databases, applications and user interfaces.

A prerequisite for this flexibility is of course that the interfaces between the layers are well defined and public. This also includes the semantic level, and therefore the success of technological development should be seen in context with the new modelling paradigms.

Furthermore, as shown in figure 1, the applications can be divided into components. If these components are developed as web-services, they can be used outside the single hospital. The PICNIC project [10] has described several basic components and common health related components, which have the potential to be used at a regional or national level. Some PICNIC components are developed in Open Source, giving the possibility to adjust the components for trans national use.

## 4. Discussion

### The four models

The data models for three major EHR projects in Denmark and the standardisation initiative taken by The National Health Board were analysed and compared. The models represent different system development philosophies and scopes, relating both to the modelling and technology paradigm shifts described above.

*The generic model:* Aarhus County is developing a common EHR-system for all the hospitals in the county. They are developing a general conceptual model – the Domain Object Model (DOM). The generic model functions as the basis for a development tool for individually tailored EHR modules. These modules are based on archetype-like models called Act Description Definitions. These obtain integrity between the individual modules and enabling communication to other proprietary systems.

The development in Århus County is thus using the new modelling paradigm as well as the three-layer, component-based technology platform as mentioned above. The challenge is to optimise system performance and to obtain an extensive and coherent set of archetypes.

*The middleware model:* The Copenhagen Hospital Corporation (H:S) has chosen a middleware solution. They will build future EHR systems and integration of existing systems on the middleware's data model. The product used is Distributed Healthcare Environment (DHE). Furthermore, one of the EHR pilot installations in Copenhagen the presentation layer is based on a web portal communicating with various modules in the application layer.

This project is thus based on a three-layer technology platform but is using the information model that is built into the DHE product. One challenge is to interface the middleware to a large number of legacy systems.

*The communication model:* Hospitals in Vejle and Viborg counties use a number of different proprietary EHR systems. To give access to data across counties and systems the two counties have launched the SUP standard (Standardised Extraction of Patient data). Data is exported from the systems according to the SUP structure and stored in a database. The data then becomes accessible by other authorised parties through a web browser. The standard will be disseminated nationwide.

The shared record project in Vejle and Viborg counties is not aimed at close integration between systems, but rather to give access to a view of patient's data across systems and platforms. The simplified SUP model lays out the common structure and format for the

EHR data. The challenge in this project is to ensure correct and consistent mapping from the EHR systems to the common SUP based database.

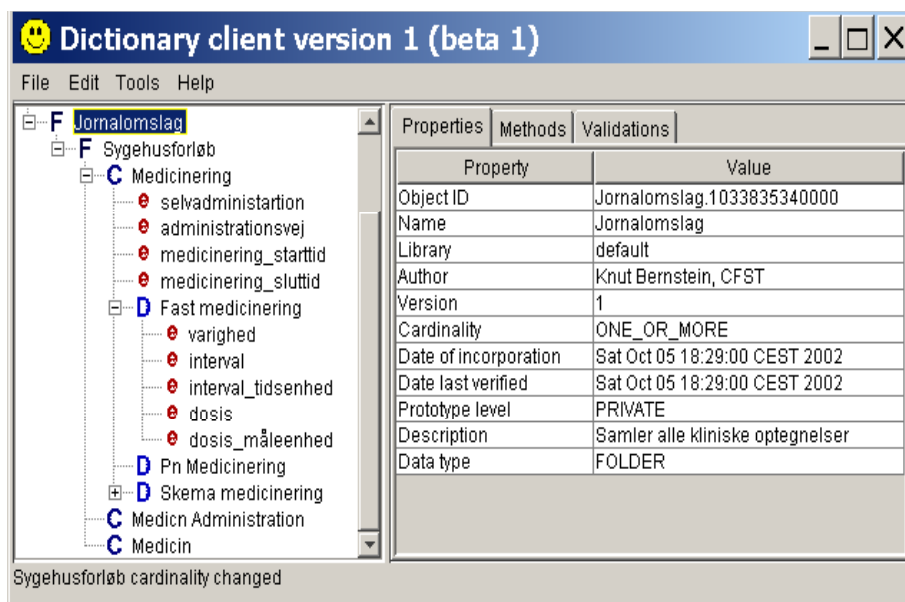
*The semantic model:* The National Board of Health has developed a basic information model for EHR systems and for data transfer between EHR's. Currently, two areas of the basic model have been documented in more detail: the medication area and the diagnostic imaging area. The model is based on problem-oriented way of documenting the activities. Furthermore, it requires the systems to be based on the "period of care" principle. This implies the all contacts to health care providers in relation to one illness should be linked together. When fully implemented, it will be possible to trail the interventions made and the assess the results achieved for a specific patient problem – regardless what health care party provided the service.

The challenge is to continue the detailed development of other areas of the model. Furthermore, validation of the model is needed and broad uptake by vendors needs to be stimulated. Pilot projects are established to achieve this, but this process is expected to involve considerable effort.

### Use of archetypes

As described above, there are several modelling activities in Denmark, with somewhat different purposes, methodologies and results. From the Counties (the hospital owners) there is a clear commitment to the National Board of Health' Basic EHR Model. Also several vendors are planning to use the model or are testing parts of the model. However, systems will be implemented in parallel with the development of the Basic EHR Model, and several legacy EHR systems and other systems exist on the market. There is therefore a need to ensure proper mapping between the various models. Furthermore, the extensive international modelling initiatives need to be taken into account, i.e. HL7 version 3, CEN, OpenEHR.

The Danish EHR Observatory has proposed to use the archetype paradigm to establish a common framework for mapping between the models (see fig. 2). A database with archetypes should be available as well as mapping schemas for the relevant models.



**Figure 2. The medication part of the Basic EHR Model documented in an archetype tool provided by OpenEHR. The correspondence to CEN's ENV 13606 is: F = Folder, C = Composition, D = Headed Section and e = Data Item**

## 5. Conclusion

A few 2<sup>nd</sup> generation EHR systems – with secure communication of structured, standardised datasets and a flexible component based middleware platforms – is expected to be operational in Denmark the next years. The development in Aarhus and Copenhagen Hospital Corporation seems to be the prime candidates – even there are several technical, modelling and organisational challenges.

There is a need to support the development of 2<sup>nd</sup> generation EHR systems. This implies increased structuring of information, development of regional middleware (regional platforms), initiatives to migrate to a national architecture, and development of common web-services on a regional and national level

Several implementation projects in Denmark are striving towards integration and communication between EHR systems and between EHR systems and other systems (i.e. HIS). However, neither new technology nor new modelling techniques results in the desired semantic interoperability by itself. This is only achieved by continuous standardisation work with participation from health care professionals and industry – and supported by validation and evaluation. Possibly can the archetype tools be used in the harmonisation process.

## 6. Acknowledgement

The Danish Electronic Health Record Observatory (EHR observatory) consists of three organisations: The Danish Centre for Health Telematics, Aalborg University and the consulting company MEDIQ. It is funded by the Ministry of Interior and Health and have since 1998 been monitoring the development of EHR in Denmark. The Virtual Centre of Health Informatics runs the secretariat.

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