# Timeline-based Clinical Case Manager

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**Abstract— The main purpose for visualizing medical data in Clinical Information Systems (CISs) is to convert the medical data in relevant information about the patient's health status. The process of conversion from single disparate data into useful information considers as relevant input datasets the known clinical problems and their clinical pathway, the already collected medical data and the social, demographic and administrative data. Visualization of the medical data represents the operational decision support system at point of care. The concept presented in this paper is a potential solution to the existing CISs' shortcomings, through the extent of the timeline-based social networking experience to medical software, and at the same time, by applying the industry standard of business process modeling, Business Process Modeling Notation (BPMN) 2.0 in encoding the clinical pathways and administrative processes. The primary goal of the Timeline-based Clinical Case Management System (TCCMS) is to give a comprehensive picture of patients' condition, both real-time as well as historically, using textual and graphic means, and to sustain, in a task-oriented approach and based on advanced decision support algorithms, the application of accurate treatment plans and actions. This paper presents a data visualization concept that hides under a simple temporal relation all the complexity of medical field, into a familiar Graphical User Interface (GUI), promoted by social networks in the last years, finally giving the chance to healthcare IT to become completely paperless.**

***Keywords-Medical data visualization; clinical pathways; timeline; case management; BPMN.***

## I. INTRODUCTION

*"The Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data and radiology reports." [1]*

A large majority of the existing CISs emphasizes the need for separating between accessing medical history and the operational user interface.

The current CISs' market covers most of the healthcare provider operational needs in regard to clinical services with some degree of support for point of care clinical decisions. The GUI for documenting clinical cases is centered usually on patient and patient banner in order to help the medical personnel to easily identify the current patient clinical context.

This ensures a comprehensive standard-based approach in regards to CISs functionalities, which is regulated by the world's leading medical informatics organizations: HL7 EHRS [2], CCHIT [3], Eurorec [4] / Prorec [5], etc.

In this context, in order to analyze the current state of the art, we need to structure the existing knowledge in three domains: clinical pathway visualization, relevant medical data visualization (medical and administrative) and the combination of these two - medical data in clinical context.

Clinical pathway visualization should be considered from two points of view: from the point of view of clinical pathway encoder or designer, and from the point of view of the one who is executing the patient current clinical pathway requested actions. Projects/solutions like Protégé [6], Tallis Toolset [7], GUIDE [8], GLARE [9], VisiGuide [10], AsbruView [11], etc., are suitable for encoding and/or execution of a clinical pathway, but with limited adoption by the healthcare providers.

Not necessary in relation with the clinical context, projects like Graphical Summary of Patient Status [12], Time Lines and LifeLines [13], PatternFinder [14], KNAVE and KNAVE-II [15], VISITORS [16], VIE-VISU [17], Interactive Parallel Bar Charts (IPBC) [18], Gravi++ [19], and others moved in the direction of visualizing the medical relevant data.

There are also very few combined approaches of medical data in clinical context: Guideline Overview Tool (GOT) [20], Midgaard [21], CareVis [22], NHS Common User Interface [23], Visual-D [24], but most of them failed to be widely adopted.

The barriers in CISs' adoption are mainly generated by the GUI complexity through the magnitude of change perceived by medical personnel accustomed to work with paper documents. The CISs usually ignore their practices and their social, communication and professional context and this is reflected in unified browsing experience for heterogeneous data and inefficient decision support at point of care.

The potential solution to the previously mentioned CISs' shortcomings consists in extending of the timeline-based social networking experiences to medical field by hiding under a simple temporal relation all the complexity of medical field with benefits especially in user adoption and learning curve.

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The paper structure, section by section, is presented below:

Section II describes the challenges experienced in conversion of medical data into relevant information about the patient's health status,

Section III describes the concept and the elements of novelty of such a system in the Electronic Health Record (EHR) context,

Section IV describes the main set of functionalities required for the concept implementation and

Section V presents the way forward in concept implementation.

## II. MEDICAL DATA VIZUALIZATION

The main purpose of medical data visualization in patient-centric CISs is to convert the medical data in relevant information about the patient's health status. The process of conversion from disparate data into useful information should be analyzed at least from several perspectives: communication, computer science (and GUI) and healthcare domain (especially, clinical context and clinical pathway).

The relevant input datasets which are used by the data visualization process could be grouped in three categories: known clinical problems and their clinical pathway, the already collected medical data and the social, demographic and administrative data.

Basically, the medical data visualization in a CIS should represent the operational decision support system at point of care and at the same time a Clinical Case Management System (CCMS).

It is essential to visualize the current clinical problem and its corresponding clinical pathway; also, to know what are the active problems (including chronic clinical problems), what the medical history is, what the recent objective observations are, what the social, demographic and administrative details are, etc. The progress observed in the patient treatment, the definitions of the clinical pathways with specific actions, stages, conditions and so on and nevertheless the best practices of the clinical problem (to treat the health problem) should be accessible.

It is obvious that the level of adoption of industry standards in terms of functionality it's quite limited and the main barrier in adopting comes from the fact that implementation does not take into account the end user practices and their context.

Medical personnel are accustomed to work with paper documents and previous attempts to create paperless solutions have failed due to the magnitude of change perceived by the often non-technical end users mainly because of GUI complexity.

So, the medical professionals need a Clinical Case Management System, developed around their current social, communication and professional context, able to manage operational processes and, at the same time, to provide an efficient point of care decision support.

## III. TIMELINE-BASED CLINICAL CASE MANAGEMENT SYSTEM

The concept presented in this paper is a potential solution to the previously mentioned shortcomings in order to extend the timeline-based social networking experiences to medical software and at the same time to introduce the industry standard of process modeling, BPMN [25], in encoding the clinical pathways. The primary goal of the Timeline-based Clinical Case Management System (TCCMS) is to offer a comprehensive picture of patients' condition, both real-time as well as historically, using textual and graphical means, and to sustain, in a task-oriented approach and based on advanced decision support algorithms, the application of accurate treatment plans and actions.

Furthermore, using clinical protocols and timelines, in combination with the visualization of patients' relevant medical data, dramatically improves the point of care decision support.

Another important characteristic of TCCMS is the fast development and reusability of medical templates, achieved through an external component, part of a Business Process Management Solution (BPMS) [26] also used to execute clinical protocols and guidelines that encode and organize the decisions and action tasks for the medical personnel.

A BPM-based case management solution in healthcare offers the benefits of configurable workflows for both the medical areas (clinical pathways) as well as the administrative areas (Admission, Discharge and Transfer). An example of BPM implementation of administrative processes (outpatient encounter) is presented in Figure 1. The presented process allows the basic management of the outpatient encounter, managing also the exceptions like encounter reactivation, automatic checkout or canceling the encounter. The notifications are also part of the process definition by the fact that the process can be started based on a received message from the appointment system, and also, the process contains a throw notification event designed in fact for the communication with inpatient encounters systems.

Based on the medical documents associated with a patient and on a complex array of business rules as a part of the current clinical pathway, relevant alerts regarding a specific patient (e.g., allergies, high cardiovascular disease risks etc.) will be triggered. Moreover, the alerts must suggest recommended actions to be taken as a consequence.

During clinical pathway encoding, using the clinical pathway development environment as a collection of workflows designer, advanced business rules designer, process simulators and execution engine, the clinical pathway encoder has the possibility to define customized alerts based on a patient conditions, in order to generate at runtime all sorts of critical patients' status notifications.

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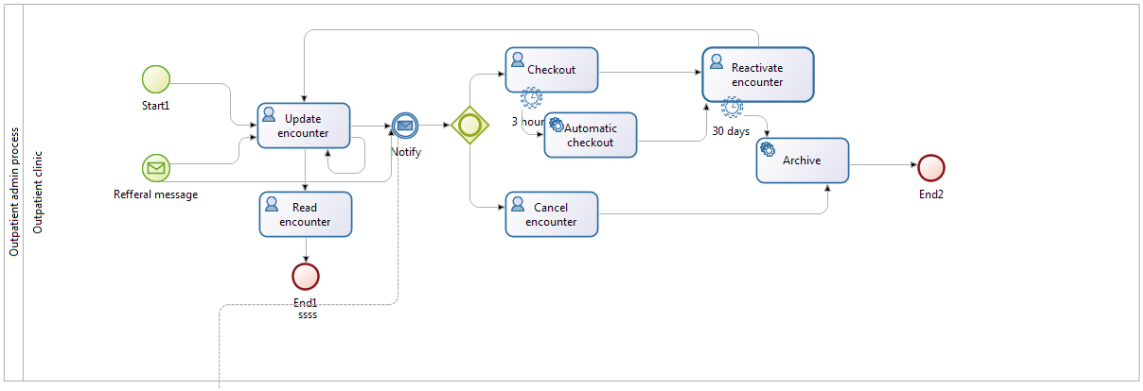


Figure 1. TCCMS - Simple BPMN representation of outpatient encounter

TCCMS overcomes the problem raised from the unavailability of easily interpretable clinical guides within existing medical applications and takes the recording of clinical information beyond historical and statistical reasons, by being a proactive solution that is giving a strong decisional support to the medical personnel. As a concept, TCCMS targets directly any type of healthcare provider.

The central piece of this approach is the Clinical Timeline, representing a historical view of clinical documents disposed along a vertical time axis as thumbnails, which offers a clear and actionable insight into the patient's clinical history, as presented in Figures 2 and 3.

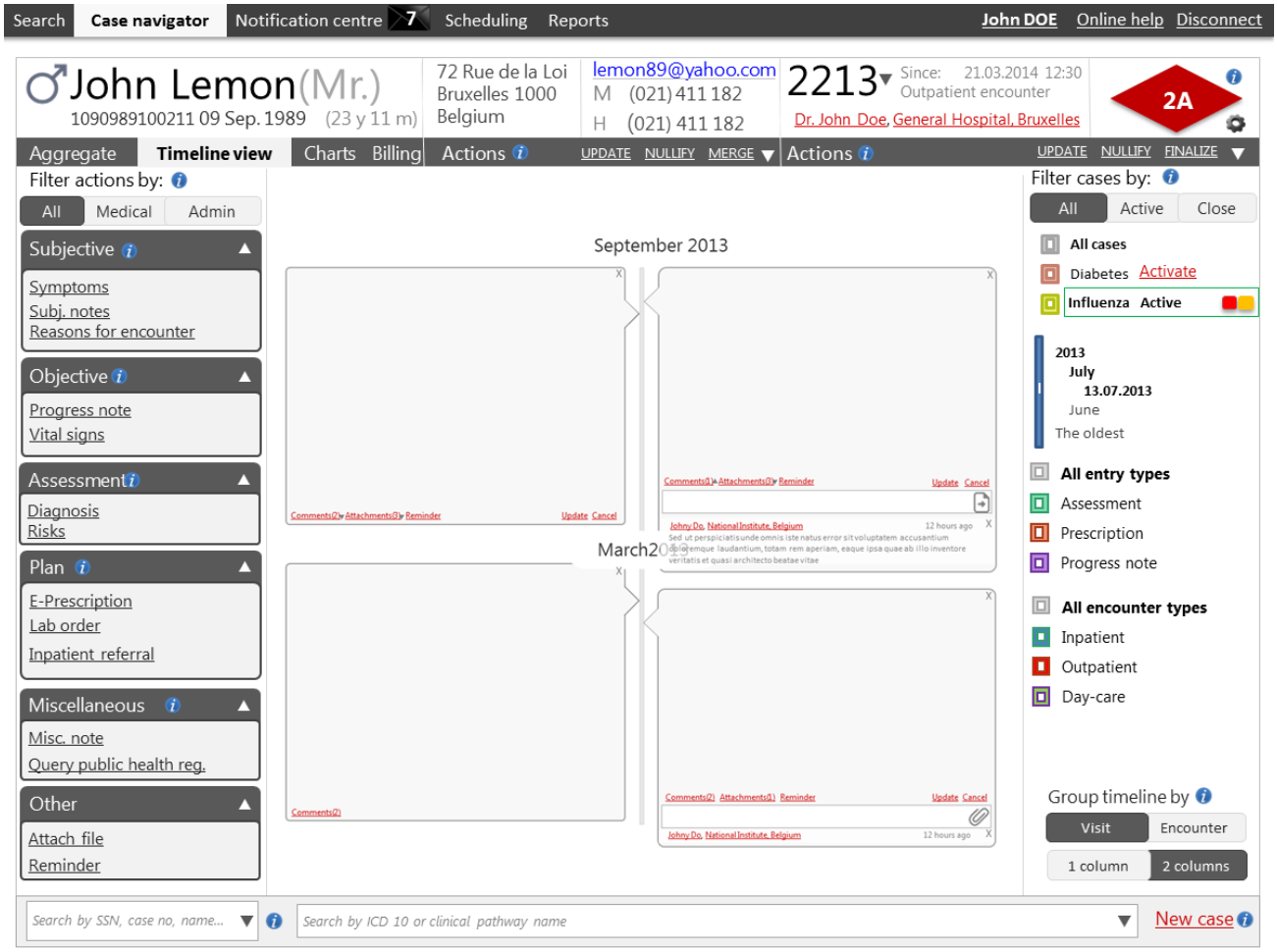


Figure 2. TCCMS - Timeline view with entries grouped by event dates (concept)

## IV. TCCMS KEY FEATURES

There are few core features implemented by the proposed system:

Visualization

Medical documents displayed as thumbnails along a vertical timeline;

Problem management

Capability to initiate, activate or inactivate a new episode of illness;

Encounter management

Capability to execute administrative actions like admission, discharge and transfer;

Documentation and actions

Case-level actions;

Document-level actions;

Document-level comments that can generate actionable alerts;

Possibility to attach unstructured documents;

Capability to also view the documents added directly by the patient through the PHR;

Filtering

Filtering records by medical staff, problems/diagnoses, types of medical documents;

Filtering records by administrative events/medical encounters;

Integration

Integration with diagnostic departments (laboratory, radiology, functional explorations, etc.);

Integration with local or national e-Health services (e-Referral, e-Prescribing, national EHR, etc.) and reflected by specific actions (e.g., dispatching a referral);

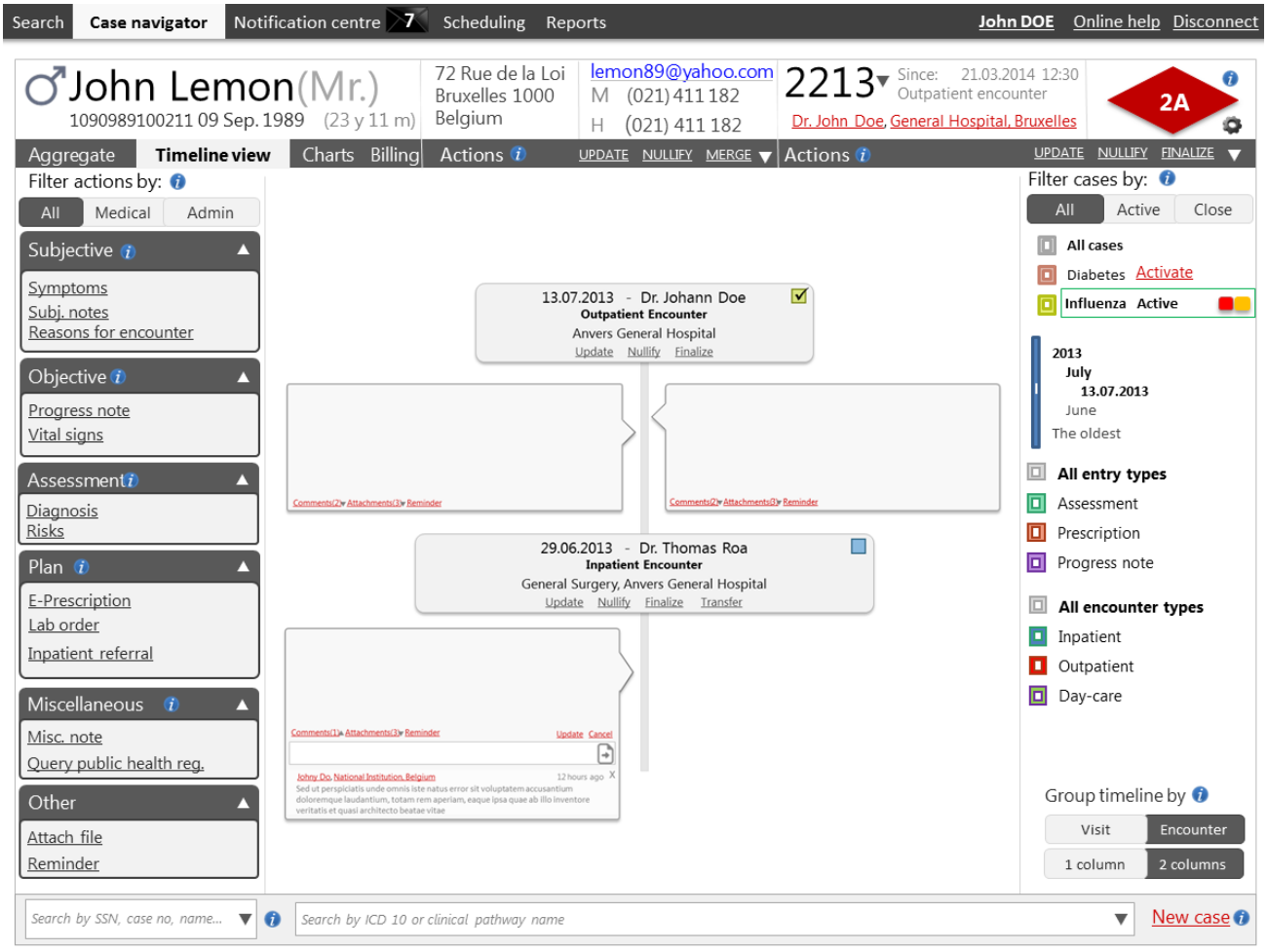


Figure 3. TCCMS - Timeline view with entries grouped by encounters

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As medical data sit at convergence the episode of care (the administrative sequences, usually collection of encounters) and episodes of illness (the medical events that are performed for treatment of a clinical problem), a comprehensive view of a patient's case must include both these interrelated aspects. Moreover, complex clinical workflows and treatments available today lead to the collection of patient-centric information in the form of series of numbers (often representing analyses results), medical documents, images and videos, all coming from different equipment at different points in time. As such, one of the main benefits of this approach, when compared with the tried and proven patient encounter-based interfaces, is represented by the possibility of dynamically loading a large volume of data that is time-sorted, meaning that most recent analyses and results will be shown first, allowing physicians to have a quick overview of the patient's situation. Moreover, the clinical timeline provides a unified browsing experience for a volume of heterogeneous data that was collected at different points in time and using a wide range of medical equipment.

The pervasiveness of computing platforms and their wide-scale adoption has led to the emergence of several new methodologies for user interface design that have been widely embraced by the public. One of the relatively new means of data presentation is the timeline. In order to provide a gentle learning curve and natural grouping of information, TCCMS GUI concept presented in Figure 4, is developed around familiarity gained from social networking services like Facebook and suitability of this approach to the medical domain, and therefore embraced the established graphical presentation patterns.

While not a new idea with regards to the presentation of medical information [29], timelines have been embraced with the advent of widely used social networks that popularized them. As such, they can be considered an already mature and well-known mean for data presentation, significantly reducing the steepness of the learning curve.

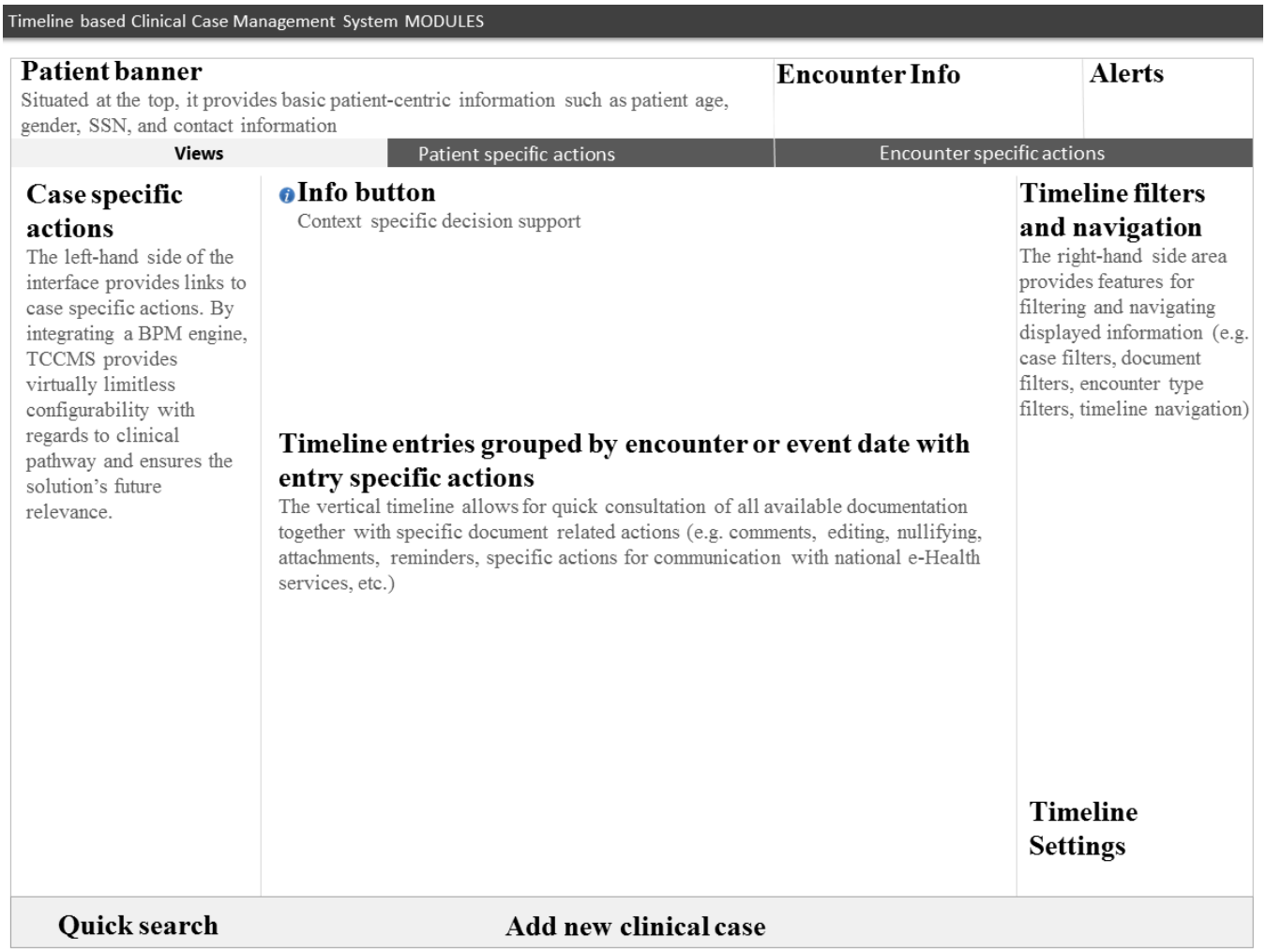


Figure 4. Conceptual layout description (concept)

## V. CONCLUSION AND FUTURE WORK

Despite the fact that EHR Systems are widely used, the paperless CISs are still a desideratum and the previous attempts failed due to the magnitude of change perceived by the often non-technical end users.

The last decade has created a new paradigm in which users have realized the need for systems that do not need or have very little need of training. This paradigm is based on user habits and their knowledge field.

Basically, the concept of Timeline-based Clinical Case Management System presented in this paper hides under a simple temporal relation all the complexity of medical field, the complexity of clinical pathways and administrative protocols and the decision support into a familiar Graphical User Interface, promoted by social networks in the last years, finally giving the chance to healthcare IT to become completely paperless.

Part of the concept described above is implemented in a Personal Healthcare Record solution [27] since 2012 and in 2013 was tested on small scale healthcare professionals' pilots on two verticals: oncology and family doctors. All the implementations proved significant benefits in user adoption and learning curve.

Currently TCCMS is under industrial implementation as a multitenant/cloud solution and the underlying development technologies are: Bonita BPM [28], Node.js [29] and AngularJS [30].

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