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A Goal-Driven Crime Scripting Framework

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***Abstract*—**Crime scripting is a simple and effective crime modeling technique that aims to improve understanding of security analysts about security and crime incidents. Low-quality scripts provide a wrong, incomplete, or sophisticated understanding of the crime commission process, which oppose the purpose of their application, e.g., identifying effective and cost-efficient situational crime prevention (SCP) measures. One important and overlooked factor in generating quality scripts is the crime scripting method. This study investigates the problems within the existing crime scripting practices and proposes a crime scripting approach that contributes to generating quality crime scripts. It was validated by experienced crime scripters. This framework helps analysts develop better crime scripts and contributes to their effective application, e.g., SCP measures identification or policy-making.

***Keywords*—**Attack modeling, crime commission process, crime script, situational crime prevention.

I. Introduction

SCP is a crime reduction approach that functions by altering potential offenders' judgements of the risks and rewards. Specifically, it seeks to deter offenders from taking certain courses of action by influencing their perception of opportunities, typically at or near the time and place of its envisaged commission [1]. Cornish [2] recognized the importance of taking a crime-specific approach in SCP and understanding how certain types of crime tend to be committed. He expressed the advantage of using a general procedural framework to make sense of the data (rather than 'extracting' a plan from the data themselves) as a useful way of detailing crime commission that provides a more understandable perspective of the data about a crime event. His proposed procedural framework provides a step-by-step account of the crime event and contributes to identifying the decision points to influence (pinch points). This is widely known as 'crime scripting' and originally aimed to elicit and visualize the crime commission process adopted by offenders, based upon script concept.

The script-theoretic approach has a lot to offer to crime analysts. Many studies have referred to it as a tool for eliciting the offender's behavior and the rationale for their decisions [3]-[12]. Others have highlighted its utility in organizing existing knowledge about the requirements of crime commission such as the skills or resources that criminals need to deploy in order to execute a crime [2], [7], [13]-[20].

Since its introduction, crime scripting has become increasingly employed by researchers in crime and security [21]-[23]. It has also been used in various ways such as for crime prevention or risk analysis and from different disciplinary perspectives including criminology, crime science, and computer security [10], [24] to study various crime types such as robbery, vandalism, and auto theft [2], internal computer fraud [25], sex offences [4], [26], drug manufacturing and drug dealing [5], [27], illegal waste activities [28], identity-theft [29], and wildlife poaching [30].

Borrion [24] listed 12 criteria that a quality crime script should be expected to have: accuracy, ambiguity, completeness, consistency, context, parsimony, precision, traceability, transparency, typology, uncertainty, and usability. All his listed criteria should ideally be considered in assessing crime scripts, as meeting them contributes to satisfying crime scripts' applications needs, e.g., identifying pinch points/ interventions. For example, an incomplete script can result in failing to identify effective and cost-efficient pinch points and a non-parsimonious script makes the analysis more complicated and wastes the analyst's resources.

A script's quality is affected by various factors, including the scripters' skills or experience, available resources (e.g., data, or time), or the deployed scripting approach. The latter is the one that can be controlled by the deployed crime scripting practice and is the main concern of this study.

A. Elaborating Crime Scripts

While no structured crime scripting method has been established, some semi-structured patterns of elaborating crime script could be found in the literature:

Universal script: Cornish's [2] seminal article has a few crime scripts which were developed using the *universal script*. Such universal scripts, consisting of scenes arranged into a sequential order which further the overall actions, offer standardized guidelines for constructing scripts, whatever the state of knowledge about the offence in question [2, p.10].

Template method: The universal script is a static and generic template that can be used to describe different aspects of criminal activity from its involved entities (e.g., actors or their actions) to its requirements (e.g., motivation, expertise, or resources). However, it cannot practically be re-used to model any types of crime. It might include some non-required scenes or may not include some required scenes, which implies the need for using dynamic templates. As a more dynamic method, Cornish [2] mentioned the *script permutator* as a simple three-dimensional model of a typical crime-commission script that can be used as a model for defining new scripts. Following this, Cornish and Clarke [31] adopted this more detailed method and used a newly designed template which outlines the necessary crime scenes or functions involved in a crime process (e.g., preparation, entry, doing, and exit). The current work calls this method *the template method*, which is a dynamic version of the universal script.

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This approach has been used in a number of studies including [4], [25], [28], [29], [32]-[37].

To represent the crime specific process, the template approach follows the universal script's central idea: defining a set of generalized scenes and identifying all the relevant actions for each scene in the template. The generated scripts range from comparatively simple sequences of actions to more complex models within which many participants, locations, and actions may be involved, possibly resulting in the emergence of multiple crime scripts.

The other scripting methods: before Cornish [2], and as pointed out by [38], 'free-form techniques followed from cognitive psychology' were initially used for eliciting detailed scripts (e.g., 'people's knowledge of routine [civil/criminal] activity'). However, later studies used more systematic and structured approaches for crime scripting, including Jacques & Bernasco [27] who used rational choice and opportunity perspective in identifying the necessary conditions for offences, Brayley et al. [26] who deployed their own scripting method and typology of symbols for generating their crime script, Morselli & Roy [39] that arranged multiple crime scripts considering possible variations of each step, Leclerc et al. [40] that focused on crime setup phases to elicit the offenders' actions and finding relevant interventions, and Smith [41] who worked on 'casting requirements' that are needed in the script to carry out the crime.

Intuitive methods: while there is no truly well-established crime scripting practice, most crime scripters use an intuitive method when developing their scripts [21]. An intuitive method is based on people's intuition and their ability to acquire knowledge without proof, evidence, or conscious reasoning, or without understanding how the knowledge is acquired [42]. As a result, the content of the generated script will depend on scripters' cognitive abilities, experience, knowledge, interest, and biases. While the cost of developing scripts (e.g., required time, tools, and data sources) using intuitive methods should be reasonably low, the quality of intuitive scripts is questionable. There is no guarantee that the generated scripts will satisfy the purpose of crime scripting or they will be of sufficient quality. Although this claim has not yet been directly examined, the results of similar studies support it, e.g., the finding of a study conducted by Tyre et al. [43] where they compared systematic and intuitive methods in general. Following Dawes [44], they suggest: "According to psychologists, most people are poor intuitive problem solvers. They tend to adopt a definition of a problem without having collected descriptive data on the situation. They formulate [explanations] based upon incomplete data and fail to seek out possible alternative explanations. Even when information is available, it is often ignored if it does not support existing preferences and assumptions".

Relying on these studies, it can be implied that crime scripts that are developed using intuitive methods are likely to have the above deficiencies. That being said, there are benefits of using intuition in the production of robust crime scripts. For example, i) the amount of resources (e.g., time, tools, and data sources) required for developing scripts is likely smaller for intuitive approaches, ii) using intuition may also allow more space and flexibility for the creativity of the scripters; they can freely follow their instincts and do what "feels right", iii) structured methods have been developed using their designers' intuition, and iv) no matter how structured a crime scripting method is, scripters are still required to use intuition in completing specific tasks e.g., choosing data-source or visualization [42], [43], [45].

II. Aim

Although the use of crime scripting has increased in recent years (see e.g., [46], [22], or [23]) still there is little known about crime script development. It seems most of the studies rely on intuitive methods in their script development and consequently the quality of scripts depends on the scripters experience, knowledge, and personal biases, which not necessarily are in favor of generated scripts' quality [21]. It means scripts generated for the same application by different scripters may include different details about the crime, so would direct the analyst to different SCP measures. Therefore, there is no certainty that the most efficient and relevant prevention measures will be identified for the application. The key problems with the existing crime scripting practices are that they are not systematic and are too intuitive. Therefore, they have the same shortcomings as any other intuitive method e.g., resulting to incomplete scripts, intuitive scripts' contents are up to the scripters' personal interests and knowledge, they are not re-usable, and they cannot be verified and assessed. In addition, when scripting methods are placed into context, and the goal of the script-to-be is indicated, they tend to focus on the same goal— crime reduction. Crime reduction is often presented as the main goal of SCP studies [47], [48]. However, there should be other stakeholders goals e.g., to ensure that the side-effects are in an acceptable level [49]. This is because focusing too much on a single general goal will result in ignoring a wide range of [other] goals that are concerned by different parties that affect or are affected by a security product.

The existing studies use an intuitive method for developing their templates. For example, Brayley et al. [26], Cornish & Clarke [31], and Tompson & Chainey [28] used templates and provided some details of their used templates deployed very different process in finding the scenes and populating them. Thus, the template method has the same shortcomings that an intuitive method has— these are described later in this section. Furthermore, designing a generic template that covers all the possible patterns of various types of crime, if possible, would be very complicated and would result to a very sophisticated model that will not be practically usable.

To improve the mentioned problems, this work aims to represent a generic and structured goal-driven crime scripting framework that covers all the [necessary] activities to be taken in scripting process and assists scripters (e.g., practitioners or academics) in their script elaboration tasks. The goals will be derived from the application of crime-script-to-be and its stakeholders.

III. The Goal-Driven Crime Scripting Framework

The crime scripting framework that is suggested in this section has been developed based on the crime scripting process model presented in [50]. This model lists the activities involved in crime scripting: formulating the problem, analyzing the information requirements, selecting the data source, improving data, extracting information, selecting a visualization model, organizing information, and evaluating the generated crime script. This has been reviewed and improved using the existing knowledge from goal-based approaches in requirements engineering [51]-[54] and business process models [55], [56] to develop a clear and usable crime scripting framework. The former inspired this study on how to involve goals in the scripting process and its related activities and the latter helped in organizing the activities, their orders, and movements.

A. The Framework

Fig. 1 shows the proposed goal-driven crime scripting framework that consists of six stages:

1) Problem definition: This is the first stage of the proposed framework that aims to clarify the security problem or crime type to be modelled. This includes:
- Defining the security/crime issue to be scripted,
- Describing why the crime-script-to-be is being developed and where it will be used,

2) Goal identification: Two types of goals to be identified and analyzed are: i) organization's overall goals/ preferences and ii) stakeholders' goals and requirements. This stage will likely include:
- Defining the overall goals/preferences of the organization. This is to better understand the main priorities and overall goals or preferences of the organization; e.g., increasing revenue or maintain reputation. These are likely to be required in filtering and prioritizing the final goal. However, this can be skipped if there is no preference.
- Identifying the crime scripts [main] stakeholders (those who are affected by/can affect the crime commission process e.g., the offender, the victim, or security measure designer), and their goals and requirements (in the scope of the crime commission process). These goals are the main focus of the current goal-driven method.
- Analyzing goals by relating them to each other and also by relating them to the organizational priorities/ preferences. Here, there is a possibility that the goals can conflict with each other which means satisfying one goal would result in not satisfying another. These kinds of issues should be identified in this step.
- Selecting and finalizing the goals. When there are too many goals or requirements or there are some conflicting goals or requirements, goals should be prioritized and filtered. This will result in a final list of (selected) goals or requirements for the rest of the process.

3) Information requirements analysis: Here, the information that should be included in the crime-script-to-be, considering the selected goals/requirements, is discussed. The output from this stage would inform the level of details required for the final script and the specific components that should be included in the final script (e.g., different actors, their actions, locations, etc.), and the scope of the model (e.g., focusing only on the crime scene, or considering a wider scope for example preparation, motivation, after crime points).

4) Data source selection or data collection: In this stage, any existing relevant data sources are reviewed and it is determined whether further data collection is needed to complement the existing data. This consists of two steps:
- Choosing data sources and collecting data; and
- Reasoning whether the available data contains the required information.

5) Script construction: This is where the actual script is modelled following two steps:
- Selecting the required information: This selection process is done based on the shortlisted goals and information requirements from step 2 and step 3,
- Organizing the elicited information and constructing crime script: finally, the selected information should be organized and presented in an appropriate visualization, e.g., table, narrative, or flowchart. That is considering the final application would help in selecting the best visualization model. For example, tables might be more useful if the main purpose is intervention identification whereas flowcharts might be more useful if the result will be shared with others.

6) Quality assessment: This is the final stage of the script elaboration process, and here the quality of the generated script is assessed. While a comprehensive list of criteria for assessing scripts could be considered, it is more effective to have a customized list based on the outcomes of the step 2 and step 3 about the applications' goals or information requirements.

B. Model Validation

The initial evaluation involved assessing whether any important activity was missing in the framework. This was accomplished by comparing the activities in the framework with the reference crime scripting model [50] and the essential activities in a goal-based approach [52]. It was also assessed by checking whether there was no logical flaw in the framework and the order of the activities.

The framework was used by two scripters to develop crime scripts and its details were reviewed and tested. Both scripters were familiar with SCP, Cornish crime script, and have used scripts for the purposes of crime prevention analysis. They reviewed and used the method independently. Some modifications were applied to the model at this stage, specifically where the order of choosing data source/collecting data and Reasoning whether the selected/collected data contains the required information were swapped.

Finally, a 3rd expert was introduced in the group discussion in terms of determining if i) the developed framework was an acceptable representation of crime scripting process, ii) it involves all the required activities for constructing a crime script from scratch, iii) no unnecessary activity seems to have

been included, and iv) the organization of the activities is reasonable. Some improvements were applied to the model to address the outcome of the group discussion, e.g., the combination and organization of the activities were updated and more feedback loops were inserted in the model.

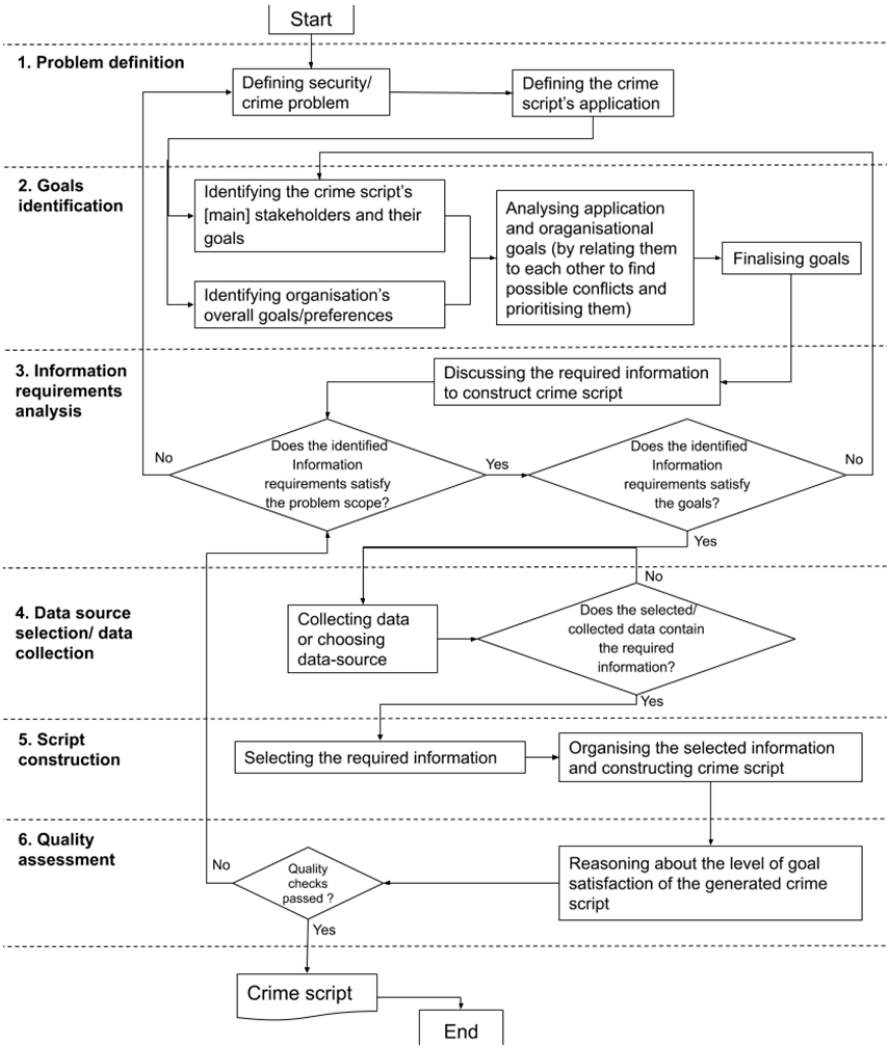

Fig. 1 The goal-driven crime scripting framework

C. Illustrative Example

To provide a better understanding of the proposed framework and to test how it works in practice, it was used to construct some crime scripts. One of them, which regards stalking on Facebook, is described here as an illustrative example:

1) Problem definition

- Definition security/crime issue to be scripted: cyber-stalking is a growing and serious issue. In this crime event, an offender or offenders use the Internet or other electronic means to stalk or harass an individual, group, or organization. Our concern is about stalking on Facebook (FB) where the offender creates a false identity, approaches their victim, gathers their information, and then misuses that information e.g., to harass or intimidate the victim.
- Description of why the crime-script-to-be is being developed and where it will be used: FB tasked a team of crime analysts to analyze this problem and identify possible ways of protecting its users against such a crime.

2) Goal identification

- Identification of the crime script's [main] stakeholders and their goals and requirements: whilst there is potentially a wide range of stakeholders (e.g., victims, offenders, etc.), here, FB (the client) is the main stakeholder. The FB's goal, in this case, is to prevent stalking. This can be further derived into the below [scripting] goals:
  - to prevent account creation using fake/stolen identity,
  - to protect users' profiles from unauthorized access,
  - to protect users' personal information from malicious uses.
- Defining the overall goals/preferences of the organization: FB might have various overall goals and preferences e.g.,

increasing revenue, keeping up to date with the latest technologies, maintaining reputation, etc. However, related to the current example, here, three main high-level goals/preferences are listed that are:

- providing user friendly environment,
- providing easily accessible service, and
- increasing the revenue.

- Analysis of these goals by relating them to each other and also by relating them to the organizational high-level goals/preferences: the selected scripting goals conflict with FB's high-level preferences, as follow: Easily accessible service and increased revenue both likely conflict with the goal to prevent account creation using fake/stolen identity, as its prevention would require hard or further authentication when creating an account (against easily accessible service) and may dissuade or prevent new users (increase revenue). As such, the goal to prevent account creation using fake/stolen identity should be modified, e.g.,
  - Hardening the process of creating account using fake/ stolen identity.
- Selecting and finalizing the goals. The three goals, discussed above, are about three separate stages of the crime commission process: opening an account, making a friend, and gathering information. They are clear, simple, independent, and do not [seem to] conflict. As such, all three are selected as the application goals.

3) Information requirements analysis: the goals of the current application are about the three main stages of the crime commission process to be scripted. As such, we need to have sufficient information about those three stages. This information should cover the activities of the main actors (e.g., offenders, victims, and FB), their behavioral patterns, and their skills (e.g., account creation, working with FB, stalking, etc.)
4) Data source selection/ data collection:

- Choosing data source/collecting data: Here, existing data can be collected from FB, for example, FB tutorial/ process description, FB cyber-stalking incidents' reports, making friends on FB, etc.
- Reasoning whether the selected/collected data contain the required information: it is likely the selected data sources cover the listed information requirements. Complementary data sources can also be searched later if required.

5) Script construction:

- Selecting the required information: This step is conducted based on the listed information requirements. Three stages for the crime commission process were listed above. For each stage, relevant actors (e.g., victim, offender, FB, parents, etc.), and their relevant roles, activities, and skills are sought in the selected data.
- Organizing the elicited information and constructing crime script: The elicited information are organized, ordered, and presented in a table format such that it can be easily used later for identifying possible interventions.

6) Quality assessment: Three goals were identified in the 2nd stage of the crime script development. Here, the written crime script is assessed based on those three goals.

While different criteria could be considered for assessing the written script, this was only assessed using the completeness criterion. More specifically, it was discussed whether the generated script covers sufficient information about all the listed goals.

Due to time limitation and also for the purpose of illustration, this example was simplified and some of the details were assumed upfront, e.g., the offender modus operandi and the selected prevention strategy. The assessment process was simplified too, focusing on only one criterion, although in real case multiple criteria could be considered for assessing a script's quality.

IV. Conclusion

The aim of this study was to develop a goal-based crime scripting framework that offers a simple, clear, and structured approach to crime scripting. The proposed framework was inspired by the crime script process model which was developed based on the activities that were observed in the existing crime scripting literature. Following this process model and using information from two other fields (requirements engineering and business process modeling), a goal-driven crime scripting framework was developed and presented.

The developed framework provides a usable, clear, structured, and task-based approach for constructing crime scripts. Scripts developed using this framework are expected to have higher quality, especially in terms of completeness, parsimony, and traceability criteria. This has the potential to help analysts develop better crime scripts, which might then contribute to their effective application, for example, the identification of SCP measures, policy-making, or requirements identification.

The framework adds some improvement to the existing methods. For one, it offers a complete and simple guideline for new scripters that includes a list of actions required in crime scripting. Secondly, it provides a systematic way of scripting that limits the effects of possible personal interests and biases in the scripts' content. It also introduces a more generic scripting approach that can be used to model various crime problems. Finally, it involves quality assessment in scripting that was overlooked in the existing approaches and it focuses on the applications' goals as the direction of crime scripting activity that is expected to result in achieving a higher stakeholder satisfaction.

The developed framework was reviewed and assessed by experienced and independent crime scripters. The experts were satisfied with the clarity, usability, and completeness of the model and all managed to develop their script and their final results were satisfactory.

For future work, the developed method should be (empirically) compared against the existing crime scripting methods (e.g., [28] or [26]). This can be done in various ways such as by conducting an experiment and using both methods to develop scripts and comparing the resulting scripts.

Alternatively, a more comprehensive validation exercise could be conducted where a larger number of validators could be used with the aim to improve the reliability of the model.

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