Assessing elements of crime based on an agent simulation of a street robbery

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Abstract. Agent-based simulation is a useful tool in terms of assessing human behaviour under the criminal law. We developed a street robbery scenario generator with elements of a criminal law expert system to provide a tool for better understanding complex criminal matters.

Keywords: agent simulation, expert system, criminal law, narration

1 Introduction

In this work we use an expert agent system in which two agents interact in a crime related situation according to their personal and situational features. One agent has a criminal intent and the other one is a potential victim. Every step in an evolved scenario system is assessed from the point of view of culpability. Since the knowledge base was designed using quilt taxonomy [3] (in accordance with the described notions concerning a selected crime) we can generate multiple offence and no-offence scenarios.

The expert system operation follows judicial procedures for crime determination [1, 2]. In this work we specialize to European Union country jurisdictions and the US Model Penal Code.

The expert system is divided into five blocks. The first one concludes if an action have taken place, and the second one infers whether the action is forbidden by law. The next block checks if the action forbidden by law is illegal (there are no justificatory reasons). The fourth block determines whether the action forbidden by law is illegal and socially harmful (the case of Croatia, Poland, Czech Republic, Greece, Hungary, Bulgaria, Lithuania, and Romania jurisdictions, but does not pertain to Austria, Germany, Estonia and Portugal jurisdictions). Finally, last block checks if the action forbidden by law is illegal, socially harmful and blameworthy (guilty) – constitutes an offence.

The criminal law systems of European countries have been described in [3] based on the guilt ontology. Our long term goal is studying correlation between sentences and legal rules. To accomplish this goal we need a database of sentences in an electronic form. One such database is Massachusetts SJC and Appeals Court Cases [4].

Therefore, we need to analyse principles of the US common law, particularly in aspect the of structure of crime approach.

The paper is organized as follows. Section 2 presents a short description of the US state penal law. Section 3 describes our agent expert system. Section 4 gives details of evolving crime scenario and Section 5 provides an example of the simulation. Section 6 contains concluding remarks and our plans for future work.

2 The US criminal law

A criminal guilt model is important not only for passing sentences but also for drafting law. What happens when there is no general theory shows analysis of the US federal penal law [5]. With over 4450 in federal statutory crimes in 2010 [6] (the strict number is not known) and an estimated tens of thousands more in federal regulations, neither criminal law professors nor lawyers who specialize in the US criminal law know all of the conduct that is criminalized, not to mention an ordinary citizen. A common result of poor legislative drafting is uncertainty as to whether a mens rea term in a criminal offense applies to all of the elements of the offense or, if not, to which elements it does apply.

The idea of "element analysis" in place of "offense analysis" was established by Model Penal Code (MPC) [7]. Under the MPC, crimes are defined in terms of a set of "elements of the offense". There are three types of elements:

- conduct of a certain nature,
- attendant circumstances at the time of the conduct, or
- the result of that conduct.

The most important elements are those facts that:

- appear in the definition of forbidden conduct as provided by the statute, or
- establish the required culpability, or
- negate an excuse or justification for such conduct.

3 Agent expert system

To apply existence of guilt in a given crime we would need a large number of real cases of a given type (i.e. robbery) that are appropriately classified. This is very laborious: either we have to annotate these cases by a human or use some linguistic tools combined with machine learning techniques. A simpler although not as valuable approach would be to generate/model crime descriptions as a function of parameters of a crime. This is a path we follow in this work using a simple agent system.

3.1 Agent System as a Part of the Expert System

Agent behaviour can be viewed and described through a design, physical or intentional stance [8]. The most frequently observed approach in the legal domain would probably be the last one - intentional. As it was stressed in [9] it is worth taking under

consideration also the second, physical stance, when inferring from knowledge base. Our agent system architecture (Fig.1) is similar to the one used in [8, 9].

The agent system is organised according to the elements of the structure of a crime into a:

- Percept.
- Belief (knowledge about the environment).
- Utility function (confidence).
- Intent (purpose, knowledge):
  - Intellectual aspect of the Intent (plan).
  - Volitional aspect of the Intent (will/desire).
- Action.

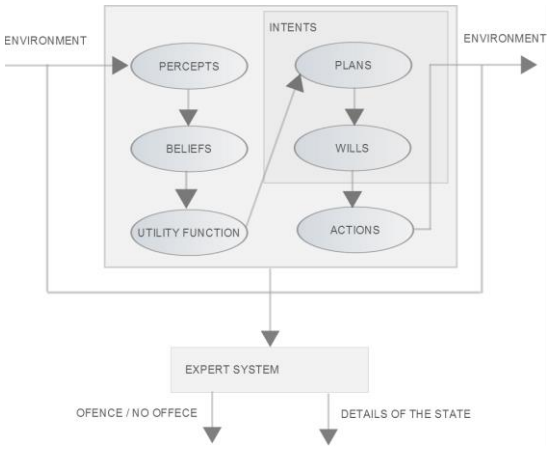

Figure 1. The agent and expert system architecture.

An Agent Based Approach to expert system explanation is widely used in legal domain [9-14]. Here we apply it to inferring from elements of an offence. We do not model the penalty related rules.

At a higher level of abstraction we are able to model aspects of an offence that are common for many jurisdictions. Going deeper into the nature of crime we use elements that are universal in their nature such as ontological descriptions of human behaviour or mental disabilities. There are many approaches to a problem including discrepancies, numerous inconsistencies contradicting one another, when comparing jurisdictions [1-3]. Segmenting makes it easier to compare and understand differences between them. We divided the structure of a crime into blocks that can be added or removed according to the needs of modelling a particular state. The expert system besides inferring that a crime occurred provides a user with information about particular elements of an offence. We design the agent system in an accordance with the described notions concerning crime, so that we can generate multiple offence and no-offence scenarios.

3.2 Assessing culpability of an action

The first part of the system determines whether action or omission took place (Fig. 2). This part is a primary element of every framework of an offence. A rule that there is no crime without action can be considered a universal one [1-3]. Similar conclusion can be reached concerning the legal status of omissions. Having in mind minor exceptions (duty of the first aid [1]), an agent can be held liable for not acting only if there was a duty to act. The actor cannot be an object of external force. Our model contains two interacting actors: a criminal and his potential victim. He/she must have a control over own body in order to start the procedure of determining a crime. Both agents have the intention and ability to move and there is no duty imposed on their behaviour. Therefore, in every simulation an action takes place.

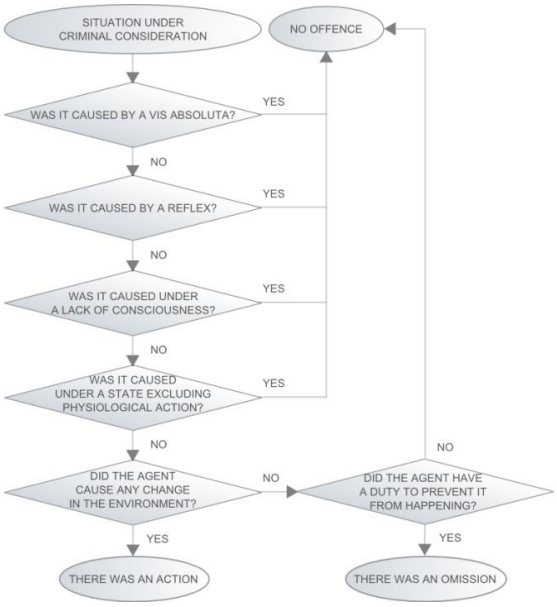

Figure 2. The first block. An occurrence of an act.

3.3 Inferring that an action is forbidden

The second block represents elements that in common law systems are considered to be actus reus (the objective side of an act) and mens rea (the subjective side of an act). In the German criminal law [1] this block is called *Tatbestand* (facts of the case) and in Polish [3] is *znamiona czynu zabronionego pod grozbą kary* (constituent elements of a forbidden action). This two-part division corresponds with the bipartite and tripartite framework. A subject and an object of the act were distinguished in the quadripartite framework [1,3].

3.3.1 Subject of the act

The first element in this block is a subject. According to this criterion offences are divided into common and individual ones. Common crimes can be committed by a person under a particular jurisdiction. In the other case a subject must be of a specific type, for example, under Polish Criminal Code only a mother can commit an infanticide. A robbery, on the other hand, is the common crime.

3.3.2 Objective side of the act

The second element of the same block is an objective side of the forbidden act which concerns all the details of the act itself. The question here is whether the act was finalized or was abandoned, was the act committed by possession (e.g. possession of radioactive material) [1,3]. The time, place aspects and the details of the whole situation have to be taken into account. The other important distinction is the one between a result-based and a conduct-based (false oath) offence - fundamental both in German and Polish criminal law [1,3]. The conduct-based offence, contrary to the other one, does not require any result separate from the act itself to happen. Though the Model Penal Code in the article 2 § 2.03 concerning causal relationship between a conduct and a result does not mention such a distinction, the paragraph concerning false swearing does not specify any result that is imperative for an offence to take place [7]. Therefore, we will not err if we assume that the distinction between a result- and a conduct-based offence is present in the American legal system.

3.3.3 Subjective side of the act

The third part of the second block describes the intellectual and volitional relationship of a person to its action. There are four elements of a subjective side of an offence, divided into two categories: intent and negligence. Intent is determined by two conditions that both have to exist: an intellectual and volitional condition. It is imperative that the agent imagines that the action can be performed, and plans how to behave. The second condition is the will to perform the action. The agent wants the perception to become reality. There are two types of intent, direct or meaning purpose and indirect or meaning knowledge [1,3,7]. The list of direct intents is the following:

- dolus coloratus – intent aiming at a direct purpose,
- dolus praemeditatus/deliberatus – deeply considered and planned intent,
- dolus repentinus – intent caused by sudden stimuli,
- dolus directus cumulativus – intent to fulfil constituent elements of many forbidden actions,
- dolus directus alternativus – intent to fulfil constituent elements of a forbidden action, but the agent reckons upon the possibility of fulfilling constituent elements of another forbidden action.

For indirect intent the intellectual aspect is the same but an agent does not want a certain situation to happen. Therefore, he acknowledges that it is possible that this situation could occur. The second part of the dolus alternativus fulfils that condition.

Negligence can also be either direct – recklessness, or indirect - indirect negligence or just negligence [1-3,7]. Here the volitional aspect is negative – the agent does not want a situation to take place. In the case of recklessness the intellectual aspect is present but the agent disregards that the situation may happen. Negligent behaviour does not involve neither intellectual nor volitional aspects of intent. The basis for evaluation of such an action is what a reasonable person would do in this situation.

3.3.4 Object of the act

The last part of the second block is the object of an act. Here, the distinction is made upon the nature of the object that is being attacked, that can be a property or a human being. A generic object is specified by the chapter it is placed under. A direct object is specified in a particular provision that underlines what features a generic object needs to have in order to be protected by law [1,7]. We should address two other important subjects: forms of committing and assessment of an offence.

3.3.5 Form of committing the act

We limit our inquiry on the matter, to say that forms of committing a crime are divided into two subcategories. The first is the involvement of others in the crime, such as complicity, incitement, commission or aid. In the field of law and AI these matters were discussed in [16]. There are no other agents on the side of the robber in the agent system. The second one is the level of completing the crime whether it was planned, attempted or finalized [1-3,7]. For the purpose, in our simulations we use the attempt and of course the finalized form. An attempt is a situation that directly leads to commitment of an act but eventually the act does not take place.

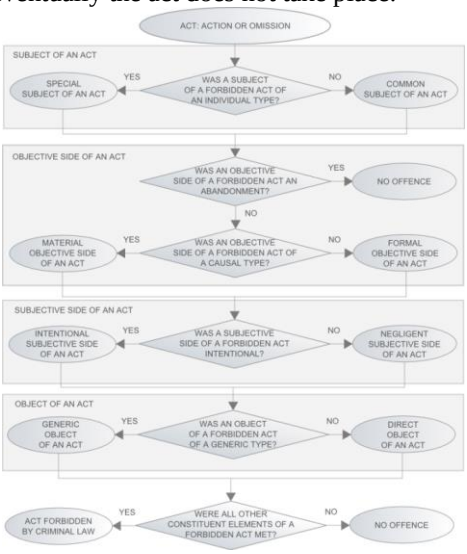

Figure 3. The second block. Occurrence of an act.

3.3.6 Assessment of the act

Certain situation can be viewed from many angles. In the case of a single action, many legal norms can be breached. For example, taking someone's property by force fulfils both the constitutive elements of robbery and theft. If there were many actions, this can lead to many separate crimes or one complex offence.

A robbery is such an example. A person deprives the other one of his/her property and inflicts serious bodily injury in the process. The situation cannot be qualified as a theft and an assault [7]. That is how the expert system interprets the provisions in our case.

3.4 Inferring that an action is illegal

The third block is a set of conditions that justify an action. They could negate the illegality of the behaviour. If one of the conditions is met then there is no crime [8, 3, 4, 5, 19]. We describe a self-defence justification, because it happens in the robbery simulation. Both MPC and Polish Criminal Code provide with five main points with one difference that changes the inference process. The MPC provides with the following main constructive elements of self-defence:

- actor believes that he/she is in a danger,
- the danger is immediate,
- the dangerous force is unlawful,
- the defence must be directed at the person causing the danger,
- the use of self-defence is necessary.

The same elements can be found in Polish criminal law, except the dangerous force has to be present in the outside world, not in just actor's belief [2]. For the same scenario, if the action was undertaken in a self-defence and the belief did not mirror the reality, according to MPC it would be a self-defence and in Polish law it would be an excess of self-defence.

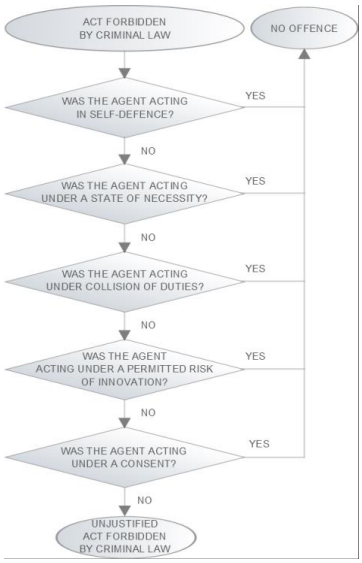

Figure 4. The third block. Inferring that an act is illegal.

The fourth block is of a simple construction. Social harm of an action can be considered *in abstracto* as a ground and reason why a particular behaviour is dangerous to society and should be penalised. This approach corresponds to the object of the forbidden action in the second block. *In concreto*, in an actual, single case every action should be evaluated if the level of social harm is higher than negligible [1]. It seems that this construct may work only for petty crimes because for example robbing a person should always be considered socially harmful.

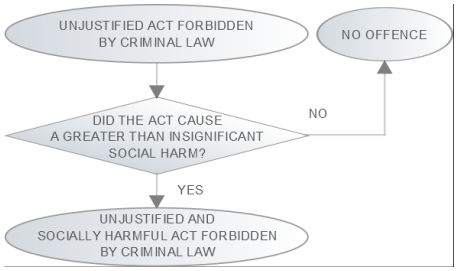

Figure 5. The fourth block. Inferring that an act causes social harm.

The last block algorithmically is the same as the third one but it negates the guilt of the actor. Therefore, it represents a list of excusatory conditions. The same elements depending on a jurisdiction can appear in the third or the fifth block. For example, duress is a justification in Slovenian Criminal Code and an excuse in French Penal Code [1]. For the purpose of explaining some of the possible inferences we provide more details on the issue of mental diseases and mental defects. Acting under one of

these states excludes, as a principle, criminal responsibility in the USA and Poland. Since mental disorders are jurisdiction independent, the following enumeration [7] should be of interest to any legal expert:

- hearing and seeing perception disorders (illusions, hallucinations),
- delusions (mood-congruent delusions, oppressive delusions, delusions of grandeur),
- memory disorders,
- emotional disorders,
- will disorders,
- sexual urges disorders,
- states of deliria (alcohol and drug related),
- intellectual disability (profound, sever, moderate, mild),
- social behaviour disorders.

Five distinguished flowcharts, with the first one being a part of the second one, were derived from ontologies describing frameworks of crimes in European Union member states described in [1,3].

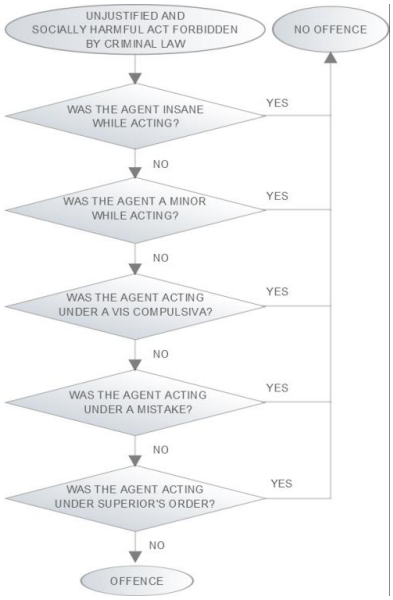

Figure 6. The fifth block. Inferring from a guilt model.

4 Evolving crime scenario

The idea behind this part is that modelling intelligent, social agents that mimic human behaviour is an efficient way of inferring from criminal law. Lawyers and theoreticians often imagine a situation to validate a certain legal construction [1]. A narrative simulation [15-17] is a natural tool when working with criminal law analysis.

In criminal law one needs to model internal, mental or emotional states.

4.1 Starting point for the agent system

The majority of the described elements of the expert system were taken under consideration while designing the agent system. The expert system plays a role of an insider narrator [12] and has access to agent's knowledge. In every step in the simulation the expert system runs through the system of rules and infers from the elements of the blocks. As a result, for every simulation, all of the elements can be viewed whether they have occurred or not, and if a crime occurred. An offence does not happen in every scenario. For example, a robber might decide that the potential victim is too strong for him and during the event changes his mind and walks away. In that case the expert system would infer that the illegal act was abandoned and there was no crime.

The crime of robbery in the Model Penal Code is described in a separate article (art. 222) that stipulates that the following elements must occur at the same time:

- theft, and
- infliction of serious bodily injury, or
- threat of immediate serious bodily injury, or
- putting in fear of immediate serious bodily injury, or
- commits any felony of the first or second degree, or
- threatens immediately to commit any felony of the first or second degree.

4.2 Agent behaviour

The division physical/intentional is a fundamental one in our case, because it largely influences the mental elements of agents and determines agents' behaviour. An action is restricted to the 10 x 3 field with opened narrow ends that correspond to a narrow passage between streets. The first agent is a potential robber and the second agent is a potential victim. The robber will try to get property from the other agent, while the victim will try to pass the alley. A victim needs not to be necessarily harmed - it may defend himself. There are two types of victims, a conformist who is passive in reactions and an evolutionist who is a more active character. The agents can see and hear each other, they can both carry a weapon, a knife, a pistol or nothing (can use fists), and can draw it when they decide it is necessary.

4.2.1 Agent features

The agents also have visible features: vigour and suspiciousness. There are scenarios where a victim is more suspicious and vigorous than the robber, that may run away if not prepared to face a strong opponent. Another key characteristic of both agents is their bravery index which is invisible to the adversary. Vigour and bravery can have value in the range 1 – 5, suspiciousness can be 1 – 8 and weapons count 1, 5 and 20 for fists, knife and pistol, respectively. There is a function for estimating possibility that the other agent carries a weapon which assigns: nothing for 1 – 4 of suspiciousness points, knife for 5 - 6 and pistol for 7 – 8. The estimated weapon value is added to visible values: vigour and suspiciousness to give an EST value estimating opponent's confidence. Because bravery and weapon are the agents' private values, the calculates its private sum REAL of bravery, weapon, vigour and suspiciousness. A confidence index CONF plays the role of a utility function and is calculated by subtracting the EST from REAL. If CONF is less than 0, the agent runs away. This configuration covers many possible scenarios encountered in real life.

4.2.2 Possible movement scenarios

At the beginning the agents approach each other with one field per turn choosing a horizontal or a vertical move. The agents calculate the distance between each other. They converse if they are within the Moore's neighbourhood. For the robber all configurations are acceptable, except the opposite one. They can use a knife on each other on all the adjacent fields or fire a pistol.

4.2.3 Plan and will

Agent plan and have will to execute it on in order to produce actions.

These plans are:

- plan how to approach an agent,
- plan how to take something,
- plan how to run away,
- how to have a talk,
- plan how to use a weapon,
- plan how to avoid contact.

The types of will are:

- will to rob without violence - dolus coloratus and dolus praemeditatus,
- will to rob with violence - dolus directus cumulativus,
- will to rob with accepting violence - dolus directus alternatives,
- will to talk,
- will to get something without robbing;
- will to defend one-self,

- will to pass along.

4.2.4 Communication between agents

According to his plan and desire the robber can say: '-' (nothing), 'give me money', 'give me your wallet' and can draw a weapon. The victim can reply: '-', 'yes', 'no', and in the case of self-defence some slang phrases like: ‘pity, fool'. Since we model possible scenarios of robbery, our agents have to be able to harm one another. The simulation ends when conversation ends or the robbery act ends.

Fulfilling the MPC robbery definition, we did not distinguish a threat from a situation of putting an agent in fear. As for ‘threats of immediately committing any felony of the first or second degree’, a robber can threaten with committing, the following crimes:

- murder,
- kidnapping,
- robbery.

5 Example of simulations

Below we present console views in subsequent movement steps. At the beginning, all the characteristics are randomly chosen. We present a simple map of the street with positions of the Victim (V) and Thief (T). Also actionable information about the utility index is given together with the analysis of the legal expert system. The project is available at https://github.com/jkbno/StreetRobbery.

```
-------STREET ROBBERY SIMULATOR--------

Random thief's vigour index(1-5) is 1.
Random thief's bravery index(1-5) is 4.
Random thief's suspiciousness index(1-8) is 4.
Random thief's weapon: fists(1), knife(5), pistol(20) is 5.
Random victim's vigour index(1-5) is 1.
Random victim's bravery index(1-5) is 4.
Random victim's suspiciousness index(1-8) is 1.
Random victim's weapon: fists(1), knife(5), pistol(20) is 5.
Random direction the victim should be heading(east/west) is west.
Thief's location is [1,2] and victim's location is [10,1].
Victim's random belief (conformist/evolutionist) is conformist.


| | | | | | | | | |V|
|T| | | | | | | | | |
| | | | | | | | | | |

Thief's turn.
Thief's action utility index is 12.
Victim's turn.
Victim's action utility index is 6.
```

							V	
	T							

Action: 1
Forbidden action: 0
Illegal forbidden action: 0
Illegal forbidden socially harmful action: 0
Guilty illegal forbidden socially harmful action: 0
There is no crime
Thief's turn.
Thief's action utility index is 12.
Victim's turn.
Victim's action utility index is 6.

						V		
		T						

Action: 1
Forbidden action: 0
Illegal forbidden action: 0
Illegal forbidden socially harmful action: 0
Guilty illegal forbidden socially harmful action: 0
There is no crime
Thief's turn.
Thief's action utility index is 12.
Victim's turn.
Victim's action utility index is 6.

					V			
			T					

Action: 1
Forbidden action: 0
Illegal forbidden action: 0
Illegal forbidden socially harmful action: 0
Guilty illegal forbidden socially harmful action: 0
There is no crime
Thief's turn.

Thief's action utility index is 12.
Victim's turn.
Victim's action utility index is 6.

				V				
				T				

Action: 1
Forbidden action: 0

Illegal forbidden action: 0
Illegal forbidden socially harmful action: 0
Guilty illegal forbidden socially harmful action: 0
There is no crime
Thief's turn.
Thief's action utility index is 12.
THIEF: Give me a phone.
Victim's turn.
Victim's action utility index is 6.
VICTIM: No.

				V				
			|T|				

Action: 1
Forbidden action: 0
Illegal forbidden action: 0
Illegal forbidden socially harmful action: 0
Guilty illegal forbidden socially harmful action: 0
There is no crime
Thief's turn.
Thief's action utility index is 12.
THIEF: Or I'll kidnap you!
Victim's turn.
Victim's action utility index is 6.
VICTIM: Yes.
Victim gives its property: phone.

				V				
			|T|				

Action: 1
Forbidden action: 0
Illegal forbidden action: 0
Illegal forbidden socially harmful action: 0
Guilty illegal forbidden socially harmful action: 0
There is no crime
Thief's turn.
Thief's action utility index is 12.
Game over, the thief wins!

				V				
			|T|				

Action: 1
Forbidden action: 1
Illegal forbidden action: 1
Illegal forbidden socially harmful action: 1
Guilty illegal forbidden socially harmful action: 1
There is a crime
true.

6 Conclusions

We developed a street robbery scenario generator with elements of a criminal law expert system to provide a tool for better understanding complex criminal matters. Outcomes of simulation scenario are close to situations that have to be considered by judges. In future, we could enrich manually created ontologies exploiting rules for traversal decision trees [18].

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