Paper Session IV: Toward Understanding Digital Forensics as a Profession: Defining Curricular Needs (**Research in Process**)

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Defining Curricular Needs

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ABSTRACT
This research paper presents research in process which attempts to define the common body of knowledge (CBK) of digital forensics. Digital forensics is not well defined nor does it have a generally accepted CBK. The first three phases of completed research, in a four-phase research process are discussed. The early results have created a preliminary CBK, and final validation is underway.

1. INTRODUCTION
The FBI estimates that cyber-crime in the United States costs more than $10 billion per year, with up to 80% of the losses unreported, in part because law enforcement agencies cannot respond effectively to these kinds of incidents (Holsapple 2004). A key challenge of investigating computer crime is that the computer is both a principal instrument of the criminal activity and a key source of evidence about that activity. Digital evidence (i.e., a file on a disk drive), because it is less tangible than physical evidence (i.e., a print-out of the file), presents special challenges to the criminal investigator. Finding, authenticating, and preserving digital evidence, and documenting the chain of custody in a way that is legally admissible in a court of law, are all activities that the field of digital forensics encompasses. However, that field needs better definition.

The digital forensic(s) (DF) analyst is trained to copy and examine digital data in ways that leave the original data intact. They are trained to maximize the amount of information they can recover during an investigation, not only by searching files left in place by suspects, but also by checking for residual traces of files that were erased by the users, maximizing the amount of relevant information retrieved during the investigation (Feldman et al. 1998). However, the training received by these analysts is not well defined. This paper explores the concepts that underpin DF and reports on research that creates a conceptual framework for professional training in this field. It reports on research in process that can be used to give definition to this emerging topic as well as to create appropriate curriculum.

Our approach to determining a conceptual framework for DF parallels the work that created a framework for data quality (Wang et al. 1996). Our research uses a similar methodology for explicating the professional knowledge which defines DF by:

- Identifying DF attributes via an intensive review of digital forensics related programs and courses offered in the United States at technical schools, colleges, and universities;
- Reducing the attributes to a smaller number of DF dimensions;
- Categorizing the dimensions into a conceptual framework for digital forensics.

2. IS DIGITAL FORENSICS A PROFESSION?
A profession has four defining hallmarks:
- a durable domain of human concern;
a codified body of conceptual knowledge;

- a codified body of practices – embodied knowledge including competence;

- standards for competence, ethics and practice. (Denning 2001)

In today’s technology-driven world, DF is clearly a durable domain of human concern. In fact, the use of computers in criminal activity is a growing concern; digital evidence is less tangible than physical evidence and presents special challenges to criminal investigators. DF involves finding, authenticating, and preserving digital evidence, and documenting the chain of custody in a way that is legally admissible in court. The socio-legal and technical nature of DF support the necessity of creating a framework for the DF profession (Feldman et al. 1998). However, since DF is not well defined, the questions of whether it is a profession is fuzzy, at best – there appears to be no universally accepted codified body of conceptual knowledge, codified body of practices, or standards for competence, ethics, and practice. This research attempts to create a codified body of conceptual knowledge that can get us another step closer to recognition of DF as a profession.

3. DIGITAL FORENSICS EDUCATIONAL OFFERINGS

DF, as a recognizable skill set has emerged fairly recently, thus the common body of knowledge is not well established. DF education is offered at many levels, from tool-specific technical courses to graduate degrees. It is interdisciplinary - that is, the education is a combination of several fields such as criminal justice, law, network security, etc. Whether DF is a profession or discipline in the academic sense is open to question. A common conceptual approach is needed for DF to be recognized as a profession and accepted in the courts (Rogers et al. 2004). We believe that DF is a profession that is in need of an accepted common body of conceptual knowledge. The study reported in this paper is being undertaken to uncover that knowledge and to create a categorical conceptual framework that gives substance to it.

4. METHODS

This research consists of four phases. To date, phases one through three are completed. The phases are:

- Phase 1 - Review of existing courses and content, creating DF attributes
- Phase 2 - Collapse the DF attributes in dimensions and prepare statements for VCS
- Phase 3 – Create a preliminary conceptual framework
- Phase 4 – Validate the preliminary conceptual framework (in process)

In order to simplify discussion of the methodology for this study, the following terms are used:

- Attribute - concepts uncovered during the review of courses and content
- Dimensions - attributes that have be grouped together since they are intuitively similar
- Statements – dimensions that seem to be in similar a priori knowledge domains

5. PHASE 1 - REVIEW OF EXISTING COURSES AND CONTENT

As a first step in constructing a preliminary conceptual framework for digital forensics, 89 attributes were uncovered from college catalogs and college/technical course descriptions. Organizations were selected in two ways:

- Academic institution were identified through an online search service, College Source Online (www.collegesource.org). They bill themselves as “the worldwide leader in college information resources.”
Additional on-line searches for technical and non-academic training programs were conducted using Google. The only keyword used for the searches was computer forensics. This was done because, after initial preliminary searching, computer forensics seemed to best capture the type of results that the researchers were attempting to retrieve and using just one keyword simplified the searches.

Phase 1 resulted in 89 attributes (Table 1 – Digital Forensics Attributes), yielded from 19 different academic and non-academic organizations. The dimensions were gleaned from the organizations online course and program catalogues. Our review included:

- 1 organization that did only tool-based training;
- 5 organizations that offered professional certifications;
- 3 associate degree granting schools;
- 2 Bachelors granting schools; and
- 8 schools offering graduate degree programs.

6. PHASE 2 - COLLAPSE THE ATTRIBUTES IN DIMENSIONS AND PREPARE STATEMENTS FOR VCS

The 89 attributes that were uncovered in Phase 1 were somewhat vague and overlapping. There were intuitively apparent relationships between the attributes that led the researchers to collapse them. A three-step method was employed to create the statements:

- attributes were collapsed because they were so similar as to apparently belong to the same *a priori* knowledge domain
- attributes were eliminate if they were extremely vague and a more representative attribute already existed (in all cases more representative ones were on the list);
- attributes which were grossly overlapping were collapsed were grouped together.

The result was a set 19 statements and associated dimensions that appropriately represent the intent of the 89 attributes. Some dimensions were added to the statements to maintain integrity and to be true to the original content. Each statement consists of a statement label created by the researchers to succintly describe the content of the statement, followed by a list of dimensions which describe the statement. During statement creation, no more than 4 attributes/dimensions could be assigned to any one statement.

7. PHASE 3 – CREATE A PRELIMINARY CONCEPTUAL FRAMEWORK

During Phase 3, a preliminary conceptual framework was created. This framework was created by grouping statements together into like categories using visual card sorting (VCS). The goal of VCS is to discover latent structure in an unsorted listed of statements or ideas (Bevan 2006). VCS is appropriate to show how individuals categorize concepts within particular knowledge domains. Using VCS generate similarity matrices by having the subject identify salient categories and identifying the pattern of statement assignment to them (Budwar 2000). The researchers did multiple VCS passes in order to create the preliminary conceptual framework – the preliminary framework was not considered finalized until all researchers agreed to its structure and content. Once all the dimensions were properly placed, the categories were named and the preliminary conceptual framework was complete (Figure 1 - Digital Forensics Preliminary Conceptual Framework).
<table>
<thead>
<tr>
<th>Table 1 - Digital Forensics Attributes</th>
</tr>
</thead>
</table>

Access Control Systems and Methodology  
Access Controls  
Administration  
Advanced Computer Forensics (UNIX, TCP/IP, firewalls, network scanning and tools, etc.)  
Analysis of Digital Media  
Application Development and Security; Operations Security  
Applied Cryptography; Security Risk Management  
Assessment; Information Systems Forensics  
Audit and Monitoring  
Business Continuity Planning  
Collection and analysis of digital evidence  
Computer Forensic Technology  
Computer Forensics  
Computer Forensics (includes lab with Expert Witness or other industry software)  
Computer Forensics (operating systems, file systems, disk cloning, forensic tools, etc.)  
Computer Forensics I  
Computer Forensics II  
Computer Systems and Networks  
Criminal Activities & Investigative Procedures  
Criminal Investigation  
Criminal Law I  
Criminal Law II  
Cryptography  
Cyber crime  
Data Communications  
Economic Crime Investigation  
Ethics, Privacy & Digital Rights  
Forensic Accounting  
Forensic Collection and Examination of Digital Evidence  
Forensic Internship  
Forensic Technology  
Foundations of Information Assurance  
Gathering and preserving evidence in ways that ensure its admission in courts  
Hidden or deleted files  
Illegal software  
Information extraction from digital devices  
Intelligence Analysis  
Internet Vulnerabilities  

| Introduction to Computer Forensics and the Law  
Introduction to Digital Forensics (4th Amendment search and seizure, media imaging, hard drive/storage device investigation, network attacks, investigating Windows and Unix systems, security through forensics)  
Introduction to Forensic Technology  
Intrusion Detection (includes lab with Smartwatch or other industry software)  
Intrusion Detection Forensic Analysis  
Intrusion detection systems  
Investigating High Technology Crime (privacy, copyright laws, how to conduct a forensic examination, etc.)  
Investigation of pc workstations, servers; and PDAs; media analysis  
Investigative Interviewing  
Law, Investigations and Ethics  
Malicious Code/Malware  
Methods used to hide or disguise digital information  
Network Security  
Network, & Internet Security  
Physical Security  
Principles of information security  
Procedures for the admissibility of evidence  
Profiling  
Response and Recovery  
Risk  
Search and Seizure  
Security Architecture and Models  
Security Management Practices  
Security System Design and Analysis  
Seizure and Examination of Computer Systems; Computer Forensics II  
Stenography  
Techniques of intrusion detection  
Technology Issues in Computer Forensics Investigation (wireless and mobile communications, security aspects of software engineering, database management, etc.)  
Telecommunications  
The criminology of cyber-crime  
Topics in Forensic Science  
White Collar Crime |
# Table 2 - Digital Forensics Statements

<table>
<thead>
<tr>
<th>Statements</th>
<th>Number of Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accounting</strong>: General Accounting; Forensic Accounting</td>
<td>2</td>
</tr>
<tr>
<td><strong>Computer Forensics Theory</strong>: Disk Cloning; File Systems; Forensic Tools, Etc.; Technology Issues In Computer Forensics Investigation</td>
<td>4</td>
</tr>
<tr>
<td><strong>Criminal Law</strong>: Computer Forensics Law; Cyber Crime; Ethics, Privacy And Digital Rights</td>
<td>3</td>
</tr>
<tr>
<td><strong>Criminology</strong>: Criminology Of Cyber Crime; Economic Crime Investigation; Profiling</td>
<td>3</td>
</tr>
<tr>
<td><strong>Cyber-Criminal Procedures</strong>: Computer Systems Seizure And Examination; Evidence Admissibility Procedures; Evidence Gathering and Preservation</td>
<td>3</td>
</tr>
<tr>
<td><strong>Digital Media Analysis</strong>: Digital Device Information Extraction; Digital Evidence Collection And Analysis; Hidden Or Deleted Files</td>
<td>3</td>
</tr>
<tr>
<td><strong>General Business</strong>: Business Continuity Planning; Human Resource; Introduction To Business</td>
<td>3</td>
</tr>
<tr>
<td><strong>Illegal Software Activity</strong>: Malicious Code/Malware; Stegnography</td>
<td>2</td>
</tr>
<tr>
<td><strong>Infrastructure Security</strong>: Access Control Systems; Internet Security; Physical Security</td>
<td>3</td>
</tr>
<tr>
<td><strong>Intelligence Analysis</strong>: Analysis Of Massive Volumes; Multilingual And Multimedia Data</td>
<td>2</td>
</tr>
<tr>
<td><strong>Internship/Practicum</strong>: Assessment; Forensic Internship; Information Systems Forensics</td>
<td>3</td>
</tr>
<tr>
<td><strong>Introduction To Networking</strong>: Computer Systems And Networks; Telecommunications</td>
<td>2</td>
</tr>
<tr>
<td><strong>Intrusion And Vulnerabilities</strong>: Internet Vulnerabilities; Intrusion Detection Methods And Techniques; Intrusion Detection Systems; Risk</td>
<td>4</td>
</tr>
<tr>
<td><strong>Investigative Procedures</strong>: Conducting A Forensic Examination; Criminal Activities; Investigation Of Desktop Devices, Servers, And PDA’s</td>
<td>3</td>
</tr>
<tr>
<td><strong>Legal Topics</strong>: 4th Amendment; Investigations And Ethics; Law (privacy, copyright)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Operational Security</strong>: Operations Security; Response And Recovery; Security Risk Management</td>
<td>3</td>
</tr>
<tr>
<td><strong>Security Practices</strong>: Audit And Monitoring; Security Management Practices</td>
<td>2</td>
</tr>
<tr>
<td><strong>Security Theory</strong>: Information Assurance Foundations; Information Security Principles; Security System Analysis And Design</td>
<td>3</td>
</tr>
<tr>
<td><strong>Software Security</strong>: Application Development Security; Applied Cryptography; Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL DIMENSIONS</strong></td>
<td>54</td>
</tr>
</tbody>
</table>
8. PHASE 4 – VALIDATE THE PRELIMINARY CONCEPTUAL FRAMEWORK (IN PROCESS)

The final conceptual framework will be created using a closed VCS to validate the preliminary framework created in Phase-4. A convenience sample from both the ISWORLD and JDFSL ListServe will be selected for this purpose. Each ListServe will be sent a request for subject participation. The request will contain URL. By visiting the URL, subjects will receive instruction (Figure 2 - Instruction Screen), a small amount of demographic information will be collected (Figure 3 - Demographics Screen), and then subjects will be asked to complete the closed VCS exercise (Figure 4 - VCS Screen). The VCS is considered “closed” because the categories are pre-labeled in accordance with the preliminary conceptual framework. Subjects will be given the 19 statements and will be asked to sort the dimensions into the pre-named categories, as was done in the creation of the data quality framework (Wang et al. 1996). This will validate the researchers’ preliminary framework. Some dimensions/statements may be moved based on the results of the VCS. Results of the visual card sort exercise will be analyzed using the Chi Squared technique to compare the expected results that were determined in the Preliminary Conceptual Framework to the actual results that were received from each user.

9. DISCUSSION

Ways of comparison – Like Wang and Strong the researchers used both an intuitive and the empirical approach to create the preliminary conceptual framework. The collection of the attributes, and the proposed validation of the preliminary conceptual framework use an empirical approach, while the collapsing of attributes into dimensions and statements use an intuitive one. These approaches seem well suited to the tasks to be performed. These approaches were further buttressed by using Denning’s paradigm as a way to define a profession.

The descriptive survey of digital forensics education programs conducted by the researchers during the summer of 2004 disclosed a relatively wide variety of digital forensics instruction. Some of the potential reasons for this are:

- DFs relative infancy as a field of study;
- the interdisciplinary nature of the educational offerings for DF;
- the fact DF education is offered at many different levels including tool-based courses, professional certificates, undergraduate degrees, and graduate degrees.

This review uncovered differences, which leave the expertise of DF analysts open to question; it is at least unpredictable, and at best variable. Certificate programs are often vendor-specific, and academic programs vary in their depth, rigor, and approach to the subject. The degree of disparity in the approach to and subject matter of digital forensics education raises the question- is digital forensics a discipline/profession in an academic sense and if so, how should it be defined? This study sets out to do start that definitional work.
Figure 1 - Digital Forensics Preliminary Conceptual Framework

The results of this research will be recorded into our database where we will work to analyze the categories of digital forensics.

Your participation in this study is voluntary and no identifiable information will be collected. Only aggregated responses will ever be reported and your individual responses will never be identifiable.

This survey involves categorizing key concepts related to Digital Forensics and will take approximately 10 minutes to complete.

The top of the next screen has a series of balls, each of which represents a statement related to digital forensics. When you hold your cursor over the ball the statement appears.

Your task is to drag the balls into like categories. There are category labels to assist you. The un-categorized label is for those statements that you feel do not belong in any of the other categories.

Once you are ready to continue, please click NEXT.

Figure 2 - Instruction Screen
Figure 3 - Demographics Screen

Figure 4 - VCS Screen
10. REFERENCES


