Winning the Battles, Losing the War? Rethinking Methodology for Forensic Computing Research.

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Abstract

In the last ten years Forensic Computing (FC) has emerged in response to the challenges of illegal, criminal and other inappropriate on-line behaviours. As awareness of the need for the accurate and legally admissible collection, collation, analysis and presentation of digital data has grown, so has recognition of the challenges this requirement poses for technical, legal and organisational responses to these on-line behaviours. Despite recognition of the multi-dimensional nature of these behaviours and the challenges faced, agreement on coherent frameworks for understanding and responding to these issues, their impacts and their interrelationships appears to remain a long way off. As a consequence, while significant advances have been made within technical, organisational and legal 'solution centred paradigms', the net result appears to be a case of 'winning the battles but losing the war' on computer misuse and e-crime.

This paper examines this situation and reflects on its implications for academic researchers' methodological approach to understanding and responding to these challenges. This paper suggests the need to reconceptualise the term 'solution' and advocates an additional methodological step, (that it is anticipated will generate data) for the development of a framework to map the value propositions of, and interrelationships between the individual sets of responses within the dynamically evolving forensic computing landscape. By exposing issues, responses and underlying assumptions it is anticipated that this will improve the possibility of calibrated responses that more effectively and coherently balance the interests for security, privacy and legal admissibility.

Introduction

The last decade has seen an explosion of research and development by computer security specialists, legal professionals, information managers and others on technical, legal and organisational issues arising from illegal, criminal and/or inappropriate on-line behaviours. Researchers drawn from a variety of disciplines have explored different aspects of the issues and advocated different solutions to these forensic computing challenges (for example, Reno, 1996; Venema & Farmer, 1995; Verreck, 2000a, 2000b). To date however, despite numerous attempts there is a lack of agreement on frameworks for either understanding and/or responding to these issues, their impacts and their interrelationships. This can partly be explained by the fact that with growing demand for practical solutions to the challenges faced, different business, legal and organisational imperatives drive developments in ways that militate against coherence in the name of competitive advantage.

Significantly however, it is evident that this lack of coherence is of more than purely academic interest and has directly inhibited awareness of the issues and challenges in the community, impaired the development and diffusion of specialised forensic computing skills and, most importantly, impacted directly on the effectiveness of responses to computer misuse and e-crime (Broucek & Turner, 2005; Broucek, Turner, & Frings, 2005). Indeed, whilst many forensic computing specialists have advocated the need for more integrated solutions that balance the requirements for network security, individual privacy and legally admissible digital evidence, there remains little evidence of these emerging.

From the perspective of academic research this situation raises a series of questions about the nature of the discrete technical, organisational and socio-legal responses being developed towards computer misuse and e-crime, including:

- What is the nature of the frameworks that individual sets of responses use to conceptualise the issues and challenges their solutions aim to address?
- How do individual sets of responses conceptualise the relationships between themselves and other sets of responses?
- What key value propositions underpin individual sets of responses and how does this influence their perceptions of what constitutes a solution?
- How can a framework be developed that will more explicitly map the value propositions of, and interrelationships between the individual sets of responses?

This paper considers these issues and reflects on their implications for academic researchers' methodological approach to forensic computing research. The paper commences with a review of attempts to define and model the forensic computing domain. This review highlights the limited agreement that exists on models for understanding and/or responding to issues, their impacts and interrelationships. The paper also presents evidence highlighting how the interrelatedness of these issues means that responses in one area can have negative consequences for developments in another area, thereby inhibiting the overall effectiveness of the current approaches. On the basis of this analysis, the paper acknowledges that whilst, in the short term at least, technical, organisational and legal responses to computer misuse and e-crime will remain fragmented, academic researchers need to reconceptualise the notion of a 'solution' and take steps to develop a framework to map the value propositions of, and interrelationships between these individual sets of responses. In this context, the paper outlines an additional methodological step that is anticipated to generate data that will enable the development of this framework. By exposing issues, responses and underlying assumptions it is anticipated that this will improve the possibility of calibrated responses that more effectively and coherently balance the interests for security, privacy and legal admissibility.

Models and Frameworks: A Help or Hindrance?

Previous research has identified the absence of an overarching conceptual framework for forensic computing and revealed how this has contributed to limiting exploration of the interdisciplinary dimensions of issues concerned with the identification, collection and analysis of computer evidence (Broucek & Turner, 2001a, 2001b). However, given that this paper is directly concerned with the reasons for, and methodological implications of this lack of coherence, the first part of this paper reviews existing models and frameworks as a way to explore their differences and underlying suppositions.

In this context, it is first important to examine the definitional ambiguity that has surrounded forensic computing itself. In this regard the following definitions can be presented as being representative of the range of definitional approaches:

- 'The process of identifying, preserving, analysing and presenting digital evidence in a manner that is legally acceptable'. (McKemmish, 1999)
- 'Gathering and analysing data in a manner as free from distortion or bias as possible to reconstruct data or what has happened in the past on a system'. (Farmer & Venema, 1999)
- 'The use of scientifically derived and proven methods toward the preservation, collection, validation, identification, analysis, interpretation, documentation and presentation of digital evidence derived from digital sources for the purpose of facilitating or furthering the

reconstruction of events found to be criminal, or helping to anticipate unauthorized actions shown to be disruptive to planned operations.' (Palmer, 2001)

As the above quotes indicate, Forensic[1] Computing has continued to remain problematic to define. Broucek & Turner's (2001a; , 2001b) preliminary taxonomy of forensic computing (FC) highlights how, as an academic discipline, FC builds on knowledge drawn from several other fields of expertise. This taxonomy also illustrates the broad range of issues and approaches within FC and suggests the following working definition of FC as being:

- 'Processes or procedures involving monitoring, collection, analysis and presentation of digital evidence as part of "a priori" and/or "post-mortem" investigations of criminal, illegal or other inappropriate on-line behaviours.'

Subsequent work expanded this initial taxonomy to include law enforcement and the basic taxonomy of the FC domain is illustrated in Figure 1. For further information on this approach refer to (Broucek & Turner, 2001a, 2001b; Hannan, Frings, Broucek, & Turner, 2003; Hannan, Turner, & Broucek, 2003). It should however be noted that this taxonomy is by no means the only attempt to define the domain.

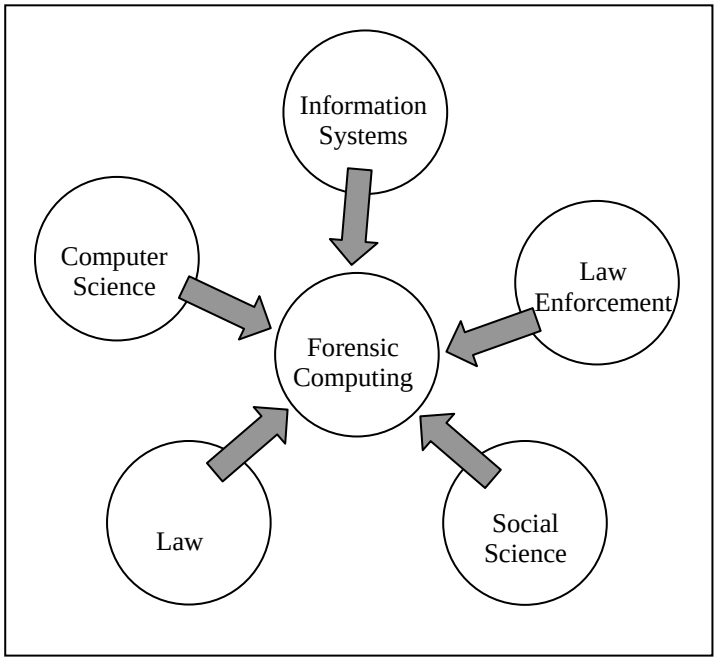

Figure 1: Forensic Computing Domain

Indeed, as a result of work at the First Digital Forensic Workshop (DFRWS) in 2001 an entirely different approach based not on constitute disciplines but rather specific fields of computer forensic activity led to the development of an alternative model referred to as the "Nucleus of Digital Forensic Research". This model is displayed in Figure 2 below.

[1] It is useful to note that the term 'forensic' is defined as: 'used in or connected with court of law' (Hanks, 1991)

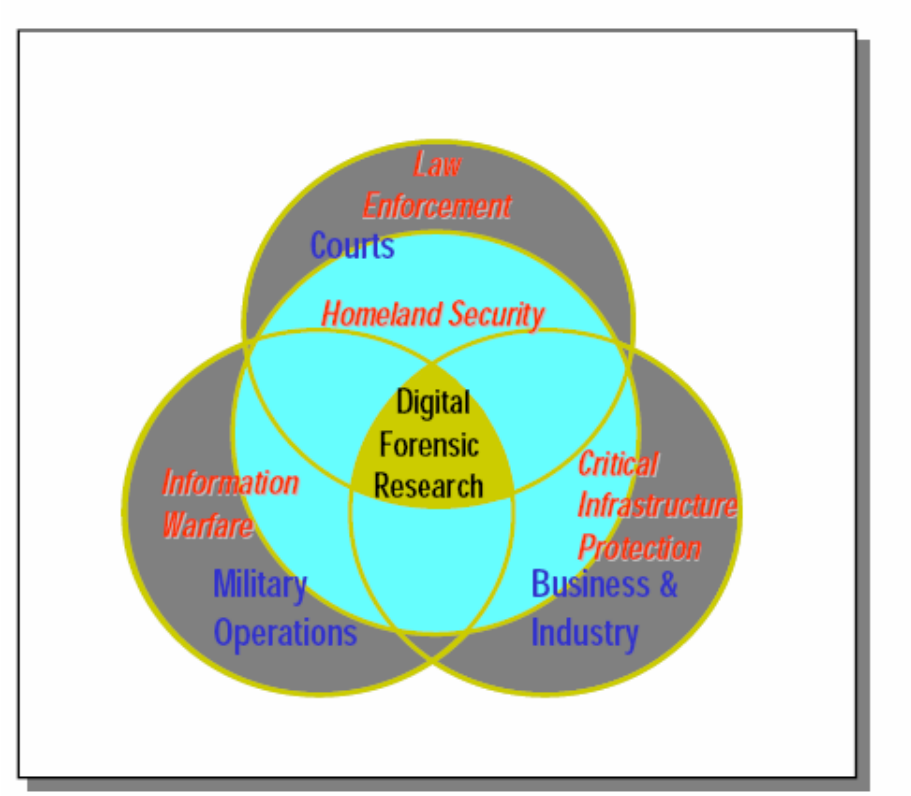

Figure 2: Nucleus of Digital Forensic Research (from Palmer, 2001)

Interestingly both the 'taxonomy' and 'nucleus' frameworks emphasize the need to stimulate cooperation and collaboration amongst the various disciplines and fields concerned with forensic computing issues. The same urgency to support interaction and collaboration has also been suggested by Spafford (cited in Palmer, 2001, p. 7). Spafford argues that it is necessary

- To abandon current "band aid approach" to forensics. The same approach was and still is often observed in the security world – the security elements are added into the existing or new systems, instead of designing the systems with security already built in;
- To know exactly how much information and what type of it needs to be collected for further analysis in particular circumstances;
- To understand social aspects of 'the game'.

Spafford concludes that in the forensic computing domain 'All aspects of the problem are essential. Therefore, it is imperative that each collaborates with the other. Researchers, investigators, legislators, and jurists must all work toward a central goal. This requires constant discussion within groups that have representation from all essential parties' (Palmer, 2001, p. 8).

What is significant about these remarks is that despite there apparent conformity and agreement, an academic analysis of the work arising from, for example, the First Digital Forensic Research Workshop, reveals the markedly different aims/goals/objectives underpinning the approaches of different domain experts.

As the presentations of the main speakers at the DFRWS workshop illustrate (i.e. Eugene Spafford representing academic research and government, Charles Boeckman representing DOD Operations, Chet Hosmer representing Commercial Tools development, David Baker representing Critical

Infrastructure Protection and John Hoyt representing Law Enforcement), the different underlying positions can be summarised as follows:

- Law enforcement agencies appear primarily interested in gathering evidence that can later be used for prosecution[2];
- Business requirements are more or less driven by economic pressures of remaining viable and competitive;
- Academics are interested in exact, scientific methods and data and the advancement of new knowledge;
- Military and Information Warfare Operations are mainly interested in what is referred to as Defensive Information Operations (DIO). DIO represents a multi-disciplinary approach to protecting digital systems. It includes Communication, Computer, Information and Operational Security as well as Physical Security, and other tactics used in active systems protection[3].

The result of DIO is research conducted in defence operations concentrated mainly on:

- Optimisation of data collection,
- Minimisation of data corruption or destruction risks, and
- Accommodation of operational time constraints.

Table 1, adapted and extended from Palmer (2001), clearly demonstrates that investigators from each area deploy different paradigm when approaching FC and its analysis. Furthermore, the workshop appears to agree that they also attempt to do this in different environments (that the authors here would prefer to call time frames). Significantly, it is suggested that Law Enforcement is only interested in "post-mortem" while all the other players tend to anticipate and try to take an action to thwart a possible threat even before it happens including such factors as financial cost, reputation, service availability.

Area	**Primary Objective**	**Secondary Objective**	**Environment - Time Frames**
Law Enforcement	Prosecution		After the act/post-mortem
Military IW Operations	Continuity of Operations	Prosecution	Real Time
Business and Industry	Availability of Services	Prosecution	Real Time
Academics	Advancement of knowledge	Dissemination of knowledge	Variable: subject to externalities

Table 1: Suitability Guidelines for Digital Forensic Research (adapted and extended based on Palmer (2001).

It is noticeable that the approach advocated by DFRWS can be directly linked to models that subsequently emerged focused on how to respond in conducting/implementing FC investigations. Broadly these models can be divided into three categories Simple, Advanced and Complex. These are discussed below.

[2] It is worth pointing out that such evidence must follow rules of evidence established by particular jurisdiction to maintain evidential integrity (chain of custody) and that the digital evidence should form a part of 'whole case' and non-technical elements should also be taken into an account.

[3] The main differentiation of defence operation requirements from those in law enforcement is willingness of DIO to sacrifice absolute and/or even measurable accuracy for quickness in order to serve a mission's timeline.

Simple Models

Arising directly out of the DFRWS was the development of 7 Step linear model for the conduct of FC investigations:

- Identification
- Preservation
- Collection
- Examination
- Analysis
- Presentation
- Decision

Reith, Carr, and Gunsch (2002) extended this model to nine steps and called it the Abstract Digital Forensic Model. The nine steps included are:

- Identification
- Preparation
- Approach strategy
- Preservation
- Collection
- Examination
- Analysis
- Presentation
- Returning Evidence

These models concentrate on processing digital evidence. They do not identify flow in investigation, do not include issues like chain of custody and different requirements and needs of different groups of users as defined above and in (Palmer, 2001).

Advanced Model

Carrier & Spafford (2003) after analysis of several other models developed their 'Integrated Digital Investigation Process (IDIP)'. This model is based on crime scene theory for physical investigation. They argue that this investigation process has been refined over time through its use in thousands of investigations, and as such, is the most suitable model upon which to establish a model for digital investigations. As a result their model is premised on the assumption that the computer should be treated as a separate crime scene to the extent that they use the analogy that the computer should be treated the same as a "*body at the murder scene*". (Carrier & Spafford, 2003, p. 18). Carrier & Spafford's model has been extended more recently by Baryamureeba & Tushabe (2004) with their Enhanced Digital Investigation Model (EDIP). The EDIP expands the IDIP to enable tracing back to address the issues of digital investigations in networked and wireless world. However, even with this enhanced model it is useful to consider how far the physical investigation analogy can be pushed given the challenges of incidental/multiple digital copies of any individual data element and the capacity of systems to 'tamper' with data during analysis.

Complex models

Most recently, one of the most complex models/frameworks has been developed by CTOSE. Discussion of this model has been widely published and is can be examined in depth through the following papers (Broucek & Turner, 2004a; Broucek, Turner, & Frings, 2005; CTOSE, 2003;

Leroux & Pérez Asinari, 2003; Sato, Broucek, & Turner, 2005; Urry & Mitchison, 2003) and at CTOSE website (http://www.ctose.org/). In summary, the CTOSE model was developed as a high level tool aimed to assist companies or other individuals/groups to respond correctly during the investigation and analysis of on-line behaviours in order to generate legally admissible evidence. The CTOSE approach was to develop an 'expert system' to guide users (for example, a company's security officer) in their preparations and responses to e-security incidents.

Importantly, the CTOSE approach aim is to bring to these organisations an overall benchmark against which to compare their own operations and procedures relating to evidence handling. CTOSE framework offers integrated functionality across whole spectrum of involved actors in different groups that have a stake in the process of evidence handling, whether organisations, IT, law enforcement or the legal establishment. It appears that CTOSE framework is the only framework to be comprehensive across the entire chain of evidence handling, flexible across different types of organisations as well as portable across countries. However, questions now arise over adoption and use of this comprehensive approach and what factors would stimulate more widespread implementation of the approach.

Finally, it is useful to review(Ciardhuáin, 2004) 13 step model that integrates each step with sequence of activities and information flows. To date, attempts have been made to validate this model through the conduct of interviews with police investigators and to deploy the model as part of genuine police computer forensic investigations. The thirteen steps of this model are:

- Awareness
- Authorisation
- Planning
- Notification
- Search for and identify evidence
- Collection of evidence
- Transport of evidence
- Storage of evidence
- Examination of Evidence
- Hypothesis
- Presentation of hypothesis
- Proof/Defence of hypothesis
- Dissemination of information

In summary, it is evident that despite numerous attempts to model the forensic computing domain definitional heterogeneity remains. It is evident that this heterogeneity is at least partly due to the differing assumptions, aims, goals and objectives underpinning the approaches outlined above. Significantly, however despite widespread recognition of the multi-dimensional nature of on-line behaviours and the challenges of understanding and responding to them, little progress has been made. Indeed, even where comprehensive frameworks have been developed the additional challenges of adoption and utilisation have emerged to limit the benefits as the problems of computer misuse and e-crime continue to grow.

While some readers may consider these issues merely of academic interest, the next section highlights how this lack of coherence has directly inhibited awareness of the issues/challenges in the community, impaired the development and diffusion of specialised forensic computing skills and, most importantly, impacted directly on the effectiveness of responses to computer misuse and e-crime (Broucek & Turner, 2005; Broucek, Turner, & Frings, 2005).

Winning the Battle and Losing the War

The increasing incidence of computer misuse and e-crime has led to strong demand across the public and private sectors for effective ways to address these behaviours and has contributed to the stimulation of research, development and commercialisation of technical, organisational and socio-legal responses. Whilst individual responses can be complemented for their innovation in continuing to address the evolving challenges faced, it has become increasingly obvious that truly effective offensive and defensive solutions will require both integration and implementation of insights from each.

Following Spafford (Palmer, 2001, p. 7) further research must address individual challenges in the technical, procedural, social, and legal realms as well as the integration between them 'if we hope to craft solutions that begin to fully "heal" rather than constantly "treat" our digital ills'. More specifically, Spafford advocates the need to 'incorporate forensic hooks into tools rather than use our current band aid approach that produces point solution tools' and also mechanisms to begin to answer the problem of training and experience. Much more effort is required in producing user interfaces that address deficiencies in skill levels that will always be with us and will no doubt get worse as the problems grow. We need to know how much information and what type exactly we must collect to afford the most accurate analysis under particular circumstances. Common terms of reference are needed as well as common analytical standards and practices'.

In working towards more integrated solutions that balances requirements for network security, individual privacy and the need for legally admissible digital evidence it is useful to reiterate the recommendations previously articulated by Broucek & Turner (2004a)

- Best practice for digital evidence handling should involve deployment of the highest investigative standards at all stages in the identification, analysis and presentation of digital data;
- Targeted training and education of network administrators and end-users in the key principles of digital evidence handling is urgently required as well as education and awareness amongst users of the consequences of their on-line behaviours for system security;
- Opportunities exist for the further refinement of e-forensic methodologies and processes such as those developed by CTOSE and these must include a recognition of the dynamic and multi-faceted nature of the forensic computing domain;
- Enhancing e-forensic professionalism through the rapid development of processes for e-forensic computing competences and certification is an essential element in building and implementing integrated solutions[4].

Unfortunately, despite these recommendations and recognition of the need for integrated solutions there is still only limited evidence that these are actually emerging. While the lack of collaboration and integration can be at least partially explained by the complexity of the individual sets of issues faced, it is clear that this fragmentation of effort is inhibiting the development of awareness and specialised skills required as well as having detrimental impacts on individual responses developed. Following Broucek & Turner's (2005) argument, there is the critical need for the development of integrated solutions that acknowledge how in digital environments developments in one area have serious implications for developments in another. Their paper revealed how without a conscious recognition of the interrelatedness of these responses we will continue to create vulnerabilities

[4] Interestingly, a degree in computer science is till sufficient qualification for expert witness in court proceedings

and/or problems that may actually impair the effectiveness of our overall response to computer misuse and e-crime – this in turn impacts directly on the ability of industry, government or academia to improve things i.e. we are 'winning our respective battles but possibly losing the war'.

The commercial pressures driving research, development and commercialisation further complicate the situation. These pressures often militate against mutual cooperation. For example, major players in the Computer Anti-virus industry still cannot reach agreement on a common naming system. This appears to be partly because of different organisations desire to acquire a "commercial edge". Another example of development of security tools without taking in account forensic capabilities has been identified by the authors' recent analysis of a premier digital data visualisation tool that appears to have been constructed and developed without consideration as to whether or not the output of its analysis would be legally admissible.

It is also evident that the marketplace sees commercial benefit from developing tools with anti-forensic capabilities. While it is acknowledged that currently there is not widespread awareness of these tools, perhaps this is only a matter of time. It can also be anticipated that cyber-criminals are already aware of and using these commercially available tools. For example, tools like CIPHER.EXE included in the standard distribution of WindowsXP can significantly hinder forensic analysis. While some recent research (for example, Mathew Geiger's work at Carnegie Melon University) suggests that many of these anti-forensic tools are less effective than they claim to be, their existence is illustrative of the nature of the problems faced.

While perhaps, for the near future at least, we may have to accept continued fragmentation of efforts there remains a clear need for consideration of how well each approach balances the interests of security, legal admissibility and privacy should be incorporated into our discussions. Ultimately of course we also need to remember that the digital domain itself is also intimately related to the physical world where corroborative evidence and conventional investigative techniques have a role to play (Broucek & Turner, 2005). For academic researchers this situation also presents a challenge in terms of how to conduct on-going research into forensic computing and suggests the need for researchers to reconceptualise the notion of a 'solution' and take steps to develop a framework to map the value propositions of, and interrelationships between these individual sets of responses. The next section of the paper examines this approach.

Methodological Implications for Forensic Computing Research

In the context of the discussion above this section reflects on the implications of the current landscape for academic researchers' methodological approach to forensic computing research.

Previous work by the authors has:

- Developed a taxonomy of forensic computing and explored models and frameworks for understanding and responding to the issues, their impacts and interrelationships arising from online behaviours (Broucek & Turner, 2001a, 2001b; Hannan, Frings, Broucek, & Turner, 2003; Hannan, Turner, & Broucek, 2003)
- Investigated and analysed technical, organisational and socio-legal approaches and consequences (Broucek, Frings, & Turner, 2003; Broucek & Turner, 2003b, 2003c, 2004a, 2004b; Broucek, Turner, & Frings, 2005; Sato, Broucek, & Turner, 2005)
- Advocated approaches to education and training as well as the conduct of forensic computing investigations(Broucek & Turner, 2002a, 2002b, 2002c, 2003a)
- Explored implications of uncoordinated approaches of ensuring more integrated solutions(Broucek & Turner, 2002a, 2005)

However, as the discussion above illustrates an additional methodological step is required to generate data that will reveal the value propositions, attitudes, insights and experiences of domain experts in each stream of research, development and commercialisation. It is anticipated that by generating this data it will be possible to develop a framework that will more clearly expose the issues, responses and underlying assumptions and thereby contribute to improving the possibility of calibrated responses that more effectively and coherently balance the interests for security, privacy and legal admissibility.

At the broadest level, it is argued that the data required can be generated through the conduct of qualitative semi-structured interviews selected domain experts using methods of grounded theory for analysis of the data. More specifically, this section argues the need to explore a series of research questions about the nature of the discrete technical, organisational and socio-legal responses being developed towards computer misuse and e-crime including (but not limited to):

- What is the nature of the frameworks that individual sets of responses use to conceptualise the issues and challenges their solutions aim to address?
- How do individual sets of responses conceptualise the relationships between themselves and other sets of responses?
- What key value propositions underpin individual sets of responses and how does this influence their perceptions of what constitutes a solution?
- How can a framework be developed that will more explicitly map the value propositions of, and interrelationships between the individual sets of responses?

Interview Process

The interviews will be conducted using a semi-structured question frame to guide the flow of interview. Transcripts will be constructed and analysed via a coding process drawing on the principles of grounded theory (Glaser & Strauss, 1967) (Glaser & Strauss, 1967; Strauss & Corbin, 1998). The question frame will be divided into the following sections:

- Section 1: Participant's Background
  The aim of the first section of questions is to collect background information about the participant, his/her knowledge of and involvement in Forensic Computing and his/her organisation. Questions will be framed to determine core business of the organisation and its requirement for Forensic Computing readiness.
- Section 2: Forensic Computing Expectations
  The questions in the second section will focus specifically on expectations that participant from different backgrounds and areas (research/law enforcement/defence/government/ISP) have from Forensic Computing. It is expected that the expectations of each group may be completely different as suggested in the literature review part of the research.
- Section 3: Forensic Computing Problems and Issues
  Section three questions will ask to explain the problems and issues that participants face in day to day life. The participants will be guided towards various technical, legal, organisational and other issues identified in this research as well as in previous section of the interview.
- Section 4: Solutions to Identified Problems
  Section four questions will be aimed at identifying possible solutions and/or at least improvements for the issues identified in section three of the interview. Specific questions will be given to identify critical opinions about who, when and how should provide solutions/tools/answers for the issues identified.

The aim of the questions will be to encourage participants to discuss issues related to the study without imposing limitations or constraints on how the participants answer these questions (Doolin, 1996). The main target is to explore with the experts in the spaces/paradigms:

- Their attitudes, experiences, insights in relation to their domain expertise and how they view the e-forensics space
- The assumptions underpinning the way they navigate, move forward in their domains and how they identify problems, generate responses and evaluate what they do – their 'solutions'
- Their perception of causes for the criminal on-line behaviours and other incidents involving forensic computing
- Recommendations for moving forward

Conclusion

This paper has identified a series of issues addressing the realities of research work in the forensic computing domain. From an academic perspective it has reviewed current understandings and issues arising due to the lack of coherent approaches. It has also identified the implications of current situation for methodologies used by academic researchers and suggested an additional step that may generate data that can be used to enhance the coherency of responses being developed.

This paper strongly demonstrates the need for developing a procedure to understand and model competing requirements for digital data investigations (forensic computing). It proposes to use semi-structured interviews with experts from various organisations followed by grounded theory analysis of the interviews to:

- Better understand the needs of various groups,
- Find commonalities between these groups, and
- Help researchers in the field of Information Systems to better understand needs and requirements for further research in this ever evolving field.

This paper is the first step in generating the necessary data and the authors look forward to implementing aspects of this methodological approach through frank and vigorous interaction with experts present at this year's EICAR conference. The authors anticipate that this additional data collection and analysis will aid in the development of a framework to map the value propositions of, and interrelationships between the individual sets of responses within the dynamically evolving forensic computing landscape. By exposing issues, responses, underlying assumptions and causalities it is anticipated that this will improve the possibility of calibrated responses that more effectively and coherently balance the interests for security, privacy and legal admissibility.

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