



## The use of Process Mining in Healthcare and why Celonis

The provision of quality hospital services is a direct function of executing the suitable Healthcare Processes (H/P) in a most efficient manner.

H/P are a series of activities aimed to diagnose, treat and prevent any diseases in order to improve a patient's health and are supported by clinical and non-clinical activities, executed by different types of resources (physicians, nurses, technical specialists, dentists, pharmacists, clerks).

As a main goal for H/P improvement is the high impact on **patients life quality**.

Furthermore, there is the need to:

- reduce the cost of services,
- improve capabilities in order to meet demand,
- reduce patient's waiting times,
- improve resources productivity, and
- increase processes transparency

While the analysis of both clinical and administrative processes can be useful in meeting these objectives, we need to keep in mind that H/P are highly dynamic, complex, ad-hoc, and increasingly multidisciplinary, making their analysis and improvement more of a challenge.

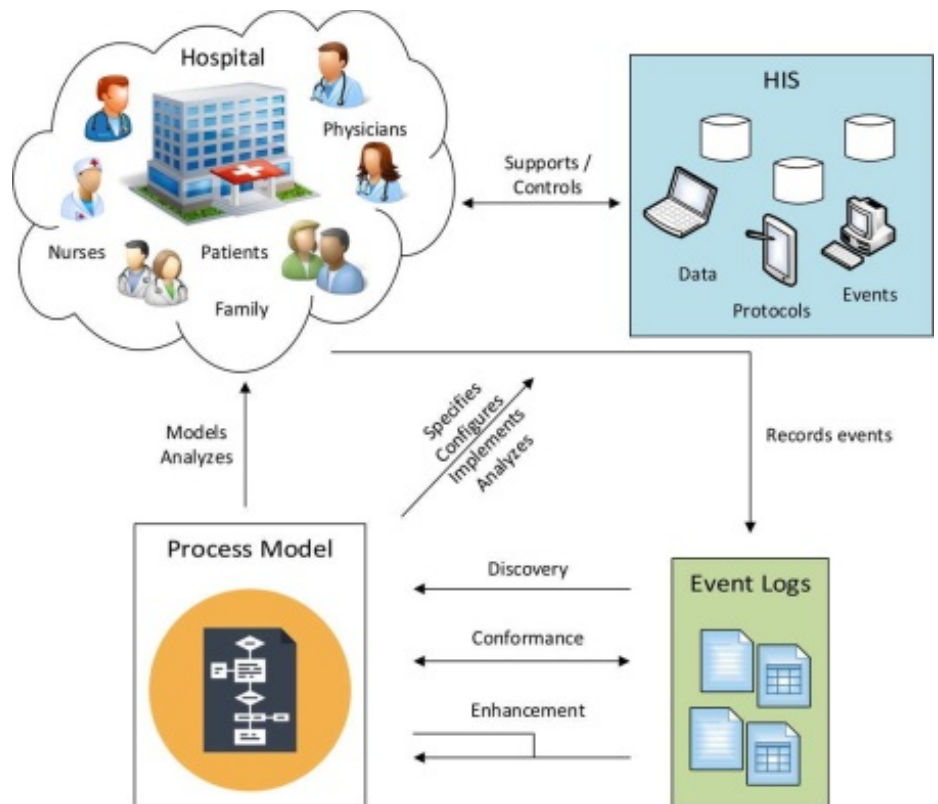
In the past, different strategies were used to analyze hospital processes, including among others Business Process Redesign, Evidence Based Medicine, and Lean.

**Process Mining (PM)** is a relatively young research discipline, developed in the past 10 years into a **leading technology by Celonis**. PM focuses on extracting knowledge from data generated and stored in the databases of (corporate/enterprise/organizational) information systems in order to build event logs [1] that today, with intelligent process analytics involving AI and ML can be used to analyze and improve executed processes.

Supported by various case studies with promising results in the healthcare domain, **PM** is an **emerging tool for improving sustainable healthcare processes**, aiming for process-aware Hospital Information Systems. The application of PM in healthcare allows health experts to understand the actual execution of processes: discovering process models, checking conformance with medical guidelines, and finding improvement opportunities.

Fig. 1 shows a **general outline of the application of PM in healthcare** [2].

Normally, any activity executed in a hospital by a physician, nurse, technician or any other hospital resource to give care to a patient is stored in a HIS (compound of databases, systems, protocols, events, etc.). Activities are recorded in event logs for support, control and further analysis. Process models are created to specify the order in which different health workers are supposed to perform their activities within a given process, or to analyze critically the process design.



Using PM techniques in healthcare processes not only ensures such procedures can be clearly understood, but can also generate **benefits associated with process efficiency**. For example, they can improve the quality of provided services as well as having a positive impact on the management of medical centers.

Furthermore, **PM can help** to:

- identify and understand the real behavior of resources and the patients;
- come up with suggestions for redesigning the process;
- analyze the performance and to reduce waiting and service times;
- obtain insight and improve the collaboration between peers;
- predict the behavior of patients according to previous cases;
- add additional information to activities such as patient data;
- identify which are the activities causing bottlenecks in the process;
- identify decision rules applied in different cases.

Moreover, process models can also be used to support the development of the HIS, for example, to understand how the information system is expected to support the process execution.

More details on PM below [3].



## Why Celonis?

A significant amount of recent research and development was invested in identifying the various benefits of technology in improving the healthcare system in general. Examples [4] include:

- reviewing the challenges and solutions for smart healthcare systems development;
- proposing the integration of different resources and technologies such as Internet of Medical Things (IoMT) and cloud computing to manage big data;
- discussing the improvements in capabilities of healthcare systems in detecting and controlling diseases when IoMT, AI and blockchain are used; and
- using deep learning for making decisions and recommendations in smart healthcare systems.

While ample research on AI-aided treatment has gained significant influence over conventional treatment methods, we can show how Celonis, the market leader in AI-enhanced (comparative and predictive) Process Mining and Process Excellence is using AI and ML today, to speed up Hospital Process Improvements.

Since the involvement of AI in the HIS is mainly aimed at Organizational Processes (like assigning tasks by shift and transferring medical information and knowledge between the different types of resources) and Business Processes for their core operations (like procurement, expenses and audit), without reaching into the Medical Treatment Processes (including tasks ranging from diagnosis to the execution of actions for alleviating each patient), there is no need for legal and ethical considerations.

Despite some massive digital investments aimed to transform their operations, healthcare providers of all sizes continue to run their core processes and operations through a complex mix of several individual systems. This complexity is not only due to rigid and fragmented system environments, but also across people [5], processes [6] and technology [7], all hindering their operational process efficiencies, generating costly execution barriers.

With the newly introduced **Process Sphere (CPS)** Celonis took another step towards ensuring Process Excellence by revealing the **full end-to-end map of the Healthcare business**, giving operational decision makers a **complete and holistic understanding** of how their Healthcare provider organizations operate.

It does this by allowing them to analyze the objects and events that make up every process:

- Objects are the individual items that are processed - think of patient admission orders or transfer orders.
- Events are the process steps that apply to those objects like approvals, changes, or status updates.

The underlying technology for CPS is **Object-Centric Process Mining (OCPM)**.

OCPM is a novel approach to process mining and execution management that allows management to better visualize and analyze the complexity and interconnectedness of Healthcare business operations.

From a user perspective up until recently there was still a great amount of reliance on experts when applying process mining in Healthcare or in any other industry. In its efforts to democratize PM, Celonis is



constantly working on ensuring that, its solutions are straightforward to apply, without the need of detailed knowledge of the tools, algorithms or techniques relating to the process-mining field, At the end of 2022 Celonis introduced **Business Miner (CBM), the collaborative PM for the non-technical business user.**

**CBM** reduces time to insights for the business user by:

- providing new and intuitive question-and-answer based exploration
- capturing, sharing, and collaborating on insights with existing and new users
- providing guided onboarding and set up for business users

CMB reduces time-to-value by helping top healthcare decision makers reach new levels of performance having better and faster process awareness, ensuring alignment and sound decisions and actions across their organization.

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*1. An event log can be viewed as a set of traces, each containing all the activities executed for a particular process instance. Process-Aware Information Systems (PAIS) [9] are systems that are readily able to produce event logs. Specific examples of such applications include Enterprise Resource Planning systems (e.g., SAP), Customer Relationship Management Systems (e.g., Salesforce), and Hospital Information Systems (e.g., HIS ). Event log data are not limited simply to the data from these applications, as many other systems can also provide useful data about process execution. Moreover, data relating to a complex process may come from more than one single source of information.*

*2. Source: Process Mining Discovery, Conformance and Enhancement of Business Processes 2011 book by Wil M. P. van der Aalst <https://link.springer.com/book/10.1007/978-3-642-19345-3>*

*3. There are three main goals of PM: process discovery, conformance checking, and enhancement. In his book [2], Wil van der Aalst, Dutch computer scientist also known as the “Godfather of PM” explains how automatic process discovery allows process models to be extracted from an event log.*

*How conformance checking allows monitoring deviations by comparing a given model with the event log; and how enhancement allows extending or improving an existing process model using information about the actual process recorded in the event log. Having an accurate model of the real behavior of a process improves the capacity of specifying and implementing the process requirements in the HIS that support the process, configuring any additional requirements not included in the system, and supporting the process analysis. In addition, the author in [2] notes the possibility of extending the analysis through other approaches, such as organizational mining, automatic construction of simulation models, model extensions, model repair, predicting process behavior, and recommendations based on history.*

*4. Reviewing the challenges and solutions for smart healthcare systems development (Sujatha & Ephzibah, 2020); proposing the integration of different resources and technologies such as IoT (Internet of Things) and cloud computing to manage big data (Elhoseny et al., 2018); discussing the improvements in capabilities of healthcare systems in detecting and controlling diseases when IoMT (Internet of Medical Things), AI and blockchain are used (Sharma, Malviya, Awasthi, & Sharma, 2021); and using deep learning for making decisions and recommendations in smart healthcare systems (Aujla et al., 2019).*

*5. Hospital stakeholders like: medical practitioners, patients, operational teams, regulatory bodies*

*6. Hospital processes like: admission, ER, transfer, medication, documentation, supply of drugs and medical devices, patient flow, etc.)*

*7. Hospital ICT like: ops support sw., infrastructure providers, storage service and cybersecurity providers, etc.)*