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META DATA TO META INFORMATION: A CASE STUDY FROM HEALTH SERVICES

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ABSTRACT

This research paper discusses the concept of M-data with reference to health care sector. Thereafter the concept of M-information is introduced including definitions, examples, nature, uses and extraction techniques. M-information can be extracted using algorithms, artificial neural networks, heuristics, data models, decision support systems, models etc. But this current paper is based on a CASE study that utilizes Queuing model. This leads to conceptual information that is represented as a series of production rules (IF…..THEN). These rules can be used to validate the concept extracted from the underlying Decision Support model.

Keywords: *Meta Information, OPD, Healthcare, Queuing Model etc.*

2000 AMS Subject Classifications: *68T01, 68T15, 68T20, 68T27.*

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1. INTRODUCTION:

A hospital information system (HIS) also called clinical information system (CIS) is a comprehensive, Integrated, computer-assisted systems designed to store, manipulate and retrieve information concerned with the administrative and clinical aspects of providing medical services within the hospital. This encompasses paper-based information processing as well as data processing machines.The aim of an HIS is to achieve the best possible support of patient care and administration by electronic data processing.

An electronic medical record (EMR) is a medical record in digital format. Many physicians currently have computerized practice management systems that can be used in conjunction with health information exchange (HIE), allowing for first steps in sharing patient information (lab results, public health reporting) which are necessary for timely, patient-centered and portable care.

This current research paper first introduces the concept of Metadata including definitions, types, use and examples. Thereafter the concept of M-information is introduced; various aspects of M-information like definition, nature, examples and generation are illustrated through a CASE-study taken from a hospital's operational data. A suitable representation for such conceptual information is illustrated and validation of concepts obtained is also discussed in reference to machine learning techniques.

2. METADATA & META-INFORMATION:

2.1. Metadata: Metadata also called "data about data", describe the content, quality, condition, and other characteristics of data. Metadata are used to provide documentation for data products, database, image, audio file etc. While this may be any type of description, the term metadata generally refers to structured text descriptions (in machine-understandable format) of attributes of resources or information-bearing objects for use and communication by computers across networks. Metadata also answer who, what, when, where, why, and how about every fact of the data that are being documented. Metadata describe different aspects of data, including identification, data quality, reference and organizational information, entity and attribute Information and distribution. Metadata is generally grouped into three types- Descriptive metadata, Structural metadata, Administrative metadata [1].

2.1.1. Need of Metadata: Metadata helps in publicizing and supporting the data that organizations have produced. Standardized metadata support users in effectively and efficiently accessing data by using a common set of terminology and metadata elements that allow for a quick means of data discovery and retrieval from metadata clearing houses. Based on standards, metadata ensure information consistency and quality and ensure that important parts of data knowledge are not lost. The need also arises from having to make inferences. M-data is also needed to represent design making information at the highest level of analysis and thought.

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2.1.2. Metadata Structure: The structure of metadata must be standardized for different computers and networks to be used and communicated consistently among different systems (interoperability).Standardization of metadata for an application or process involves specification of its structure and agreement of the specification by stakeholders at many levels of detail (with examples), character encoding (Unicode, ASCII, etc.), language (English, Japanese, etc.), controlled vocabulary (MeSH, SNOMED CT, etc.), message structure (DICOM, HL7, etc.) and formatting (ASN-1, XML, etc.).

An example of a metadata is a record that describes a journal paper within the MEDLINE/ PubMed medical citation database in extensible Markup Language (XML.) [1].

2.1.3. Use of Metadata: As described earlier metadata is used to organize and process data and information for increased usability and interoperability among different organizations and their information systems.
In medical care, descriptive metadata define demographics, diagnoses and care of patients for the purposes of documentation, communication, transaction and monitoring. Such metadata is created and used within the medical record by care providers, administrators, insurers and regulatory agencies to communicate and document care and to keep track of transactions, payments and operations. In health care transactions, structural and administrative metadata define the formats in which coded data in textual and non-textual formats (such as imaging data) is created, transmitted and stored for use and archiving, such metadata specifies the ways that data and information are exchanged between electronic systems for consistent processing (interoperability). Examples are the *health level seven reference information model* (HL7 RIM) and *digital imaging and communications in medicine* (DICOM).
In medical publishing and librarianship, descriptive, structural and administrative metadata are used extensively to archive and index publications (journal papers, books, electronic media, etc.) for identification and retrieval.

2.2. M-Information

Meta information is information about information and it is at higher level than M-Data. An example is a Library catalogue which contains information about all books in the library such as its title of the book, name of the author, name of the publishers, year of Publication and place of publication etc. Similarly a driving license is Meta information as it contains data about a person's license. At an individual level Meta information is used by the mind to perform reasoning.

This includes making inferences, storing intermediate results and information processing along with validating hypotheses. We can also call this reasoning at the Meta level, where the Meta level is the highest level of reasoning and thinking. The nature of Meta information is varied and it consists of broadly the following:

- Theories.
- Heuristics.
- Concepts.
- Meta Knowledge.
- Facts and Rules.

Thus Meta information needs to be stored, represented and then used for making inferences. The task of making inferences is assisted by its various components like theories, heuristics, concepts, Meta knowledge and by facts and rules. The human mind uses these varied components in different ways in order to generate inferences. In the current research paper, the aim is to show how concepts can be obtained, represented and then used in generating inferences, with respect to the central task of OPD management in a hospital. The corollary is that Meta information is composed also of conceptual information and the derivation and use of concepts is an important research area in AI.

2.2.1. Concepts: Concepts are the mental categories that help us classify objects, events or ideas and each object, event or idea has a set of common relevant features (Wikipedia Definition).

Concepts are obtained through the process of reasoning in the human mind and are stored for future reference and usage. They represent a generic entity. An example of a concept is - hard work pays in the long run. This information has to be derived by the process of reasoning. Can we simulate a similar process in the computer? Can we obtain a concept by the process of reasoning represented as a computer program? Machine learning has an important role to play in terms of using data mining. As an example data mining uses historical data to improve decisions – looking at medical records and applying it to medical knowledge when making a diagnosis.

In particular data mining techniques like rule induction can be employed to obtain concepts and these can be used for referencing and in making inferences. In such cases, conceptual information is represented as rule based information e.g. by If…..Then type of production rules.

In this paper it is shown that data mining is used to obtain such Rule based information, which can be used to represent the Meta Information obtained. Along with data mining, the other sources of such Meta Information are - models, heuristics, and primary concepts along with experience and Examples, which can also be a valid input for deriving legitimate concepts.

In terms of OPD management, we are interested in obtaining concepts that help us to know what we don't know – example - optimized resource allocation e.g. optimal number of registration counters, optimal number of doctors for a particular OPD department in a hospital. Such concepts can be represented by IF….THEN rules and can be obtained through the application of appropriate decision support models and data mining techniques. The task of Meta information in this case is to know the optimal resource allocation. The algorithms for getting these values insert them in the user defined template for storing this Meta information. Such optimization can be done through applying waiting line (queuing models) in this section of hospital.

3. GENERATING M-INFORMATION:

The organization of an OPD in a hospital is shown in the figure 1. While a hospital information system generates reports and automates the different departments i.e. OPD, pharmacy, diagnostics, there is a need to determine optimal allocation of resources. This is determined by M-information.

The extraction of Meta- information can be obtained through: models, heuristics, data mining techniques and algorithms etc. as shown in figure 2. In particular, the template for storing such M-information is shown in figure 3.

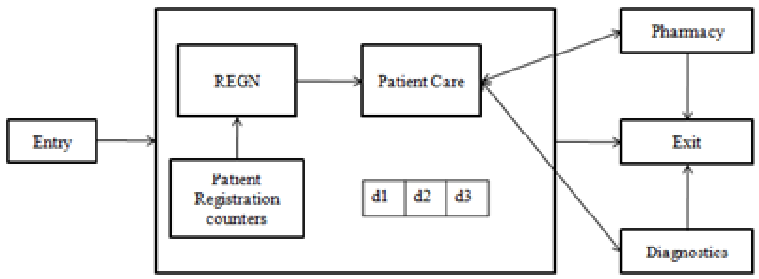

Figure -1: Organization of OPD

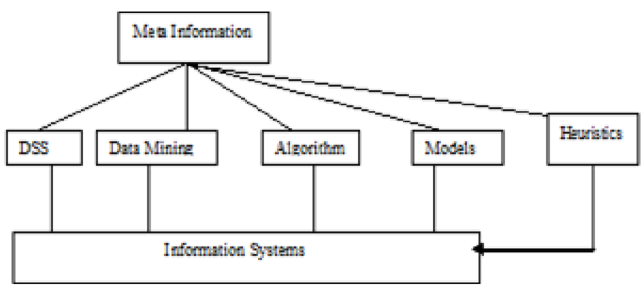

Figure – 2 : Meta Information Extraction Techniques

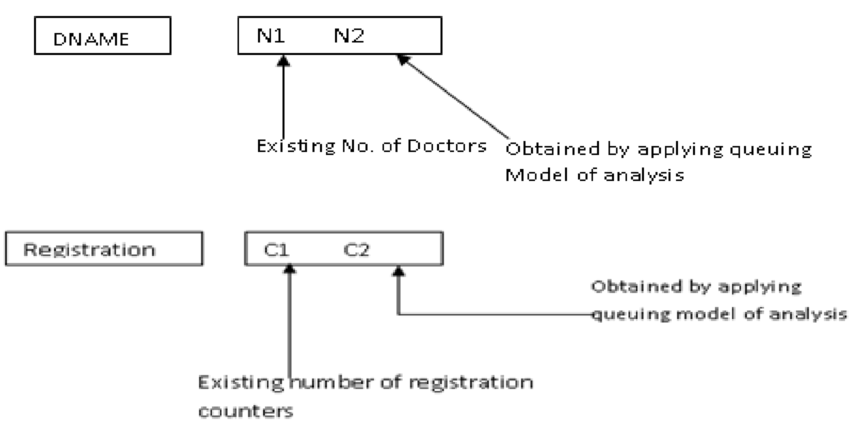

Figure – 3: Template for Storing M-Information

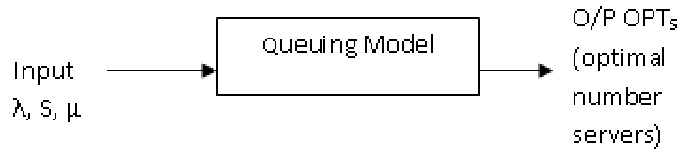

Figure - 4: Queuing Model

Where λ is average rate of arrival of patients, μ is average rate of services of patients by existing number of servers S.

The parameter values are obtained by sensitivity analysis using queuing model. The Meta information (conceptual information) is generating from these inferences made by queuing model and can be illustrated below.

The process of concept extraction and validation can be illustrated through a small example. The M/M/S queuing model [5] is applied for decision analysis in a hospital, with the objective of optimizing the number of rooms for emergency case. The patient arrival and servicin along with the existing number of rooms is input to the queuing model, which produces the following decision table, through sensitivity analysis:-

	C = 3 Rooms	C=4 Rooms
L_q	17.30	1.80
L_s	20.15	4.64
W_q	1.92	0.20
W_s	2.24	0.52
P_o	0.0118	0.0839

It can be seen that the addition of another room positively impacts the system performance. This decision table is input for concept extraction and then their subsequent validation. The concept can be represented through IF….THEN rules and are obtained by traversing through the above table. Accordingly the following five concepts can be obtained:-

1. Traffic intensity $\rho = \lambda/\mu > 1$ for M/M/S queuing model with number of servers S, $S \geq 2$ for M/M/S model.
2. As resources (number of servers) increases, P_o (probability of all servers being idle) increases.
3. As number of server's increases the value of W_q and W_s reduces.
4. As number of server's increases the value of L_q and L_s reduces.
5. If C = 3, the corresponding value of Wq, W_s, L_q, Ls and P_o can be retrieved suitably.

These concepts can be represented by IF….THEN type of rules in a knowledge base, as follows:-

R1 C1 If $S \geq 2$ ^ $\rho>1$; then valid M/M/S model.
R2 C2 If S < S1 < S2….. ; then $P_{00} < P_{01} < P_{02}$….
R3 C3 If S < S1 < S2……: then $((W_q > W_{q1} > W_{q2.....})$ ^$W_s > W_{s1} > W_{s2........})$
R4 C4 If S < S1 < S2……; then $((L_q > L_{q1} > L_{q2....})$ ^$L_s > L_{s1} > L_{s2........})$
R5 C5 If C = 3; then (L_q =17.30 ^ L_S=20.15 ^W_q=1.92 ^W_S=2.24 ^P0 = 0.0118)

Where R1 to R5 are rules and C1 to C5 are the concepts.

These production rules R1,R2,R3,R4,R5 represent the conceptual information C1,C2,C3,C4,C5. These 5 concepts represent the M-information obtained, which can be used for reasoning at M-level as given below;

C1	C2	C3	C4	C5

Figure - 5: Structure of M-Information

The validation of these concepts can be done by referring to the corresponding rules R1, R2, R3, R4, and R5 respectively such as;

(i). Query: Is it a valid M/ M/ S model.
(ii). Reasoning: Use production rules R1.
(iii). Calculate value of traffic intensity ρ.
(iv). For valid R1, $\rho>1$, this means only positive instances of concept C1.

4. CONCLUSIONS*:*

M-information is used for reasoning at the Meta level. The nature of Meta information is such that it consists of theories, heuristics, Meta knowledge and concepts. This paper shows the extraction of concepts through applying mining techniques on a data table, generated by DSS queuing model. Thereafter, the generated concepts can be validated by applying the corresponding production rules from a knowledge base. Concept validation can also be done through examples, experience and other techniques of machine learning. This paper has discussed the validation of concepts, in a case study, based on positive instances of a concept. In future work negative instances can be added to show the negation of the concept.

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