Evolutionary Framework of a Decision Support System for Forensic DNA Analysis

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Abstract—Research trend in DSS has moved from the issue of DSS development into DSS evolution. Initial works has been done in 1980's but further research has not been done continuously. The evolution issue of DSS has gained interests again; hence the focus in this research is mainly about evolution decision support systems (DSS) especially from the state-of-art of the proposed frameworks. Chosen area of interest to be demonstrated in solving problems for the evolution of DSS frameworks in this paper is in domain forensic science, or more specifically, forensic DNA analysis. DSS frameworks for forensic science are explored first. From the literatures, it shows that there are significant lacks of available research works for evolution of a DSS in many areas of interests, and not only in forensic science. Types of frameworks for a DSS in general are studied and summaries are presented. The proposed evolutionary framework for a DSS in forensic DNA analysis is initiated.

Index Terms—Decision support system, evolution, evolutionary framework, forensic DNA analysis, framework.

I. INTRODUCTION

Decision support system (DSS) has been applied in a wide range of computer applications that commonly manipulate information in variety fields. Projects have been done in developed countries and around the world to develop software tools to analyze forensic data. Besides, from the literatures, there are also a very small amount of research works found for evolution of a DSS. The terms 'reengineering' and 'evolution' are about the 'change'. The trend for DSS nowadays is more about how to design or build a system for decision-making purposes, but not on how the evolution will occur afterwards. Since the term 'reengineer' is more meaningful and mainly focus for field software engineering, the term 'evolution' is used in this study for field DSS.

The term 'evolution' is commonly associated with field biology. Evolution in biology refers to the change or adaptation of living. It usually cause by the environment for survival. Similarly, in another field such as DSS, DSS

evolution is refers to changes in DSS. But the problem here is from which views? The evolution or changes here requires more specification and details. Another term such as DSS adaptation also refers to DSS evolution. These statements are proven from literatures where in this write up, the different definitions and its variety aspects of investigations, and factors, causes or triggers will be discussed.

Some of the related works to forensic science involve mathematical and computational methods but the authors do not mentioned specifically its relationship either with DSS concepts or frameworks for DSS [1]-[3]. In the case study presented in this paper, the changes that will be applied are evolving from the Bayesian networks (BN) into Object-oriented Bayesian networks (OOBN). Secondly, the proposed graphical model [4] will evolve too, due to the changes that suggested based on problem domain in forensic DNA analysis. The DSS in forensic DNA analysis that will be applied with DSS evolution is ForAS [4], [5].

Forensic scientists need to estimate the probabilities or chance of obtaining that DNA profile in specific most-related race populations, called population database. Besides forensic DNA, there are various other research areas in forensic science. Decision-makers which are forensic scientists can set how many alleles can be considered to fit for each decision either exclusion, inclusion or inconclusive results. Final decisions can be divided into exclusion, inclusion or inconclusive results. Hence in overall, an enhancement from the previous static DSS into a dynamic DSS can be made. Evolution of DSS concepts is fit for this purpose. This paper starts by discussing the published research on previous frameworks for DSS, and then reviews frameworks for DSS in multiple areas of interests before focusing on evolution issues with frameworks for DSS.

II. DEFINITIONS FOR EVOLUTION OF DECISION SUPPORT SYSTEMS (DSS)

Evolution of framework is different from evolutionary framework. Evolution of framework is referring to the changes of the framework itself, while evolutionary framework is the framework that proposed to assist the evolution process. In this study, evolutionary framework for DSS means that the proposed evolutionary framework is focused within the scope for DSS only. Evolution of DSS is also different, where the evolution of DSS means the evolution of the DSS itself; with or without any associated framework together with it. Lack of proper definitions is one of the motivations in this study.

The development of the evolutionary framework and the

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intensive case study illuminates a number of issues for further research into the nature of DSS development [6]. Besides, they also mentioned that the discussion of current approaches and theories of evolutionary development shows that the concept of evolution for DSS theory and practice are important. The existing work on the development of DSS describes the processes in depth, but actually the final outcome is resulted from the adaptive processes. These adaptive processes and system change are referring to DSS evolution, but its real nature could be more complex.

Author [6] mentioned about clarifying the ‘evolutionary process of DSS’ in order to contribute to DSS theory. Author [7] used the term ‘DSS Evolution’, rather than ‘Evolution of DSS’. Both of them might have different or similar meaning. In their study, they relate DSS evolution to the changing of DSS features or components or technology on which the system is used, development of more efficient algorithms, evolving knowledge in the system, or changing users and user preferences over time. They also raises a few questions if DSS evolves, such as; is evolution a formal process or is evolution something that just happens? How can we tell if evolution has occurred? How do we measure the extent of evolution? Can we predict aspects of evolution, or can we facilitate evolution, maybe increasing the speed of evolution?

As the term ‘evolutionary framework’ used by [8], they refer to the evolution of the framework, even though they did not specify it for DSS. They used insight from the theory of evolution and prior DSS research. Besides shown in Table I, [9] also use the term DSS adaptation and they are referring this as a driver of system evolution. Hence, it can be said that DSS adaptation that they mentioned is also means DSS evolution. Table I shows the variety definitions of DSS evolution identified.

TABLE I: VARIETY DEFINITIONS OF DSS EVOLUTION

Aspect of definitions	Detail explanation(s)
Using Same Terms; ‘DSS Evolution’ but with Different Meaning	Author [10] elaborated key aspects to evolution in DSS that was first mentioned by [11]. Author [12] described the DSS evolution from the historical perspectives rather than specific DSS. Author [13] use the term evolution of DSS in a different context that is to describe the numerous increasing of publications in field of DSS.
Using Different Term That Has the Same Meaning with ‘Evolution’ and ‘DSS Evolution’	Author [14] discussed about longitudinal behavioral adaptation and change based on development pattern. Even though they are using different terms, this is similar to the concept of evolution. The term ‘adaptation’ offers to the same meaning to ‘evolution’.

Author [15] describes the descriptive and prescriptive views of the target decision in DSS evolution. All of these are important elements in DSS evolution. Author [16] developed three stages of DSS methodology that includes ‘iterative’ use, ‘refinement’ and assessment, which conceptually means ‘change’ or ‘evolution’ too. Similarly, seven stages of DSS design methodology developed by [17] are also related to the change, where information requirements determination exists in all stages of the DSS development process and may drive evolution.

III. RESEARCH ON PREVIOUS DECISION SUPPORT SYSTEMS (DSS) FRAMEWORKS

TABLE II: FRAMEWORKS FOR DSS IN A VARIETY AREA OF INTERESTS

Title, Year	Framework	Area of Interests
A general framework for time-aware decision support systems, 2013 [18].	A general framework is presented for time-aware decision support systems.	Market recommendations aggregation system (Business field)
Application of the Knowledge-to-Action and Medical Research Council frameworks in the development of an osteoporosis clinical decision support tool, 2012 [19].	Knowledge-to-Action and Medical Research Council frameworks demonstrated.	Osteoporosis clinical decision support (Medical field)
The subjectivist interpretation of probability and the problem of individualisation in forensic science, 2013 [23].	Normative framework from Bayesian theory. Probabilistic inference is part of this framework.	Individualization issues in forensic science (Forensic science field)
Evidential calibration process of multi-agent based system: An application to forensic entomology, 2012 [24].	A framework for a DSS in forensic entomology.	Forensic entomology (Forensic science field)
Forensic cultures in historical perspective: Technologies of witness, testimony, judgment (and justice?), 2012 [25].	Analytical framework.	Forensic issues of means of witness, accredited testimony, and the reaching of juridical decisions (Court)
A framework for an intelligent decision support system: A case in pathology test ordering, 2012 [26].	A framework designed for an intelligent DSS in the context of pathology test ordering.	Guidance for general practitioners in the context of pathology test ordering (Medical field)

The aim of this research is to identify the current problems in decision support system (DSS) frameworks. Throughout the research, it has been identified that most articles published in DSS focused on applied research using DSS methods or models compared to DSS frameworks at fundamental level. The classification of these researches in DSS frameworks may encourage new researchers in this field to categorize and organize a systematic literature survey in this field. The critical survey presented in this chapter is attempting to categorize current literature reviews on DSS according to DSS frameworks, DSS models, or DSS applications rather than DSS methods employed.

Frameworks for decision support systems (DSS) have been proposed widely in variety area of interests recently. They includes problem domain in business fields like market recommendations [18]. Other than business-related field, they also include medical fields like knowledge from pathology data, knowledge translation tools for osteoporosis

[19], environmental science field like identify tidal in-stream locations [20], patient choice in primary health care [21], predicting the forest fire [22] and forensic science fields [23]-[25]. DSS involved in multi-disciplinary research. In this paper, the scope of problem domain is forensic science. The discussions about the types of DSS framework in general is within the scope of this paper. Frameworks for DSS that are proposed in a variety area of interest are shown in Table II.

IV. EVOLUTION ISSUES IN DECISION SUPPORT SYSTEMS (DSS) FRAMEWORKS

In comparing the literatures on frameworks of DSS, evolution issue is chosen to be focused in this research. The first classical literature that was found attempting to relate DSS with evolution is [27]. They investigated two alternative strategy for implementing DSS; evolutionary and traditional. The discussions focused more on the implementation stage rather than the other process starting from the requirement for a DSS. They also did not propose any conceptual framework related to DSS and evolution.

Authors [28], [29] only have a minor discussion on evolution and does not relate to frameworks or even DSS. Authors [30] attempts to investigate on the evolutionary process of a DSS in general and does not specify their work focused on certain area of interests from any problem domain, but [31] focused on stock market trading. None was found to focus on area of forensic science. In this study, an evolutionary framework is proposed for a DSS in forensic science, specifically for forensic DNA analysis.

V. RESEARCH METHODOLOGY

The overall research methodology in progress can be divided into three main phases;

A. Phase 1 (Employ an Analysis Method)

During the Phase 1, an analysis method will be employed for forensic DNA analysis that is Object-oriented Bayesian networks (OBN) compared to previous study that employed Bayesian networks (BN). Besides, it is also important for us to reanalyze requirement from law enforcement unit that is Royal Malaysian Police (PDRM), forensic unit that is Chemistry Department of Malaysia (KIMIA) and how to integrate their functions in system design.

B. Phase 2 (Design an Evolutionary Framework)

For the Phase 2, design of an evolutionary framework will be done. Next, the evolution details that already being identified in Phase 1 will be used to for the enhancement of system prototype from the previous development. Based on these works, continuous design for study is necessary. Other than framework, architecture can be created as well if it can help to provide a more specific view of the analysis for the problem domains in multidisciplinary study.

C. Phase 3 (Evaluate the Evolutionary Framework)

Lastly, once all the previous phases completed, the evolutionary framework and the system prototype will be evaluated in terms of its usability, reliability and robustness. The system will also be tested for consistency with the

specification proposed. As examples, from the video recorded during discussions with domains experts, they talked about 'changes', which signifies 'adaptive' characteristics or 'evolution'.

D. Evolutionary Framework of a DSS

The proposed evolutionary framework of a DSS is shown in Fig. 1. The context of evolution of the DSS that needs to be evolved, can either be the software, hardware, decision variables, mathematical models or any other aspect related to the chosen DSS. From the existing work in overall, there are many methods and concepts that are being used to solve scientific problems using computer software, including models, architectures and framework for evolution. An evolutionary framework in DSS evolution is proposed in this study.

Fig. 1 shows that the proposed evolutionary framework consists of variety elements. The vertical lines signify the stages of DSS evolution in general. This framework can be categorised as a generic conceptual framework due to its applicability to many case studies in DSS evolution. The arrows signify the 'direction' or 'movement' of DSS evolution. As the evolution progresses, the problems became properly defined and its initiatives for solutions become more specific. The elements and components as in Fig. 1 are related to each other.

Referring to Fig. 1, the stages demonstrated shows that the DSS evolution is initiated by meeting with domains experts, either formal or informal interviews, meeting or discussing with domain experts. Delphi method can be applied at this stage, but more details in not included yet in this paper. At this stage, it involves identifying evolution. This is including components, elements, characteristics, attributes, alternatives and many more that is related to DSS evolution. Next stage is an understanding of evolution, followed by actions required on how to facilitate evolution. Once what kind of necessary evolution has been properly defined the pre-evaluation of DSS evolution needs to be done. This is important in order to reduce the cycle of repeating 'changes' or 'evolution' to the implementation of system prototype.

Fig. 1. Evolutionary framework in DSS evolution.

Fig. 2. Applicability of evolutionary framework in DSS evolution.

Furthermore, the applicability of this proposed evolutionary framework is proven by classification of some research works as arranged in Fig. 2. The proposed work by numerous researchers in field DSS evolution is classified or categorized into stages of an evolutionary framework presented in this paper. There is a gap for identifying and specifying an evolution process, which will be detailed out in the future research using a more sophisticated framework, initiated from an evolutionary framework in Fig. 1 and Fig. 2 as presented. From these fundamental of DSS evolution, case studies focused on forensic DNA analysis can be implemented.

VI. CONCLUSION

The evolution from the manually written hardcopy documents into computerized typed softcopy files has tremendously changed the way human work. Since decision support system (DSS) involves human, user, or specifically domain experts, its evolution could possibly expected to increase the productivity and efficiency of current work loads. DSS evolution has been introduced since 1980's but there is lack of related literatures compared to DSS development, whereas both are equally important.

DSS frameworks have been discussed since the beginning of DSS concepts. There are generic framework, strategic framework, conceptual framework, and many more which contributes to the DSS development concept but not DSS evolution. This research is an attempt to propose an evolutionary framework, which is a framework for DSS evolution. This arise the issue like how to categorize or classify DSS development, DSS evolution, and its associated different types of frameworks altogether.

Furthermore, in case study forensic DNA analysis, inferences and additional mathematical formula can be implemented. Decision-makers which are forensic scientists can adjust on how many alleles can be considered to fit for each decision either exclusion, inclusion or inconclusive results. This paper concludes on; the significant of DSS evolution issues with an evolutionary framework, the expected outcomes based on objectives of the study, and in progress implementation components or elements that will be applied in case study forensic DNA analysis.

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