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UNIVERSITÀ DEGLI STUDI DI PADOVA

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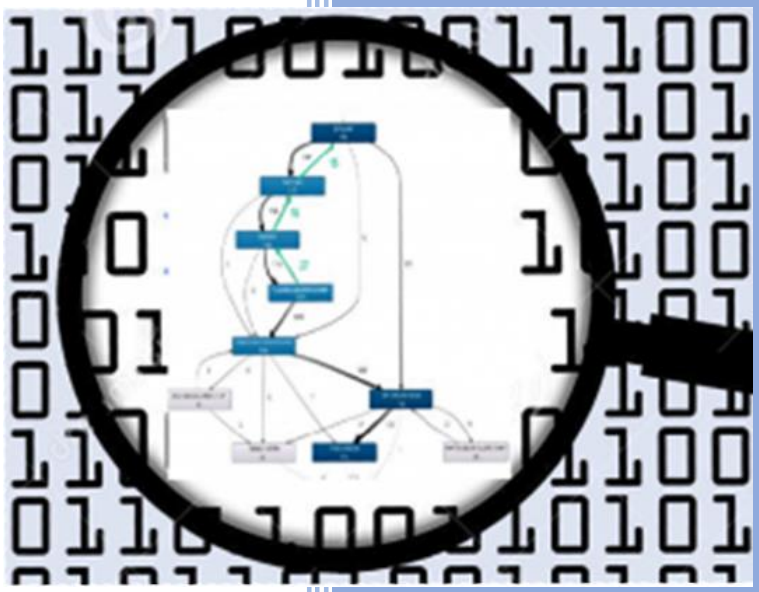
Analysis and Simulation of a Process

Project for the Process Mining Course – University of Padua



The assignment focuses on the analysis and simulation of the process carried out at an emergency department. A real life event log is available along with this document (*ED_Log.xes*).

The outcome of the project must be a document that shows the answers to the questions below. The document should not be more 15 pages, including screenshots, with a character size of 12 pts or more.

Note the following:

- ✓ Always provide evidence that supports your answers: always provide the pictures of the models, screenshots of different tools, conformance results, etc.
- ✓ You are not restricted to any techniques or tools. Feel free to even use techniques and tools that are not covered within the course.

Content

Description of the Process and of the Event Log

We aim to analyse the process to treat patients who visit the emergency department (ED) of a hospital in Tuscany (Italy). In fact, the event log refers to real executions of this process, and it was extracted from the information system of the hospital.

The process starts with a triage. Triage refers to the evaluation and categorization of the sick or wounded when there are insufficient resources for medical care for everyone at once.

There are two ways to perform this triage. The first is when a patient autonomously goes the ED (*Autonomous Triage)*. Alternatively, a patient arrives by ambulance (*Ambulance Triage)*. In both cases, a triage nurse carries out the required activities.

In this hospital, the triage activity assigns a triage color to the patient, which depends on the patient's severity, and thus on the urgency of the patient's treatment. The hospital managers determined a five-level triage that was each represented by a color: Red (immediate), yellow (observation), green (wait), blue (expectant), and white (dismiss).

After the triage activity, the patient may undergo a blood sampling by a nurse if necessary. Then, a physician (i.e., a doctor) visits the patient.

The physician can decide to discharge the patient immediately, but frequently (s)he decides that the patient needs further steps:

- Observation: The patient is retained at the ED to track his/her health stability. The patient is not sent to some hospital ward, but kept at the ED. There are a limited number of beds at the ED, one of which needs to be available for a patient to be under observation
- Laboratory test: This activity is at times carried out to verify the patient's condition
- Emergency Service: This activity indicates the performance of other types of support given to the patient. To simplify the process analysis, all these other support types are grouped under a single activity type.
- Radiological Examination: Sometimes, it is necessary to carry out some medical imaging of different nature:
    - Angio: Angiography
    - ECHO: Echocardiagram
    - MRI: Magnetic resonance imagining
    - TC: Computed Tomography
    - X-Ray: Radiographic testing

  After completing the required radiological examination, a radiological report is prepared as separate activity. A radiological report is not prepared for the ECHO test.

- Consultation activities: Patients are directed to medical specialists in the hospital, outside the ED.

Each patient can undergo any of the steps above, including none or everyone: indeed, each of them is optional. Afterwards, the patient is discharged.

In the event log, each trace refers to a different patient and contains the occurrence of the activities performed for those patients. The event log also contains the information about the resources that perform the activities. The ED works 7/24 with three shifts. Shifts hours are 00:00-08:00, 08:00-16:00, 16:00-00:00. **The resources are equally divided in those periods of the day**.

The event log also contains the information about the triage colors, which are the following, ordered by descending severity: red, yellow, green, blue, and white. Note that the ED defines a Key Performance Indicator (abbreviation KPI) that is used to determine whether process executions (i.e., the patient treatment) are adequate. In particular, the KPI is related to the first response time, namely the time elapsed between the triage and the beginning of the patient's treatment (e.g., the blood sampling or the visit). The satisfactory KPI values depend on the triage color. Table *1* summarizes the threshold values for the five triage colors.

Table 1. Key Performance Indicator

Triage color	Meaning	First response time
Red	Immediate	$\leq 10\ min$
Yellow	Observation	$\leq 20\ min$
Green	Wait	$\leq 60\ min$
Blue	Expectant	$\leq 90\ min$
White	Dismiss	$\leq 120\ min$

Questions

Using process mining techniques, answer the following questions.

Q1. Process Model

The hospital wants to gain further insight into how the process is executed. Suppose you are a process analyst. You want to provide a Petri net that represents the actual process executions.

Draw a Petri net and validate it by checking its conformance using alignments against the event log. If the alignment shows that the model is not satisfactory, iteratively improve the model until the quality of satisfactory. The model is deemed satisfactory if the fitness value is at least 0.85 and the precision value is at least 0.68.[1]

Q2. Process Discovery

The hospital stakeholders wonder whether the typical process behavior depends on the triage color[2], and whether patients are treated with the key performance indicator defined in Table *1*:

1. Discover process models for different triage colors, and compare whether or not significant differences are observed in the models of different triage colors.
2. Verify whether the hospital treats patients in accordance with the indicators of Table *1*. If some patients are not treated according to Table *1*, find what their percentage is.

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[1] In general, precision values of 0.68 are considered low. However, the health-care domains are typically characterized by a large variability, which corresponds to an amount of different behavior that is difficult to put into a precise model.

[2] To compare the sub-logs of different triage color, you need to filter traces according to the color attribute, which is associated with each log's event. This can be achieved via plug-in *Filter on Event Attribute Values*, which is briefly discussed in an appendix to the project description.

Q3. Process Simulation

The hospital is unsatisfied with the process and aims to deal with possible bottlenecks and overutilization of resources.

1. Build a simulation model in BIMP that defines case arrival rate, resource roles, task durations, branching probabilities.
2. Try different "what-if" scenarios to improve the process (e.g., you can reduce the number of resources of different roles at the emergency departments).

Appendix: Filter on Event Attribute Values

Filter on Event Attribute Values plug-in requires an event log that you want to filter considering attributes (see Figure 1). Click the triage color tab and select any value to filter (see Figure 2). Remember that giving a proper log name helps you to remember later.

Figure 1. Filter on Event Attribute Values plug-in

Figure 2. Selection of the event attribute