# Process-based and context-sensitive information supply in medical care

Oliver Koch[1]

[1] Fraunhofer Institute for Software and Systems Engineering (ISST)
Emil-Figge-Str. 91, 44227 Dortmund, Germany
{oliver.koch@do.isst.fraunhofer.de}

**Abstract:** The needs-based information supply for medical workplaces is a necessary condition in order to ensure a maximum quality of medical care. A survey conducted by the Fraunhofer ISST showed that physicians complain about information overload with simultaneous qualitative information poverty in medical practice. The consideration of the respective process and work context can make an important contribution to an improvement of the physicians´ information supply. Within this paper first approaches of a differentiated context model and challenges for the future research work are described.

**Keywords:** Context Modelling, Information Need, Information Logistics, eHealthcare

## 1    Motivation

In the context of treatment activities physicians rely on patient information, their diseases, adequate treatment methods and guidelines as well as new research results in the medical and pharmaceutical area. They usually get access to information and knowledge by using medical information systems (clinical information systems, laboratory systems, medical practice management software etc.), local databases, e-resources or traditional print media. Basically it can be assumed that, the amount of available information affects the quality of medical decision making and acting positively. This positive effect, however, is confined by human and individual cognitive limitations. If too much information is available, the phenomenon of "information overload" reduces the performance of human actors rapidly [1]. Information overload occurs whenever the information processing requirements of an individual exceed its information processing capacities. The information processing requirements and abilities can be made measurable over the available and/or necessary time to process this information. Consequences of information overload are that important information is not considered when making decisions, that the ability of setting priorities is reduced and that people find it more difficult to recall previously stored information and are generally more confused.

The causes of information overload can be found in three areas. Firstly the already mentioned problem regarding of the time that is available to process information can

be named. If there is not sufficient time, information can not be processed thoroughly. Closely connected to the problem of processing time is the problem regarding the quantity of information. Available time and information processing capacity affect each other mutually. If there is little time available, only a small quantity of information can be processed. If plenty of time is available, a large information capacity can be used. The characteristics of the information represent a third problem area. If the information is for example very complex, has a high novelty level or is ambiguous, then the data processing capacities are affected negatively.
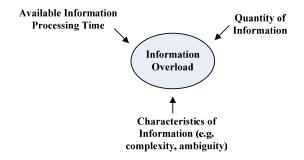


**Figure 1**: Main Causes of Information Overload

The work of medical staff in healthcare is - to a considerable degree - a highly information-intensive job. Anamnesis data, findings, radiographs, current medication, discharge letters, but also current research results from the clinical research, technical and specialist literature or guidelines must be considered within medical decision making and medical acting. At the same time ever more patient and non-patient-referred information are made available over the Internet and new telematic services (as for example electronic patient records). Therefore the information capacity, which has to be processed by physicians, is very high (problem area 1). If one regards the characteristics of medical information, then these are often complex and ambiguous. The processing of such information makes great demands on the information processing skills of physicians (problem area 3). The fact that sufficient allocations of time are missing in the health service for the processing of information is particularly significant (problem area 2).

In the years 1996 – 1999 the Eurocommunication Study was conducted in six different European countries [2], [3].[1]The differences in physician-patient communication were examined with general practitioners in the six countries. Altogether 190 general practitioners and 2825 patients were included into the study. Concerning the average duration of a doctor-patient consultation the study brought the result that on average in the six examined countries 10.7 minutes are available. In Germany and Great Britain the average consultation duration is even only about 7.6 and accordingly 9.4 minutes.

Within these few minutes the general practitioner must examine and talk to the patient, update electronic patient records and gather additional information, e.g.

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[1] Netherlands, Great Britain, Belgium, Germany, Spain and Switzerland.

specialist / technical literature, guidelines, experts contact data. Thus the risk of information overload occurring in an actual treatment situation is particularly high for the physician. This leads to the consequence that often important additional information, e.g. new treatment and therapy methods, current indication-specific guidelines or information gathered from consultations with other experts is not used.

Conceptual and technical mechanisms are missing to integrate such additional information context-sensitive and according to the physicians' information need and also make them available in the physicians` primary systems (clinical information systems or medical practice management software). Thus there is a need for information logistic research, which addresses the following requirements:

1. The physicians' workflow should be interrupted by information retrieval and utilization as less as possible (time factor)

2. The information supply should be reduced to the quantity of information which is necessary and useful in a concrete situation (factor quantity of information).

3. Only such information should be provided that physicians can process in a concrete treatment situation with respect to its complexity, novelty etc.

The information supply should therefore take place regarding to the following information logistic paradigm: Delivering of the right information, in the right amount, at the right point of time to the place, where it is needed. The consideration of context information represents a main lever for the implementation of a need-based information supply in the information logistic research. Beside the physicians' context and its working environment as well as the patient / case context, especially the (treatment) process context, for example in terms of clinical pathways, provides useful information to optimize the information logistic.

First results of the research work on process-oriented and context-sensitive information supply in medical treatment especially the underlying sophisticated context model should be outlined in this paper.

## 2 Results of a questioning about information need in medical practice

Accompanying to the research work on the topic of "model driven and context-sensitive information supply for medical workplaces" and for the recess of the knowledge concerning the information need of physicians the Fraunhofer ISST conducted a written survey on the information need of physicians at their workplace in the neighboring German large cities Essen and Bochum in 2005 in the context of

the project „Needs-based supporting of physicians at their workplace by information logistic applications" [4].[2]

The data acquisition took place as complete survey under all 2.543 physicians of the cities Bochum and Essen. This total number of respondent physicians divides into about 1.500 resident physicians, 1.000 hospital physicians as well as 40 company medical officers. All medical specialist areas were represented in the questioning. With 240 answered questionnaires the total return ratio amounts to 9.4%. Concerning the professional experience and thus the age structure of the answering physicians, for example with younger physicians, no significant emphasis was recognizable. 43 % of the answering physicians have more than 15 years of professional experience.

The dispatched questionnaire consisted of 28 open and 4 closed questions. Questions about the research area 'information need' and 'information seeking' behaviour were placed in the questionnaire. In the following in short form selected results of the questioning in statement form are presented, which were of interest for the research work:

**Statement 1:** The acquisition and processing of information are connected for physicians with high expenditure of time. 40% of the physicians indicate that they spend more than 6 h per week with information retrieval. About 30% of the physicians need besides again more than 6 h per week, in order to evaluate the information. Physicians stop the information retrieval in on an average 30% of the cases due to lack of success.

**Statement 2**: The physicians still expect an increase of the temporal effort for the information retrieval for the future. The time expenditure for the information acquisition is assessed highly till very highly of 68% of the physicians. Clearly over 50% of the physicians expect that the time requirement will in the future still increase.

**Statement 3:** The majority of the physicians want to have the same information supply with sinking expenditure for the information acquisition procurement. 59 % of the physicians prefer a constant information supply and information quality with less expenditure of time for the acquisition of the information. This preference is more strongly pronounced with resident physicians (62%) than with hospital physicians (56%).

**Statement 4:** The respective activity in the treatment process determines the physicians' information need. About 70 % of the interviewed physicians indicate that their information need is high with the reporting of findings and the diagnosis. With the progressing of the treatment process the information need sinks. During the diagnosis (67 % of the answers) and therapy (58 % of the answers) frequently ad hoc and situation-referred information need occurs.

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[2] The project was accomplished in co-operation with the national Ministry of Health (North Rhine-Westphalia), promoted by the state chancellery of North Rhine-Westphalia and co-financed with funds of the European Union.

**Statement 5:** The present ICT solutions for information retrieval are rated as too slow and not easy to handle. 62 % of the physicians confirmed the statement that the information acquisition takes to long. 71 % stated that the information supply is too unclear and 67 % called the frequently inaccurate search results as negative point. With a value of 2.5 on a scale of 0 - 3 the problem that the information acquisition takes to much time was called particularly strong.

It can recapitulatory be noted as result of the questioning that information acquisition and processing are important activities of physicians (Statement 1). Both activities are however afflicted - despite the fact that physicians are knowledge workers - in practice with substantial problems. The statement that about 30 % of the information retrieval activities are abandoned because of unsuccessfulness makes this impressively clear. On the basis of different statements the problem of information overload and its causes is mentioned. The factor time is particularly critical (-> Statement 2 and 3). Physicians don't wish any more information, but a temporally more efficient access to information. In doing so, the treatment process and the particular activity in the treatment process, which is the trigger for the specific information need, build up the main context of the information supply (Statement 4). A context is defined below as „any information that can be used to characterize the situation of an entity". The hitherto available concepts and solutions aren't able to give physicians a quick access to the information needed and make them available context-sensitive and for this reason need-oriented and quickly available (Statement 5).

As a result of the study the retrieval and working context of physicians was identified as a main focus of the further research work in information logistics. The results also indicate that the physicians' information supply can be significantly improved by explicit considering of context information in information retrieval.

## 3    A context-sensitive information supply for medical workplaces

Since the beginning of the 90's the issue  areas of „Context" and „Context Modelling" are aspects of research in the field of „Ubiquitous Computing" and „Mobile Computing" [5], [6], [7], [8], [9]. Computers within the meaning of Ubiquitous Computing mostly communicate by using mobile ad-hoc networks. Computers and devices in the context of Ubiquitous Computing are equipped with information and communication facilities and „know", where they are, which other devices and computers are nearby and what happened to them in the past.

The context dimension „location" plays a major role in the mobile computing research area To know where a person or device is located, is essential for the need-based provision of services and data. Consequently the context dimension „location" is a central element of all context models in the literature of ubiquitous or mobile computing. Additional recurring context dimensions are „time", „nearby objects and/or persons" as well as in some cases the actual user activity. Other context attributes can be derived from the specifity of the particular application.

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The context models of the mobile and ubiquitous computing are in particular in respect to the weighting of the context dimensions only partly transferable to a need-bases information supply in healthcare. Information supply and logistics are partial aspects of information retrieval, i.e. also the corresponding context model must refer to information retrieval and not to ubiquitous computing [10], [11], [12]. The research on the subject of process-oriented and context-sensitive information supply in medical care can't take place regardless of the actual information technology background in the healthcare sector.

Physicians, who need information in the context of medical care, e.g. relating to recommended differential diagnostic activities according to the appropriate medical guideline, are usually users of certain information systems (e.g. clinical information systems, medical practice management software etc.)

Information delivered in the context of information pull or push should make accessible in the actually used information system to avoid media disruption and change of system.

Concerning medical information systems one inevitably comes across the standardization efforts of the HL7 organization. HL7 is an international standard for the exchange of data between computer systems in the health sector. HL7 provides interoperability between Clinical Information Systems (CIS), Medical Practice Management Software, Laboratory Information Systems as well as Medical Accounting Systems and Electronic Medical Record (EMR). Health Level Seven is one of several American National Standards Institute (ANSI) -accredited Standards Developing Organizations (SDOs) operating in the healthcare arena. Beside the creation and setting of data exchange standards in medical environments, the HL7-organization is engaged in creating mark-up standards for clinical documents (for Clinical Document Architecture (CDA)). The Technical Committees of the HL7-organization work on the improvement and evolution of the different HL7-Standards. The idea of information retrieval solutions for the supply of medical staff with additional information is one of the side aspects in the work of the Decision Support Technical Committee.

One important approach to implement a context-sensitive supply with additional information at the physicians' workplace is the HL7-Infobutton [13], [14], [15], [16]. "An infobutton is a point-of-care information retrieval application that automatically generates and sends queries to electronic health information resources (e-resources) using patient data extracted from the electronic medical record and context information that is captured from the interaction between a clinical user and a clinical information system [...]."
An information request (as a HL7 message) to an e-resource or a local database triggered by the HL7 Infobutton includes particular context information. These are basically elementary patient attributes (age, gender), the physicians' actual activity (e.g. patient information review) and main search concept (e.g. lab parameters or diagnosis) including additional qualifying attributes and information about the physicians' role and language.

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Section of a XML schema instance of the infobutton standard context parameter

```
<searchParameter>
    <mainSearchCriteria>
        <mainSearchConcept code="363406005" codeSystem=
        "SNOMED- CT" displayName= "colon cancer">
            <originalText>adenocarcinoma of the colon
            </originalText>
        </mainSearchConcept>
        <modifier code="D011379" codeSystem="MeSH"
        displayName="Prognosis"/>
    </mainSearchCriteria>
</searchParameter>
<searchContext>
    <taskContext>
        <task code="11" />
    </taskContext>
    <patientContext>
        <age value="68" />
        <gender code="F" />
    </patientContext>
    <userContext>
        <role code="C11599" />
        <discipline code="C13429" />
        <language code="eng" />
    </userContext>
</searchContext>
```

Compared with the physicians' real context this context information represents only a small excerpt. Capabilities to expand this approach can be identified especially in the following areas:

1. The infobutton context model isn't process-oriented. Implicit or explicit information need of physicians expresses itself in the context of a treatment process, which is if applicable even formalized by a clinical pathway or a medical guideline. It is of great concern that the context of the information need is not only related to a point of time (actual activity), but rather to a period of time (treatment process). Which activities have already been passed (e.g. anamnesis, differential diagnostics)? Which experience does the physician have with this kind of clinical pathway? What are the next activities in the process? The answers to these questions (process context) are important for the interpretation of the information need.

2. Because of the subsumption into the HL7 context the infobutton context model includes naturally only such context elements that are part of the Reference Information Model (RIM) for HL7 messages. In so far key context information outside the Reference Information Model are missing, e.g. process information, user profile (medical specialty, work experience, preferences concerning specific e-ressources), physicians' system environment (PDA/tablet-PC/workstation or CIS/RIS etc.) and so on.

These two aspects are the starting point for the proposed extended context model of the physicians' process-oriented information supply outlined in the following chapter.

## 4 An Extended Context Model of Information Retrieval for Medical Workplaces

The above named deficit areas (process-orientation and additional context elements) were specifically addressed during the composition of the first context model version. The selection of the context areas and the describing attributes within the context model takes place based on the analysis of the few existing context models of physicians information retrieval, the results of the questioning of physicians in Essen and Bochum conducted by the Fraunhofer ISST as well as own reflections.

In doing so the selected attributes have to meet three key criteria:

1. The context attributes have to be appropriate to satisfy the subjective and especially the objective information need of doctors to a preferably high degree. In what way this criterions can be matched by the context attributes, can eventually be ascertained only on the basis of empirical tests in cooperation with physicians and comparative studies of the success of medical treatment in scenarios where the physicians were supplied with additional information (context-based information retrieval) and where no additional information was provided.

2. Automatic acquisition and collection of context information should be possible to a high degree. I.e., context information should ideally be stored in digital form in the workplace information systems or a separate context storage system (e.g. patients' primary diagnosis, physicians' medical speciality). If the acquisition of the actual context information doesn't arise automatically within the treatment process, a manual acquisition is necessary. This can be needful in the case of using physicians profile data. The context acquisition should be preferably required only one-time.

3. In the context of information retrieval context information can be usefully utilized only if they have a significant influence on the search result list. I.e. it isn't adequate, when the context information slips into the formulation of a search term, but it has to be used during the execution of the search term by the search engine of the e-ressource or the local database. For this purpose a mapping of context information on objects and data fields in the retrieved information base, e.g. within the framework of a search ontology, is required.

Within information retrieval behaviour of physicians one can differentiate between the active pull information access and the passive push information supply. In the context of information pull a physician is usually searching for further information starting from a key search question (based on one or more search terms). This form of

active search has been considered in the extended context model by an optional model area, i.e. there is one (or more) key search term, which is the starting point of the information retrieval. Within push information supply a physician is provided with additional information that - related to the actual activity in the context of a treatment process – can contribute to the improvement of medical decision making and acting, which additional information can be useful, is derived from the physicians' context because in this case a key search term is usually missing.

The process-oriented context model of physicians' information retrieval is divided into four areas:

A. patient context
B. physician context
C. process context
D. environment context

At the pull access a fifth area is added, which contains the key search term and additional information related to this term.

The **patient context** covers the physicians' treatment context, in which he is actually situated und from which the information need is arising. Attributes of the patient context are for example the actual primary and secondary diagnosis, relevant findings, the actual medication as well as the patient's age and gender.

Information about the physician, who expresses an information need, is represented by the **physician context**. The doctor's medical specialty and if necessary further specializations, his work experience and role, but also his preferences regarding specific topics of interest or presentation forms of knowledge and information are described in this model. Eventually the physicians' context can be interpreted as a kind of extended user.

The sophisticated **process context** as the third component of the context model represents the main extension in comparison with existing approaches. The embedding of physicians' activities into a medical workflow is of fundamental importance to anticipate which information is needed by a physician in the next workflow step and how the information can be delivered. It is also important to know, which is the actual activity, which are the following activities and more comprehensive process sequences, how often the physician has passed through a specific process type and who are further parties involved in the medical process.

The embedding of a physician into a physical and IT technical environment is captured by the **environment context**. In this context area it is captured, where the physician is located, which workplace system and end-user devices he is actually using, which other persons and devices are nearby and at which point of time the physicians' information need is expressed. The environment context includes the essential attributes, which are also relevant in the context of ubiquitous and mobile computing.
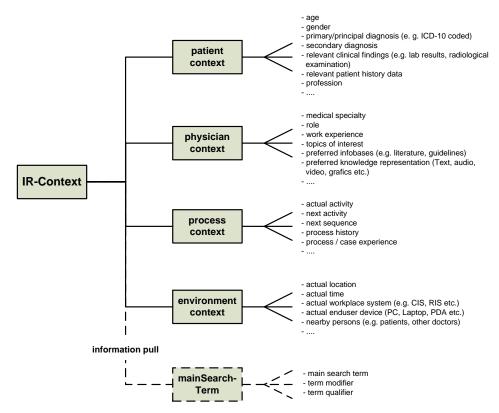
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**Figure 2:** Extended context model of information retrieval at medical workplaces

As previously mentioned the main search term as fifth context area is of high relevance for a physician in the context of active information pull. The main search term can be further specified by additional and qualifying information.

## 5 Summary and Outlook

Physicians' information supply in medical practice can often be characterised by information poverty with simultaneous information flooding. Due to lack of time, information complexity and information quantity important additional information, which can contribute to the improvement of medical acting and decision making, are not included into treatment processes. Context-based and process-oriented information supply can offer a starting point for the improvement of this problem definition. In the course of this a differentiated context model of the physicians' information need is a key element of information retrieval. An appropriate model was outlined in this paper.

In the future research work this context model and the single context attributes should be further detailed and validated by empirical studies with physicians. For this purpose it is necessary to develop an information logistic prototype, which is based on the extended context model. Starting form a clinical pathway and based on the extended context model physicians should be supplied with additional information, which can be retrieved from external e-Resources (e.g. Pubmed) and internal databases (e.g. clinical information system).

# References

1. Eppler, M.J., Mengis, J.: The Concept of Information Overload, MCM Research Paper (2002)
2. van den Brink-Muinen, A., Verhaak P., Bensing, J., Bahrs, O., Deveugele, M., Gask, L., Mead, N., Leiva-Fernandez, F., Messerli, V., Oppizzi, L., Peltenburg, M., Perez, A.: Doctor-patient communication in different European health care systems: relevance and performance from the patients' perspective. In: Family Practice 20 (4) (2003) 478 – 485
3. Deveugele, M., Derese, A., van den Brink-Muinen, A.; Bensing, J., De Maeseneer, J.: Consultation length in general practice: cross sectional study in six European countries. In: British medical journal, 2002 Aug 31, 325 (2002) 472 – 474
4. Reuter, C., Vollmer, G., Koch, O.: Work process-oriented implementation of medical guidelines. In: Shoniregun, C.A.: Proceedings of the International Conference on Information Society (i-Society 2006), August 7-10, Miami (2006) 17-24
5. Dey, A.K., Abowd, G.D.: Towards a better understanding of context and context-awareness. In: Morse, D.R., Dey, A.K. [Eds.]: Proceedings of the CHI 2000 Workshop on The What, Who, Where, When, and How of Context-Awareness, The Hague, Netherlands (2000) 304 – 307
6. Dey, A.K.: Providing Architectural Support for Building Context-Aware Applications. PhD Thesis, Georgia Institute of Technology (2000)
7. Schilit, B., Adams, N., Want, R.: Context-Aware Computing Applications. In: Proceedings of IEEE Workshop on Mobile Computing Systems and Applications, Santa Cruz (2004) 85 – 90
8. Selker, T.; Burleson, W.: Context-aware design and interaction in computer systems. In: IBM Systems Journal 39 (3/4) (2000) 880 – 891
9. Schmidt, A., Beigl, M., Gellersen, H.-W.: There is more to context than location. In: Computers & Graphics Journal, Elsevier 23 (6) (1999) 893-902
10. Gross, T., Klemke, R.: Context Modelling for Information Retrieval - Requirements and Approaches. In: IADIS International Journal on WWW/Internet 1 (1) (2003) 29-42
11. Ingwersen, P., Järvelin, K.: Information retrieval in contexts. In: Ingwersen, P., van Rijsbergen, K., Belkin, N., Larsen, B. [Eds.]: Information Retrieval in Context: Proceedings of the ACM-SIGIR Workshop 2004, Sheffield University (2004) 6-9
12. Jahnke, J., Bychkov, Y., Dahlem, D., Kawasme, L.: Context-Aware Information Services for Health Care. In: Roth-Berghofer, T.; Schulz, S. [Eds.]: Proceedings of the KI-04 Workshop on Modeling and Retrieval of Context, Ulm, September 20-21 (2004)
13. Cimino, J.J., Lia, J., Allena, M., Currieb, L.M., Grahama, M., Janetzkia, V., Leeb, N.-J., Bakken, S., Patela, V.L.: Practical Considerations for Exploiting the World Wide Web to Create Infobuttons. In: Medinfo 11 (2004) 277-281
14. Cimino, J.J., Li, J., Bakken, S., Patel, V. L.: Theoretical, Empirical and Practical Approaches to Resolving the Unmet Information Needs of Clinical Information System

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    Users. In: Kohane, I.S. [Eds.]: Proceedings of the AMIA 2002 Annual Symposium, American Medical Informatics Association, San Antonio (2002) 170 – 174

15. Cimino, J.J., Meyer, M., Lee, N.-J., Bakken, S.: Using Patient Data to Retrieve Health Knowledge. In: AMIA 2005 Annual Symposium Proceedings (2005) 136 – 140
16. Del Fiol, G., Cimino, J.J., Rocha, R., Maviglia, S., Strasberg, H., Kuhn, T.: Infobutton Communication Standard Proposal, Draft Standard for Trial Use (DSTU), Health Level 7, Date: 2006 Mar 10 (2006)