CRIMINAL PROCEDURE MANAGEMENT BASED ON BPM SIMULATION

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The Polish criminal procedure is strictly based on the Polish Constitution and complex legislation. It involves many steps, phases and stages and creates very complex processes that are composed of multiple sub-processes and activities. Nowadays, the participants of the Polish criminal procedure are provided with modern IT limitedly. Increase the effectiveness of criminal justice is possible via changes in both organizational and procedural way, as well as through the IT technologies supporting the processing of information at any stage of a criminal proceeding.

We propose two-way analysis of the criminal procedure: modelling and simulation of the process similarly to Business Processes Modelling (BPM), which forms the basis for measuring and assessing an effectiveness, and optimization based on hybrid models and methods: GAN/GERT with queuing theory and optimization. The practical result of this work is the workflow system extended with the business process simulator.

Keywords: the criminal procedure, BPM, business process simulation, court performance

1. Introduction

The new century has brought many positive changes stemming from the development of IT technology, the opening of institutions for people and thus simplifying and accelerating many official procedures. However, there are still

domains of life in which these changes are taking place very slowly. For proper functioning of a country the third power - the judiciary - is crucial. There is an urgent need for innovation in this area in the three dimensions: organizational, legal (formal) and technology. According to the social research, judicature is criticised by approximately 40% of the Polish citizens [3] – in particular, there have been criticized the costs and delays of criminal cases. From the other hand, the public budget allocated to all courts (excluding public prosecution and legal aid), as percentage of "GDP per capita", reached 0,38% in 2010 (Norway – 0,07%, Denmark 0,09%, UK – 0,1%) [4].

Nowadays, the participants of the Polish criminal procedure (judge, secretary, sites) are provided with modern IT limitedly. Although simple electronic tools for case-management are reported in 50% of courts (mostly civil, commercial or administrative courts, not criminal cases) there are rather stand-alone programs then integrated and distributed multi-function IT systems (e.g. electronic files are available in 10% of courts) [5].

Changes in the criminal process should be preceded by an analysis of the current status and the prospective changes necessary and possible to applying. If we treat criminal procedure in terms of business processes, the selected problems can be solved with the use of tools for process modelling and simulation, which will form the basis for assessing the effectiveness and finally optimization. Elimination or reduction of "bottlenecks" in that process, identifying how to redefine and reorganize the process, indicating the time and resource savings is possible to be made after identifying the real causes of problems. Simple examples are the complaints that are allowed by criminal code to submit on almost every stage of the proceedings. Another one is a necessity to service formal defects in criminal process documents (writs, letters, briefs etc.).

The subject matter is relevant in studies conducted in the world since the early 1990's. A huge effort has been done to estimate the performance of judicial systems - the analysis of court work from the point of view of economics at [1], [2], statistics or prognosis [4] and opinion polls as well as evaluation of the courts by citizens [3]. The paper presents a new approach based upon an example of a district court (case study in the District Court in Bialystok). The introduction briefly describes the background – the criminal procedure in Poland. Then we introduce IT tools for analysing the criminal process. Further, a formal model, research goals and the characteristics that describe quantitatively the processes are defined. The main task we have been conducting is a many-components workflow system extended with the business process simulator to analyse and search for the (sub)optimal management of criminal process stages using a computer simulation. Finally, we outline the requirements and concept of BPM simulator, short case study and conclusions as well.

2. Business process modelling of the criminal procedure

2.1. The background

In Poland, there are about 330 courts so-called "first instance (district)" courts, almost 50 "second instance (regional)", more than 10 "appellate" and one "supreme (highest)" court. In that structure there are ~10,000 professional judges working in courts: ~7,000 at first instance, ~3,000 at second and less than 200 at highest instance [5]. According to general statistics, more than 90% cases are proceeded by courts of first instance. Among different cases a weight of criminal ones is special, so due to the facts the role of criminal departments in district courts is really important.

The Polish criminal procedure is strictly based on the Polish Constitution and complex legislation. It involves many steps and stages that at the most general level are: Criminal investigation, Grand Jury proceeding and Execution of sentence. More detailed, there exists the following steps: Reporting of the Crime, Pre-arrest Investigation, Arrest, Arrest and Booking Process, Post-arrest Investigation, Decision to Charge, Filing the Complaint, First Appearance, Preliminary Hearing and/or Grand Jury Proceeding, Arraignment on the Information or Indictment, Pre-trial Motions, Plea Bargaining and Guilty Pleas, Trial, Sentencing, Appeals and finally Post-conviction Remedies.

The space of steps (and stages of proceeded cases) is perceived as discrete. Depending on goals it can be divided into different number of levels. Actually, this division creates complex processes that are composed of multiple sub-processes and activities. Each one is optional and can run according to various alternative paths thus a procedure can finish without executing all steps.

For the proper analysis of a criminal procedure and then the construction of supporting software tools (for workflow management and simulation) there is crucial to adapt a modern approach to business process management (BPM - Business Process Management). It is an approach that allows modern organizations and businesses to operate effectively in the market and respectively to customer needs.

2.2. BPM approach to the criminal procedure

The main objective of BPM is to adopt organizations to the needs of their customers. BPM cover the interlinked stages of activity i.e. the identification, analysis & modelling, simulation, implementation, launching and monitoring - which is also the main elements of a typical life cycle of business processes. Assumption is that the processes should be continuously improved on to ensure their accuracy, the ability to better achieve its goals and more competitive

company. The advantages are many, despite a solid effort required to implement and maintain such an approach.

According to BPM notation, every step is so called process (at the top level) and subprocess (the subordinated levels), which leads to decomposition to more complex model with more specific tasks. Main area of our interest is judicial criminal proceeding, which is the second step. Figure 1 shows its diagram at a higher level. It begins with the bill of indictment by the prosecutor. The case documents, especially indictment, are then verified by the president of the Criminal Department. This step is a complex subprocess called "Indictment verification" during which formal verification is performed and reporting judge is chosen.

If any formal problems with indictment occurs, subprocess called 120 KPK (120 paragraph of the Code of Criminal Procedure) is started, which means all formal defects should be resolved by prosecutor or indictment will be rejected. After "Indictment verification" step is completed the reporting judge has all the case files. In the next step, which also is subprocess, these documents are verified by judge and decisions including use of detention for the accused, discontinuance of the proceedings or going for trial are made. Depending on this decisions next steps are trial or session concerning the discontinuance of the proceedings (from which case also can go to trial step or sentencing step). Like steps before, trial is also a complex subprocess with multiple different paths, but unlike them it cannot be supported by BPM system. The last step, which is also subprocess, is sentencing. It is quite complex because events such as appeal or objection can occur. Diagram in Figure 1 may not look as complicated as the judicial criminal proceeding really is. In fact, there are four levels of subprocesses and some of them are executed more than once. For example diagram for process "Indictment verification" contains fourteen tasks and more than ten alternative paths. What more, two of those tasks are complex subprocesses. One is mentioned earlier, "120 KPK" step and the other one is complaint handling process. Both are used many times in further steps of judicial proceeding process. Complaint handling is particularly complex. It contains seventeen tasks and more than twelve different paths and, what causes most problems, loops (decisions made during complaint handling also may be subject to complaint). Considering fact, that almost every decisions made during judicial proceeding may be subject to complaint, it increases complexity of whole process dramatically. Steps responsible for handling defects and complains might be performed in other parts of judicial proceeding - they form so-called pessimistic paths. That is the most complex and time consuming part of this process. One of the main goal of modelling and simulation is to verify what is the impact of pessimistic paths on time of execution and cost of whole judicial proceeding.
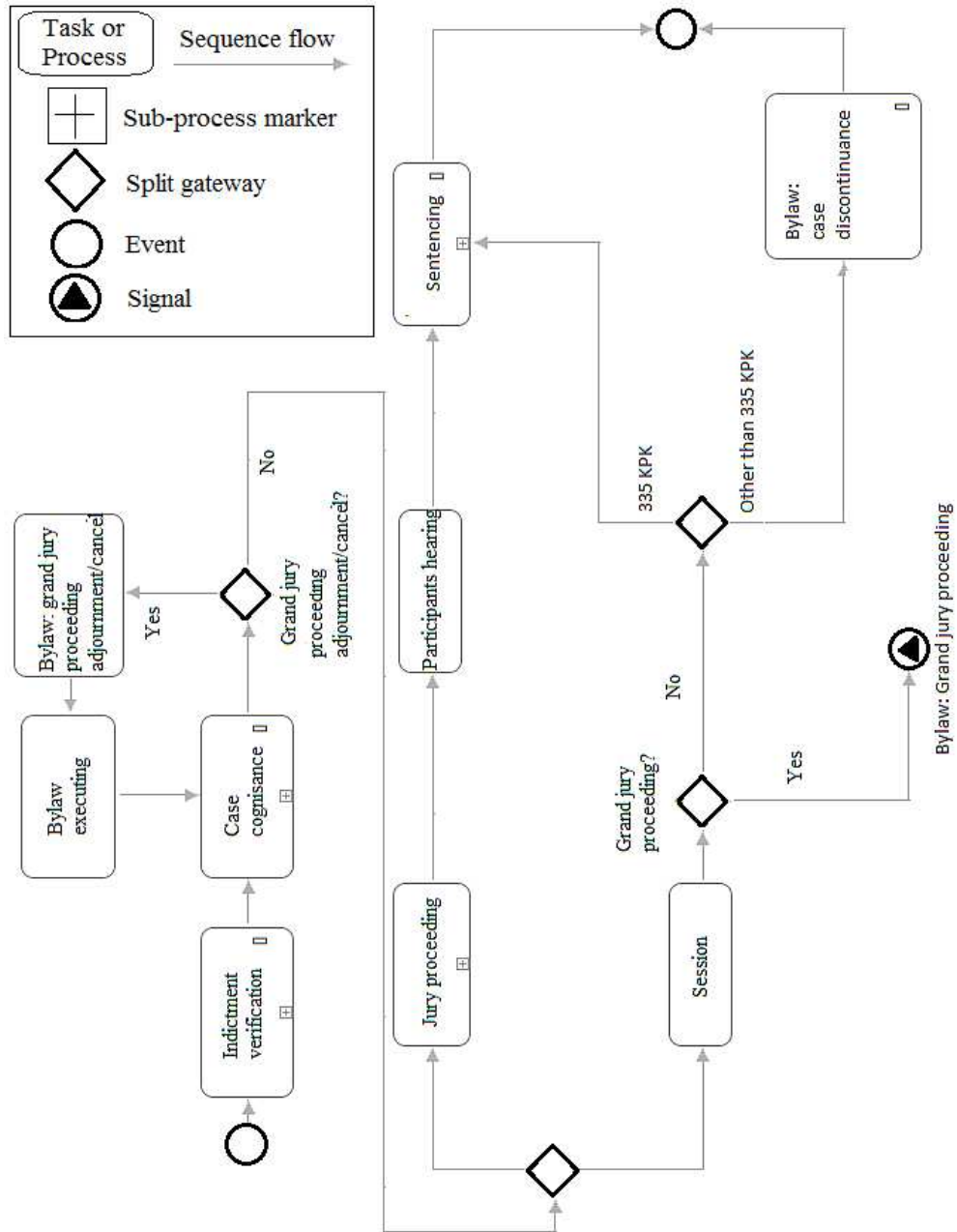
Figure 1. The higher level of judicial criminal proceeding

3. Simulation and optimization for management

Criminal procedure life cycle, similarly to BPM, follows the steps outlined at Figure 2. That cycle depends on correctness of modelling and simulation as well as reliable statistics gathered during execution. Thus, there is an obligation to develop adequate software tools for simulation analysis of effectiveness of the criminal process, which will help finding reasons of problems and allow for proceeding optimization. Generally, we focus on problems such as congestion, the high cost and delay of procedures elimination or reduction of "bottlenecks" in processes, suggestion of redefinition and reorganization processes as well as the time and resources saving, etc. Although simulation is very suitable the formal way is adopt hybrid models and methods: GAN/GERT with queuing theory and optimization.
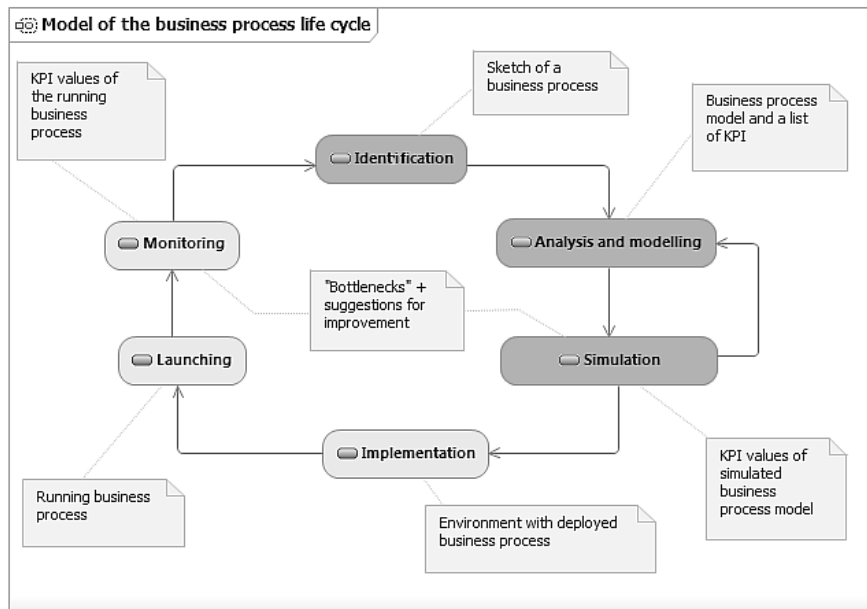

Figure 2. Model of typical business process life cycle

3.1. Formal models and methods

To model, optimize and simulate criminal process we can use some formal models and methods well known in operations research. For analysis of complex operations (processes, projects) following models and methods may be considered [8], [9]: queuing theory, CPM (Critical Path Method), PERT (Program Evaluation and Review Technique), CPM-cost, PERT-cost, GAN (Generalized Activity Network), GERT (Graphical Evaluation and Review Technique). In CPM, PERT,

GAN, GERT models events are described by graph's nodes and activities - by graph's arcs. Each of them has advantages and disadvantages. CPM and PERT methods have limitation to acyclic structure of projects and, in general, they are deterministic. CPM-cost and PERT-cost have extended properties because we may take into account not only realization time for activities but also cost, but they have the same disadvantages like pure CPM and PERT. Generalized Activity Network (GAN) proposed by Eisner [6] allows us to build project network in which realization of any event causes start of realization one of activities, not all of them for the event. GERT network [10], [11] is a type of GAN network. In GAN network activities may be deterministic or stochastic; dependencies between events and activities are being done using some logic operations which are described on "enters" to a node and "exits" from a node (see [6]).

For "enter" to nodes (events) we have following logic operations:

- conjunctive „and" – realization of the event takes place if and only if all activities which take end in the event are realized;

- alternative „or" – realization of any activity which take end in the event causes realization of the event;

- disjunctive „xor" (excluding-or) – realization of any activity which take end in the event causes realization of the event and one activity only which take end in the event can be realized at the same time.

For "exit" from nodes (events) we have following logic operations:

- conjunctive „and" – realization of the event causes realization of all activities which take start from this event;

- disjunctive „xor" (excluding-or) – if the event is realized, then one and only one activity which take end in the event is being realized with fixed probability at the same time; sum of realization probabilities of all activities which take start in the event provided that the event was realized is equal one.

In the case when all enters and exits for all nodes are conjunctive ("and"-"and") then the network is deterministic (CPM, PERT). Otherwise, the network is stochastic (GERT, GAN). Let's notice that in the crime process at the start and the end of any node in network we can have each of situations presented above. In Figure 3 we describe, as an example, a part of crime process deals with the first steps after submission of claim form.
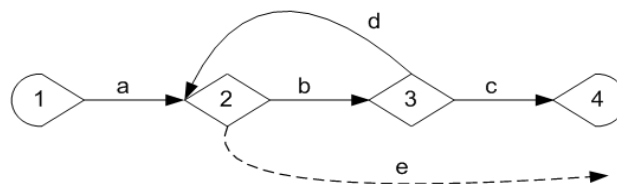
Figure 3. Example of GERT (GAN) analysis in crime process
Source: on the basis of [8]

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Activities (arcs) in the network have following interpretation:
- a – submission of claim form (for the first time);
- b – formal control of claim form;
- c – transfer of claim form for further processing;
- d – submission of claim form after removing formal defects;
- e – equivalent of path from node 2 to node 4 taking into account cycle 2-b-3-d-2.

Events (nodes) 1, 2, 3 and 4 describes, respectively: start of the process, event directly after submission claim form, event directly after formal control of claim form and event directly after transferring of claim form for further processing. Nodes 2 and 3 have alternative "enter" and "exit", node 1 has conjunctive "enter" and "alternative" "exit" and node 4 has alternative "enter" and conjunctive "exit" (in this case node 3 should has disjunctive "exit" and node 2 - disjunctive "enter" but for the example of using Elmaghraby's graph algebra the assumption is enough). It causes that the network is stochastic. Let's take into account that the network has the cycle 2-b-3-d-2. This fact causes that we can't use classical methods like CPM or PERT because in these methods it is required the network (graph) to be acyclic.

Taking into account Elmaghraby's algebra [7] for GAN/GERT networks we obtain following realization probability and time of the "e" activity [8]:

$$P_e = \sum_{n=0}^{\infty} P_a \left(P_b\right)^{n+1} \left(P_d\right)^n P_c = \frac{P_a P_b P_c}{1 - P_b P_d}$$

$$\overline{\tau}_e = \sum_{n=0}^{\infty} \left[\tau_a + (n+1)\tau_b + \tau_c + n\tau_d\right] P_a \left(P_b\right)^{n+1} \left(P_d\right)^n P_c =$$

$$= P_a P_b P_c \frac{\dfrac{\tau_a + \tau_b + \tau_c}{1 - P_b P_d} + \dfrac{\tau_d + P_b P_d}{1 - P_b P_d}}{1 - P_b P_d}$$

(1)

where:
P_x - realization probability of the x activity;
τ_x - realization time of the x activity;
n - number (count) of repetitions of the cycle 2-b-3-d-2.

A case when a cycle in a network has more than 2 arcs can be reduced to a case with two arcs only (like in the cycle 2-b-3-d-2) and we can use the procedure described by equation (1).

Conclusions:
(a) PERT and CPM (PERT-cost, CPM-cost) - graph must be acyclic; only "and" enters to nodes and exits from nodes can be modelled; deterministic graphs (even in PERT because of deterministic equivalent of characteristics described on nodes and arcs);

(b) GAN, GERT - "stochastic" events and activities give possibilities to model wider class of problems; possibility of modelling not only "and" enters to nodes and exits from nodes but also "or" and "xor"; problems to set probabilistic distribution of characteristics for events and activities.

3.2. The simulation component description

A complementary approach is BPM simulations where the basic expectations regarding proposed software tools concern the ability to construct the model of the criminal process, i.e. identification of this process and its editing (phases, activities, events, sent documents and the relationship between the components of the process), and then verify the effectiveness using simulation, including estimation of the value of certain parameters characterizing the process, e.g. the time required for the process or a fragment thereof, or the number of necessary resources needed for its running. We want to verify what is the impact of pessimistic paths on time of execution and cost of whole judicial proceeding. Identification of the parameters (potential criteria for assessment) the so-called KPIs (Key Performance Identifiers) to assess the effectiveness of the process should be conducted mostly based on the practical experience of law enforcement, prosecution and the judiciary. This could be done by making a specialized survey among experienced investigators, prosecutors and judges. Nonetheless, based on analyses carried out under this project, a comprehensive list of criteria for the evaluation process can be proposed.

It is also expected that constructed software tools will enable optimization of the criminal process involving e.g. searching "bottlenecks" of the process, an automatic (semi-automatic) reorganization of the process to achieve extreme (min or max) or reference value of the specified parameter/s of the criminal process.

An important feature of the constructed software tools should be an intuitive graphical user interface (in particular for the domain expert, such as a policeman, prosecutor, judge). For this purpose, it is proposed to use and adapt BPMN (Business Process Modelling Notation) to the specificities of the criminal process. The proposal to use BPMN follows that the notation has become a global standard for modelling business processes for different organizations of any structure and any level of complexity of the processes occurring in them. An important advantage of BPMN is the simplicity of implementation and deployment (automated transformation into an executable language such as BPEL4WS – Business Process Execution Language for Web Services) of the modelled processes within an organization, together with the support of IT systems, thanks to BPMN compatibility with concept of SOA (Service Oriented Architecture).
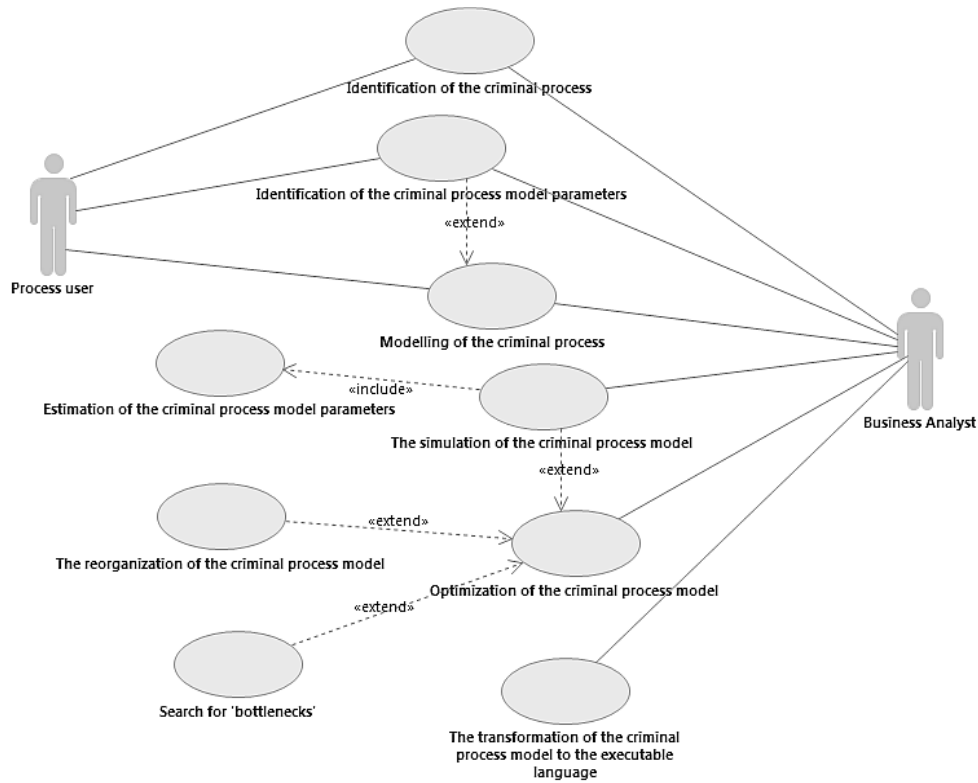
Figure 4. The main use cases for the IT system

The main component (Figure 5) is *SimulationEngine* consisting of *JGraph* and *Deskit*, which are together responsible for simulation of the judicial proceeding process. We have relied on mixed discrete simulation concept: event-driven and process-oriented. As the central elements of the simulation they provide data for the other components (by providing services for them), which are the *Optimizer* and *Statistics*. Data for visualization provides an interface called *ProcessView*. Depending on requirement, it may be used for standalone applications or web applications. *Simulation*, optimization and calculation of statistics requires a process model and setup of the experiment. They are provided by two components: *ProcessModels* and *Configurator*. The last one is also responsible for the conversion from JPDL or BPMN2 to graph model handled by simulation tool.

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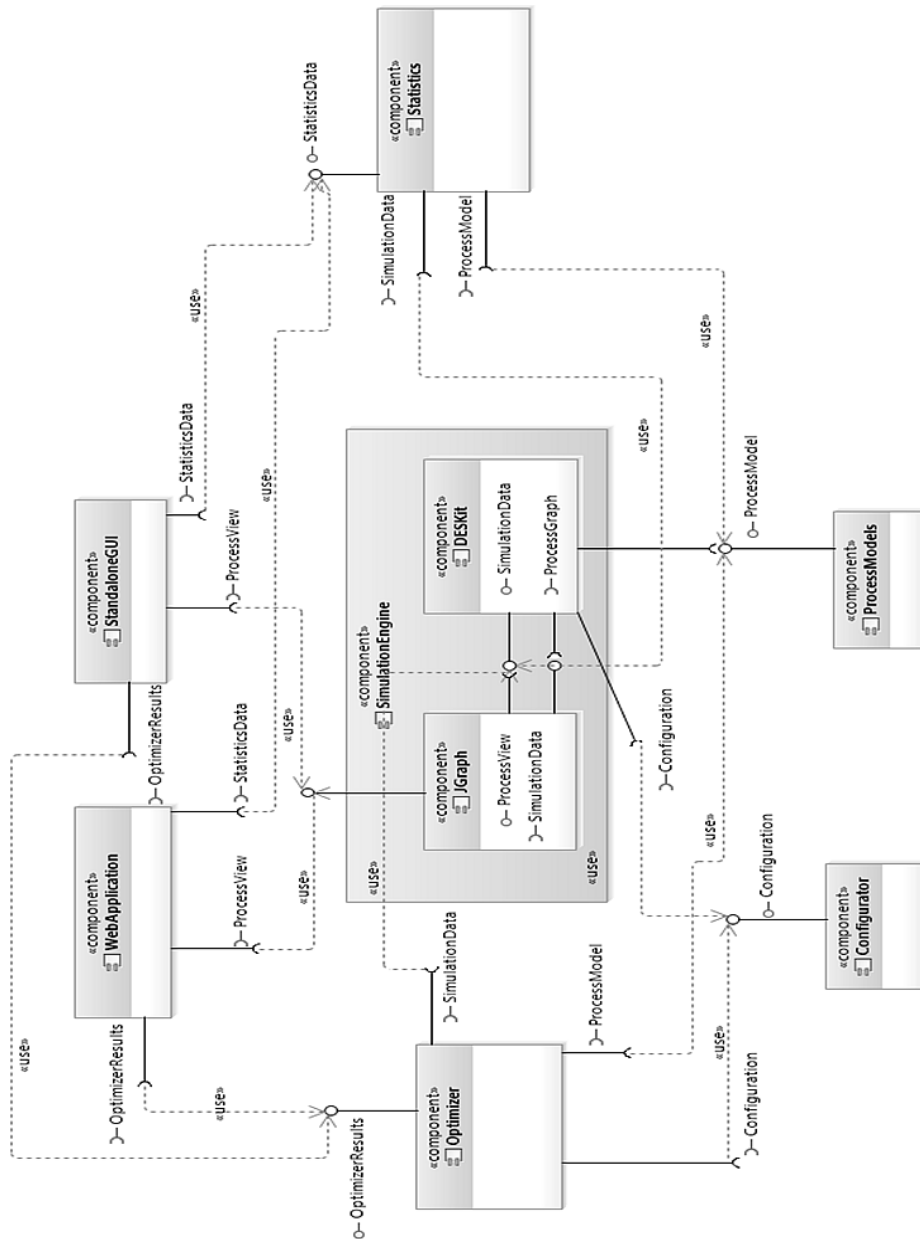
Figure 5. The architecture of simulation components

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4. Conclusion

General goal of the conducted project is elimination all reasons that might weaken the access of citizens to judiciary system, as well as make hard to keep the guarantee of "equality before the law". To date, the greatest efforts for accelerating criminal proceedings and limiting delays of cases has been directed to increasing the budget of judicial systems – it has been noted in Poland and also Belgium, Luxembourg, Austria [5]. Such a strategy is proper only for short or transitional time. There is high time to apply other methods based on IT cutting-edge tools and operational research solutions. Therefore, we propose two-way analysis of the criminal procedure: modelling and simulation of the process similarly to Business Processes Modelling (BPM) and optimization based on hybrid models and methods: GAN/GERT with queuing theory and optimization.

In the case of optimization of single subprocess (inside whole crime process) we obtain locally (for single subprocess) optimal solutions. In such organizations like judicature (but not only) we must focus on optimizing the operation of whole organization (globally optimal solutions). It seems to be essential to use hybrid models and methods: GAN/GERT with queuing theory and optimization of resource (people, courtrooms, time,...) allocations [9].

The results of this work is the workflow system extended with the business process simulator – case study is being organized in the District Court in Bialystok. Although the proposed approach is a practical step on the way to alteration of criminal judiciary, some expected benefits are strictly determined by amendments in the law (including Code of Criminal Procedure) keeping up innovative capabilities acquired with IT systems.

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