Mapping care processes within a hospital: a web-based proposal merging enterprise modelling and ISO normative principles

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Abstract

Today, the economic and regulatory environment are pressuring hospitals and healthcare professionals to account for their results and methods of care delivery. The evaluation of the quality and the safety of care, the traceability of the acts performed and the evaluation of practices are some of the reasons underpinning current interest in clinical and hospital information systems. The structured collection of users’ needs and system requirements is fundamental when installing such systems. This stage takes time and is generally misconstrued by caregivers and is of limited efficacy to analysts. We used a modelling technique designed for manufacturing processes (SADT: Structured Analysis and Design Technique). We enhanced the initial model of activity of this method and programmed a web-based tool in an object-oriented environment. This tool makes it possible to extract the data dictionary from the description of a given process and to locate documents (procedures, recommendations, instructions). Aimed at structuring needs and storing information provided by teams directly involved regarding the workings of an institution (or at least part of it), the process mapping approach has an important contribution to make in the analysis of clinical information systems.

Keywords:
System analysis: methods; Hospital Information Systems; Process Assessment

1. Introduction

Continuous quality management programmes and process-oriented reengineering of care activities are being considered as relevant and powerful approaches for managing and upgrading healthcare organisations. They both lead on analysis methods that can be applied to the design phase of patient-centred information systems\textsuperscript{1,2,3,4} to guide and emphasise requirements analysis. The following key points help to account for this fact.

First of all, the reality of cost reductions, the announcement of activity-based payment as well as the increase in social expectation as regards safety of care, have induced hospital managers and clinical staff to define, implement and evaluate new and co-ordinated care pathways. Currently, in France, all care establishments, private as well as public, are involved in the mandatory procedure of accreditation conducted by the French agency for the evaluation and accreditation of healthcare\textsuperscript{5}. To assist implementation of this nationwide program, a framework has been proposed that suggests care-process analysis as an effective means of federating both objectives and rules of practice and management. According to this programme, the factors and the levels of quality and security of care, as well as the co-ordination of care activities and data exchanges between the various parties involved are required to be traced, measured and analysed.
The second key point is related to the methods for designing and implementing hospital information systems. According to the results of previous experiments on designing and implementing process-oriented information systems, it seems that:

- process-based modelling could provide a rational means of organising information: 1) that is processed to perform care activities; 2) that can be requested by a concerned party, conveyed to him/her according to the work context, or simply be available [6].
- the use of workflow technology is deemed to be valuable for the clinical personnel since they actively support the processes in a hospital and reduce administrative overheads: 1) by proposing tasks “just in time” when all the necessary information is available to perform them; 2) by respecting deadlines and other time constraints [7].

The third key point has been pointed out by several analysis focusing on the failure of information system projects in healthcare. One of the reasons for this is the difficulty, or the inability, to link system requirements and user needs, while taking into account the organisational context in which system and users will interact. The importance of design being driven by a detailed understanding of patient care processes has been highlighted, as opposed to addressing individual or unrelated tasks [8]. Clinical information systems must satisfy two kind of clients. They have to provide end-users with full event traceability, real-time data entry and retrieval features, context-based decision supply and measurement of the performance of activities. They must also reassure patients that everything is being done in compliance with practice and organisational rules. As the tendency of clinical practice is to move to a shared care environment, the knowledge of clinical information systems should include the characterisation of all aspects of the clinical processes, as well as the functions and responsibilities of the people involved in it [9].

### Table 1 – Usefulness of process mapping applied to clinical pathways management

<table>
<thead>
<tr>
<th>Applications of process mapping</th>
<th>Typical analysis questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiting times reduction</td>
<td>Which steps consume the most time? Why?</td>
</tr>
<tr>
<td></td>
<td>Which steps add value and which do not?</td>
</tr>
<tr>
<td></td>
<td>Which steps are redundant, bottlenecks, or add complexity?</td>
</tr>
<tr>
<td></td>
<td>Which steps result in delays, storage, or unnecessary movement?</td>
</tr>
<tr>
<td>Quality improvement (adverse events reduction, safety requirement)</td>
<td>Is variation due to common or special causes?</td>
</tr>
<tr>
<td></td>
<td>What are the causes of the defects?</td>
</tr>
<tr>
<td></td>
<td>Which variables must be managed to have the desired effect on the relevant quality or safety characteristics?</td>
</tr>
<tr>
<td></td>
<td>How should the process be changed to reduce or eliminate variation?</td>
</tr>
<tr>
<td></td>
<td>Which actions can be performed to prevent new adverse or unexpected events?</td>
</tr>
<tr>
<td>Patient satisfaction measurement</td>
<td>How does process performance data compare to patient expectations and perceptions data?</td>
</tr>
<tr>
<td>Cost reduction</td>
<td>What does it cost to operate the process?</td>
</tr>
<tr>
<td></td>
<td>What steps cost the most? Why?</td>
</tr>
<tr>
<td></td>
<td>Which steps add value and which do not?</td>
</tr>
<tr>
<td></td>
<td>What are the causes of cost in the process?</td>
</tr>
</tbody>
</table>

Care safety assessment, activity-based analysis, workflow technology and knowledge of care pathways are closed to the methodological basics of continuous quality improvement, the evolution of the ISO 9000 norms that promote enterprise process analysis [10], and the use of business process redesigning to help analysts to describe major processes and cross-functional enterprises view [11]. Generally speaking, process mapping may be used in a
variety of performance improvement applications (some are listed in table 1). It is a set of maps that can show supplier-customer relationships, functions, steps and tasks.

2. Objectives

Aimed at creating the link between clinicians and system analysts, meaningful tools have to be found to assist clinicians to describe their practice and care processes, and to assist analysts to extract models from clinical maps in order to identify datasets, formalise dataflows, define mandatory data and understand the context of user needs. The solution is to define a process model that can be easily understood by a clinician and used to outline a clinical process in terms of roles, activities, documentation, objectives and indicators. This same model must provide the analyst with technical views in terms of data items, forms, and document sources. The purpose of this paper is to present and discuss the choice and the refinement of a basic process model, and to show how the process mapping tool has been implemented.

3. Method

Davenport defines a process as “a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure of action” [12]. In order to adapt modelling with various contexts and various levels of granularity, an atomic component of a process has to be defined. This indivisible element is intended to express the notion of any form of activity or task. The basis of our process model is the element of the SADT modelling technique (Structured Analysis and Design Technique) [13]. An activity is symbolised by the ICOM box: I for inputs, C for controls, O for outputs and M for mechanisms which are the four types of activity interface (figure 1).

We refined the data model of activity. We changed “Controls” and “Mechanisms” and expressed them according to five categories, taking inspiration from Ishikawa diagrams [14]: man, machine, material, method and environment. We added also concepts from the ISO 9000:2000 specifications to define the goal of an activity in terms of objectives and measurement. We detailed the description of activity with a more accurate grammar extracted from the conceptual domain of Enterprise Ontology [15]. After this refinement

Figure 1 - The basic ICOM box of SADT (grey coloured shapes) with descriptors extracted from Ishikawa diagrams (methods, men, materials, machines, and environment)
step, we designed the data model and the architecture of the process analysis tool. We implemented it as a web-based application running under Zope (Z Objects Publishing Environment) [16] in connection with the PostgreSQL relational database.

4. Results

We kept the top-down methodology of the SADT technique to breakdown a process into sub-processes and tasks and the break-down of sub-processes into elementary tasks or activities. We applied the following rule: a process is composed of sub-processes and elementary tasks, but that sub-processes are composed only of tasks. Task is defined as the smallest and indivisible functional element of a process. Each category of the Cause-and-Effect Diagram has been detailed. For “Method” we precised: 1) the type of content (rule, manual, guideline, procedure, instruction, record, planning); 2) the format of the support (folder, form, sheet, file); 3) and the source of content (legal, local, scientific society, agency). For “Men”, we adopted the semantics of Enterprise Ontology to define functions, skills needed and levels of responsibility. The representation of strategy in terms of demands, objectives, criteria, threshold has been included. The notion of measurement has also been delimited (conformity, adverse event, delay). For each objective, the factors, whether critical or successful can be defined. Factors may have their own objective and measurement. We also determined the type of activity (choose, decide, sign, check, fill, report, monitor, read, send, receive, acknowledge, transmit, call, operate, examine). Items and sets have been created to populate the interface of a task. Table 2 shows the list of the terms used in our process model, as a result of merging the three approaches: the SADT activity modelling technique, the ISO 9000:2000 norm and the Enterprise Ontology project.

**Table 2 – Attributes and grammar used to describe the components of a process**

<table>
<thead>
<tr>
<th>Identity</th>
<th>Item</th>
<th>Identity</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Title, Description, Creation date, Modification date, Author</td>
<td>Type [data element; document, file, criterion], Subtype [boolean, float, integer, long, string, text, rule, manual, guideline, procedure, instruction, record, planning], Default value, URL, Source [legal, local, society, agency]</td>
<td>Item</td>
</tr>
<tr>
<td></td>
<td>Type [dataset, folder, form, indicator], Subtype [conformity, adverse event, delay]</td>
<td>Type [choose, decide, sign, check, fill, report, monitor, read, send, receive, acknowledge, transmit, call, operate, examine], Input, Output, Role, Authority, Task owner, Function, Capability, Skill, Resource, Resource allocation, Resource substitute, Materials, Equipment, Methods, Conditions</td>
<td>Type</td>
</tr>
</tbody>
</table>

We implemented the data model of the activity, the hierarchical composition of a process and the grammar to identity its components in an open source programming environment. Zope is a framework for building web applications. It comes with a built-in web server, a web-based interface, an object-oriented database, a relational integration and a scripting language support (DTML: Document Template Markup Language). The architecture of the application consists of three parts: 1) the libraries of elementary components (item, set, role, task); 2) the library of the combinations of them into sets, tasks, sub-processes and processes; 3) a set of procedures that process information according to user interaction, and display information (figure 2). A specific object stores all the parameters to configure user interface and the values to describe the type and the content of components. For each library, a pack of management functions has been defined in order to access each component, edit its properties, delete it under user control, add or remove sub-components,
browse the entire library and list parents of each component. Predefined queries have been written to generate: 1) the data dictionary of one or many selected processes, listing all the data elements and their origin as defined when describing the tasks; 2) the list of all the documents that have been gathered to help all people involved to perform their tasks, and that have been linked to one or more task in the process.

<table>
<thead>
<tr>
<th>Z Process Analysis Tool V1.1</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Home</em></td>
</tr>
<tr>
<td><strong>Edit</strong></td>
</tr>
</tbody>
</table>

**View properties of the task: Contrôler receveur**
- **Element type:** List
- **Id:** task_contrôler_receveur
- **Title:** Contrôler receveur
- **Description:** Obtenir du receveur : son consentement écrit à la greffe et sa déclaration de non-inscription sur une autre liste d'attente.
- **Creation date:** 24/06/2002
- **Last modification date:** 24/06/2002
- **Type:** list
- **Sub-Type:**
  - **Input:** methods
  - **Output:** conditions
  - **Role:** output
  - **Material:** equipment
  - **Strategy:** strategy

**View properties of the item: Consentement pour greffe**
- **Element type:** List
- **Id:** item_consentement_pour_greffe
- **Title:** Consentement pour greffe
- **Description:** Document de consentement explicite et signé par le chirurgien au patient. Le patient doit réciter, avec le chirurgien, ce consentement.
- **Creation date:** 24/06/2002
- **Last modification date:** 24/06/2002
- **Type:** Object
- **Sub-Type:**
  - **Agreement:**

| File modified by Zope - Last modification Aug 24, 2002 1:07 pm |

Figure 2 – Top: description of an item, set of item management functions, hierarchical view of the steps of a process, tabs to access components libraries; Down: direct access to documentation for a given task

5. Discussion

There has been some debate regarding the usefulness of process models in an analysis phase of the design of hospital information system. The important thing to remember is that
maps are means, not ends. Process models can help users to find their way through the process. They can be used to interview users, managers and other stakeholders. The model is used to reveal the process, the roots of its problems, and possible trouble-shooting methods. Maps show how work currently gets done in an organisation. They represent a snapshot in time that shows the specific combination of functions, steps, inputs, and outputs that the organisation uses to provide value to its customers. Applying to hospitals, analysis of the clinical processes which the maps represent can help caregivers and managers to increase patient satisfaction by identifying actions to reduce waiting times, decrease adverse events, reduce costs and non-value-added steps to improve resources allocation, establish customer-driven process performance measures (safety and efficacy of care). The creation of a web-based tool that merges several enterprise modelling techniques is of value to make clinicians and analysts understand each other. It empowers clinical staff to structure and share useful documentation, and system analyst to build technical maps and define relevant data dictionaries. We formalised cross-functional processes such as blood transfusion and organs transplantation processes. Clinicians and analysts are now able to describe and understand care processes while keeping technical and clinical relevance.

6. References


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