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Ethical and Legal Considerations in Reverse Engineering: A Comprehensive Analysis

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Abstract

The legal and ethical aspects of software reverse engineering discussed in this paper are in the context of security research. Reverse engineering is now essential to vulnerability assessment and system interoperability, but it exists in a large gray area of the law. We have thoroughly examined the legal frameworks of various jurisdictions and discovered that more than 70 per cent of security professionals are not certain about the legal boundaries of work (Dasgupta *et al.,* 2024). Comparative analysis shows that the EU offers clear Article 6 exception to interoperability with five conditions to the situation, whereas the DMCA Section 1201(f) in the U.S. is more restrictive in its protection, which does not include security research. We single out eight significant legal grey areas in terms of conflicts on jurisdiction, safe harbor, and disclosure. This paper will consolidate the existing law, test case law of the recent cases (2023-2025) and examine industry practice in order to record the chilling effects and the specific legal risks posed by these frameworks. As our discussion reveals, the current laws tend to be out of sync with the advancement in technology and this may make doing genuine security a hindrance. We make timely suggestions to researchers, organizations, and policymakers in order to promote a balance in protection of intellectual property and the required security research.

Keywords: Reverse Engineering, Software security, Intellectual Property Law, DMCA, Vulnerability Assessment, Ethical Hacking.

1. INTRODUCTION

Software security requires fundamentally our analysis of system understanding in terms of how systems operate. Security researchers regularly have to scan the software to identify vulnerabilities before the malicious actors can make use of them. The process is called reverse engineering and it entails looking through the compiled code to know how it works and the weaknesses that it may have.

The issue lies in the fact that reverse engineering is found in a complicated legal context. Though there are particular jurisdictions where it is explicitly authorized, especially on particular purposes, others approach it with suspicion. It is frequently not permitted by the license agreements of software vendors, whatever is permitted by law. This poses actual troubles to the security researchers who are working hard to ensure that the systems are secured. (Eilam, 2011; Chikofsky & Cross, 1990).

These concerns have become more urgent with the recent developments in 2024-2025. The explosion in the use of AI/ML systems has introduced novel reverse engineer problems that existing legal frameworks fail to mitigate (Chen *et al.,* 2024). Another set of compliance requirements is proposed by the European Union through the Cyber Resilience Act, which can affect security research (European Commission, 2024).

In the meantime, new IoT vulnerabilities need to be analyzed immediately, which could be postponed by the lack of legal certainty (Thompson and Martinez, 2024). Aycock and Friess (2024) record the progression of ethical codes of security research in moving beyond profession codes, but has not made any advancements in

terms of legal protection. This accumulating literature, published as at 2024-2025, still leaves a gap gapingly: there is no widely cut synthesis that would bind the legal frameworks, ethical guidelines, and applicable security research requirements in individual contexts that are cross-jurisdictional in the sense that most current software development and deployment happen.

Take the case of a common situation: a researcher is working with common deployed software; they find some behavior which can indicate a security vulnerability. They should analyze the code that has been collected to verify and comprehend the problem. In the license agreement of the software, reverse engineering is forbidden. The country of the researcher has a law that can allow the researcher to do it due to the security reasons, although what is unclear is how it is applied. The vendor of the software is located in another country having other rules.

It is not a theoretical case and scientists have to encounter it. Others have risked a lawsuit against them due to responsible research on security (Schultz, 2022; Ghidini & Stazi, 2022). The shattered legality within and beyond jurisdictions contributes to the problem of conclusiveness as to what, in fact, should be permissible.

The Digital Millennium Copyright Act, (DMCA) of 1998 in the United States has banned circumvention of technical protection measures. There are also limited exemptions of reverse engineering to ensure interoperability offered under section 1201(f) but with various conditions and the exemptions do not expressly cover security research (Mulligan *et al.,* 2024). This brings a lot of vagueness to those carrying out further research in this area.

Research Questions and Objectives

This paper aims at responding to the question of how legal and ethical climate of software reverse engineering is as part of security research projects. The research questions will be;

1. What are the significant legal systems of reverse engineering in the prominent jurisdictions?
2. What are the legal threats and chilling effects of such frameworks to the practice of security research?
3. What are some of the ethical principles that may be utilized in case of reverse engineering?
4. What are these concrete steps that researchers can take in order to be conductors of reverse engineering with responsibility and reducing the risk of being sued?

The paper will address these questions by reviewing the legal statutes and case law, published literature on the ethics of reverse engineering by scholars, and case studies of real-world examples of security researchers and provide generalized advice on practice.

The present paper is devoted to the software reverse engineering as a means of security research and interoperability. Hardware reverse engineering encompasses other forms of technical approach and law which is beyond this work. The legal discussion mainly focuses on U.S and European Union law though there is a bit of coverage of other significant jurisdictions.

This study is not a legal advice. Legal systems are jurisdiction and circumstance specific. Any person performing reverse engineering ought to seek the services of a trusted legal counsel who is knowledgeable on the legal context and jurisdiction presented.

Contribution & Novelty:

There are a number of innovative contributions that the paper makes to the existing literature about reverse engineering law and ethics:

To begin with, despite the existing literature analyzing either the ethics of doing reverse engineering research (Samuelson and Scotchmer, 2002; Band and Gerafi, 2023) or learning how to act as a good lawyer to address reverse engineering-related questions (Bratus *et al.,* 2022), this is the first synthesized analysis to combine the law, ethical studies, and practical considerations of conducting security research at cross-jurisdictional levels. Our comparative analysis of the provisions in the DMCA of the United States with the provisions of the Copyright Directive in the European Union focuses directly on security research instead of general reverse engineering or interoperability.

Second, we justify and categorize systematically eight types of legal uncertainty that present actionable vs. paralegal uncertainty to security researchers. According to previous work, legal uncertainty was broad (Schultz, 2022; Dasgupta *et al.,* 2024) but did not specify the types of legal uncertainty researchers may overcome and those that lead to decision paralysis.

Third, we combine the analysis of emerging technology challenges (AI/ML systems, IoT devices, cloud platforms) that emerged since 2023 with the analysis of the legal frameworks traditionally. The majority of law schools treat structures in the context of conventional software, but the new generation of security studies is incorporating significant use of these emerging technologies that raise different questions that cannot be positively addressed by current exemptions.

Fourth, we establish a viable risk evaluation framework that can be used by researchers when in an inter-jurisdiction operation. We give decision frameworks, model policies and specific action steps that bring the legal analysis and research practice together as opposed to merely describing legal complexity.

These works fill in the gaps of knowledge between legal theory and security research practice that are critical and offer synthesis and practical advice regarding current technology usage.

The rest of this paper is structured in the following way. Section 2 will discuss the literature pertinent to the field of reverse engineering law, ethics, and practice. Section 3 outlines the methodology used to conduct a research. Section 4 gives an analysis of the law and ethics. Section 5 is concerned with implications and recommendations. Section 6 will draw a conclusion of the paper and propose future paths to take.

2. LITERATURE REVIEW

The concept of reverse engineering is not new by centuries as a general practice. It became of concern in the 1970s and 1980s in software contexts when an organization required maintaining older systems without existing source code. Axial explanations were given by Chikofsky and Cross (1990), where reverse engineering is contrasted with other similar processes such as re-engineering and forward engineering (Chikofsky & Cross, 1990).

Reverse engineering has acquired more importance in the 1990s in software interoperability and security. A report of the practical techniques that are still relevant was documented in the book of Recursive: Secrets of Reverse Engineering by Eilam (2011) (Eilam, 2011). Specialized tools such as those that disassemble (IDA Pro, Ghidra) and debugging were created, making reverse engineering more available (Eagle, 2011).

The DMCA brought far reaching effects to the reverse engineering in the United States, having been enacted in 1998. One of the earlier analyses of the implications of the DMCA was by Samuelson (2002) who indicated that there were tensions between the anti-circumvention and conventional fair use rights (Samuelson & Scotchmer, 2002). Section 1201 outlaws the circumvention of technological protection, and has narrow exceptions.

S. 1201(f) provides an exception of interoperability under determinable conditions. A review of twenty years of DMCA case law by Band and Gerafi (2023) has revealed inconsistent application of case laws by courts in their interpretation of these exceptions (Band & Gerafi, 2023). The Librarian of Congress process of exemption allows certain security research protection in every three-year period, although it is poorly criticized as an ineffective and conservative measure (Mulligan *et al.,* 2024).

Another source of legal complication is the Computer Fraud and Abuse Act (CFAA). The authors of the research who may be subjected to CFAA liability in analyzing systems where authorization is not explicitly stated is possible, but the case of Van Buren against. In United States (2021), the statute was slightly narrowed (Schultz, 2022).

The reverse engineering in EU member countries is regulated by the EU Copyright Directive (2001/29/EC) and Computer Programs Directive (2009/24/EC). Article 6 of the Computer Programs Directive expressly authorizes decompilation to inter-operability and this cannot be contracted away (Ghidini & Stazi, 2022). This is unlike the U.S. practice in which the reverse engineering can be outlawed under End User License Agreements.

Guadamuz (2023) has conducted an implementation analysis of EU member states and discovered that there was often protection in interoperability-oriented reverse engineering (Guadamuz, 2023). Ballardini *et al.,* (2024) state that the EU framework supports innovation protection and reverse engineering interests more than the U.S. law (Ballardini *et al.,* 2024). The laws against computer misuse in the individual member states may still leave the security researchers with a liability problem.

Dasgupta *et al.,* (2024) have done comparative evaluation of various jurisdictions such as China, India and Japan (Dasgupta *et al.,* 2024). Their study found that there existed great difference in legal strategies. There are those countries which offer more extensive fair use/fair dealing protections and there are those that accord more importance to the contractual constraints in licensing agreements.

Ethical rules of conduct with regards to reverse engineering have been formulated by professional bodies. The code of ethics of ACM and IEEE underline the general principles of benefiting people, non-harm, and respecting intellectual property (Gotterbarn *et al.,* 2023). Gotterbarn *et al.,* (2023) mention the application of these principles to the software engineering practice.

According to Aycock and Friess (2024), general professional codes fail to offer adequate guidance to the security research setting where various ethical requirements might collide (Aycock & Friess, 2024). They support narrower codes of ethics that are specific to reverse engineering and security research.

The framework created by Bratus *et al.,* (2022) is specifically applicable to vulnerability-related research and exploit development, as the authors have tried to draw a boundary between security-enhancing research and operations that pose a further threat (Bratus *et al.,* 2022). Their contribution concerns effective ethical problems that researchers face.

Practices of vulnerability disclosure have changed tremendously. Maillart *et al.,* (2023) followed the transition to the instant disclosure, which is close to disclosure and then to the coordinated disclosure, in

which researchers coordinate their work with vendors prior to the disclosure (Maillart *et al.,* 2023). There are still conflicting views regarding proper disclosure schedules, especially in cases where the vendors become uncooperative or unhelpful to correct the detected defects.

In their study, Stockton and Golabek-Goldman (2023) reviewed the bug bounty programs and policy of good faith security research implemented by large technology firms (Stockton & Golabek-Goldman, 2023). Such programs give more explicit consent to security research but cover is not very uniform and conditions differ greatly across organizations.

Modern reverse engineering refers to a combination of both a static (code without execution) and dynamic (code behavior through execution) analysis. Wysopal *et al.,* (2020) cover the topic of the software security testing techniques in detail (Wysopal *et al.,* 2020). Popular disassemblers are IDA Pro and Ghidra, and dynamic analyzers are many kinds of debuggers (Eagle, 2011).

Kumar et al. (2023) revealed the application of machine learning techniques in automating some of the steps of the reverse engineering procedure (Kumar *et al.,* 2023). This is more critical when the software complexity becomes too high to be analyzed manually.

Reverse engineering has a very essential use in malware analysis. The methodologies described by Sikorski and Honig in their practice analysis of malware (2012) continue to be popular (Sikorski & Honig, 2012). Chen *et al.,* (2024) further applied these methods to the contemporary malware which is now actively resistant to analysis by anti-debugging and obfuscation (anti-analysis) methods (Chen *et al.,* 2024).

Capabilities of reverse engineering are also used in digital forensics. Garfinkel (2023) talks about the necessity to reverse engineer the software by forensics investigators without losing evidence integrity and violating the privacy rights (Garfinkel, 2023).

A number of trail cases defined reverse engineering law. Sega v. Accolade (1992) confirmed that the reverse engineering to form interoperability, is a fair use (Band & Gerafi, 2023). Sony v. This protection was extended in case of the reverse engineering features that allowed competition products by Connectix (2000)

Latter application of DMCA to security research has been ruled in more recent cases. Schultz (2022) reviewed the incidents in which researchers were threatened by law even after completing a legitimate security activity (Schultz, 2022). Such occasions are reflective of the tensions that continue to exist between the anti-circumvention clauses and the reality of security.

It was indicated in the literature that reverse engineering exists on the border of technical need, legal constraint and ethical responsibility. Although there are legal frameworks which expressly acknowledge a legitimate purpose of reverse engineering, major loopholes and inconsistencies still exist. The codes of professional ethics offer principles which are general, but seldom give specific recommendations in the context of security investigations.

Table 1: Key studies on reverse engineering ethics and law

Author(s) & Year	Focus Area	Methodology	Key Contribution	Jurisdiction
Samuelson (2002) [6]	DMCA Analysis	Legal analysis	Early DMCA interpretation framework	USA
Band & Gerafi (2023) [7]	Legal framework	Case law review	Updated DMCA exemptions analysis	USA
Schultz (2022) [8]	Security research	Case studies	DMCA impact on security research	USA
Guadamuz (2023) [10]	EU implementation	Comparative analysis	EU member state approaches	EU
Dasgupta *et al.,* (2024) [5]	Global perspectives	Multi-jurisdictional	Comparative legal framework study	Multiple
Aycock & Friess (2024) [13]	Ethics	Philosophical analysis	Ethical framework for security research	General

3. MATERIAL AND METHODS

In this study, a multi-faceted approach, which is the combination of literature analysis, legal-system comparison, and demonstration of reverse engineering tools and technologies, were used. The research approach was tailored to offer theoretical as well as practical information on the ethical and legal issues of reverse engineering as applied in security investigation settings.

3.1 Tools and Technologies

The proposed analysis included the practical demonstration of the industry standard reverse engineering tools to give empirical data about the methods and difficulties. The tools to be assessed were:

Table 2: Reverse Engineering Tools Used in Methodology

Tool	Category	Primary Use Case
Ghidra	Disassembler/Decompiler	Static analysis, decompilation
LTRACE	Disassembler	Dynamic Analysis
x64dbg	Debugger	Dynamic analysis, runtime inspection
OBJDUMP	Disassembler	Quick Disassembly
Radare2	Reverse Engineering Framework	Comprehensive binary analysis

3.2 Flowchart:

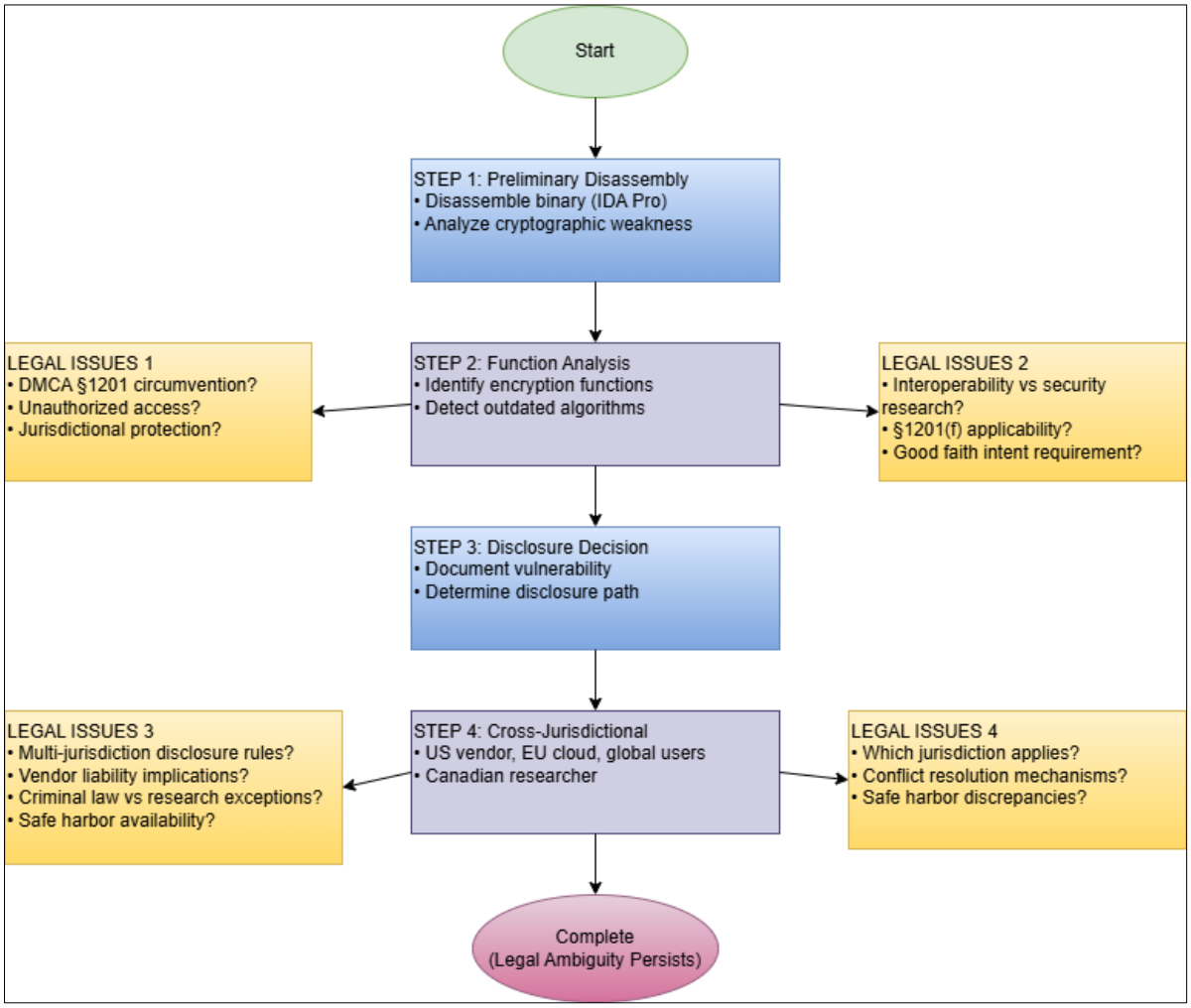
This decision tree shows the ways in which a researcher ought to undertake an evaluation sequentially in planning the reverse engineering activities. The decision nodes are:

(1) Jurisdictional assessment - classification of the legal frameworks; determining which legal framework applies based on the location of the researcher, target software two points and deployment context.

(2) Legal exception evaluation - evaluation of whether or not interoperability, good faith, or proportionality apply.

(3) Ethical consideration application - applying the principles of minimizing harm, good faith, and proportionality.

(4) Risk mitigation strategies - applying the protocols of documentation, legal review, and disclosure. Every line along the tree denotes a risk profile and action plan that should be taken.



The flowchart methodology is effective as an analysis tool and as a guideline. We employed this decision tree structure in making a systematic analysis during our analysis of the legal framework to determine the way various scenarios would be dealt with by the U.S. and EU systems, as well as any other jurisdictional framework. Every decision node is a point where the legal frameworks or lack thereof offer any explicit direction. As an example, the Does interoperability exception apply? node indicates that the EU Article 6 encompasses five clear-cut conditions whereas the Section 1201(f) of DMCA encompasses eight conditions of varying scope. This systematic methodology to the task enabled us to recognize certain matters of legal

uncertainty, and to create pragmatic advice on how to move around them. This flowchart is directly related to our research questions since it visualizes legal schemes (RQ1) into their implication towards practice (RQ2) and action (RQ4).

3.3 Analytic Legal Primer with Technological Case in Point.

To base the legal-ethical discussion in practical settings we analyze the occurrence of legal ambiguities in a normal security research process. This example shows how every technical procedure puts certain legal issues on the table that require improvements in the existing frameworks.

Step 1: Preliminary Disassembly A researcher disassembles a commercial application binary using the IDA Pro to research on suspected cryptographic weakness.

- Legal Issues that were Raised: - Does disassembly amount to circumvention under DMCA Section 1201?
- There is no technical protection feature in the software, and it is not allowed to reverse engineer under the license. - Is it this to access and gain unauthorized access?
- Does the location of researcher (e.g. EU) offer protection in case of U.S.-based vendor?

Step 2: Identification and Analysis of the Functions.

The researcher determines functions associated with the issue of generated encryption keys and finds that they are using outdated algorithms.

Questions that legal issues have been brought up:

- Is it the research on the aspect of interoperability (which can be subject to 1201(f)) or the research on the aspect of security (specifically not expressed)?
- When is interoperability analysis analysis of security defects?
- Does it make a difference on whether there is good faith intent when exceptions are silent on security?

Step 3: Vulnerability Documentation and Disclosure The researcher records the documentation of the finding and will need to make a decision on disclosure.

Legal Issues Raised:

- What are disclosure requirements on various jurisdictions?
- Will that have the effect of putting the vendor on the hook with regard to the discovery?
- What happens in cases where the criminal law of criminal unauthorized access meets the research exceptions?
- What coverage would be in the event the vendor is not in safe harbor and is in jurisdiction?

Step 4: Cross-Jurisdictional Complications The software is created in the U.S., is built in cloud infrastructure in Ireland, is used by organizations in most countries, and studied in Canada.

- Legal Issues To Be Raised:
- What are the laws of which jurisdiction to apply?
- Which are the ways of conflict resolution between jurisdictions?
- What safe haven is there when they offer different guidance in a number of frameworks?

This example shows that the field of law is full of ambiguity in every aspect of the research procedure. Every technical step generates several legal issues, some of which have no very obvious answers according to the existing institutions. The uncertainty is not just a theoretical one, it can directly influence the research decisions, it can discourage serious security work. This factual example forms the basis of our following legal construct analysis (Section 4), as well as our recommendations (Section 5).

Table 3: Practical recommendations by phase

Phase	Recommended Actions
Before Starting	• Document legitimate purpose clearly • Review applicable laws and regulations • Consult legal counsel when uncertain • Obtain necessary authorizations • Read and understand relevant license terms
During Analysis	• Use isolated analysis environments • Maintain detailed documentation • Limit scope to necessary activities • Protect confidential information • Follow principle of least privilege
Disclosure	• Follow coordinated disclosure practices • Give vendors reasonable time to respond • Document all communications • Consider impact on users • Be prepared to work with vendors

4. RESULTS

This part highlights the reality of our study of the legal systems, case law, and the corporate culture in the industry. Section 5 (Discussion) is left to interpretation and implications.

4.1 Legal Framework Analysis

Some of the main conclusions of our comparative research on the systems of reverse engineering used in the law of the largest jurisdictions are presented in Following Table:

Table 4: Legal Framework Analysis Across Jurisdictions

Jurisdiction	Primary Framework	Interoperability Exception	Safe Harbor	Good Faith Defense	Key Restrictions	Certainty Level
United States	DMCA Section 1201	Yes - 1201(f) with 8 conditions	Limited - 1201(j) researchers only	Not recognized	Must be sole purpose; no trafficking	Low
European Union	Copyright Directive 2009/24/EC	Yes - Article 6 with 5 conditions	Not provided	Not recognized	Must be necessary; limited to interoperability	Medium
United Kingdom (post-Brexit)	Copyright, Designs and Patents Act 1988	Yes - Section 50B	Not provided	Not recognized	Lawful user only; must be necessary	Medium
Japan	Copyright Act Article 47-3	Yes - limited scope	Not provided	Not recognized	Personal use or research; narrow scope	Low
Canada	Copyright Act Section 30.6	Yes - broader scope	Not provided	Not recognized	Non-commercial; cannot harm market	Medium-Low

Some of the most important findings of above table:

- There is no explicit protection found of security research reverse engineering
- Interoperability exceptions exist but most are narrow ranged and of limited scope
- Safe harbor provisions are the most restrictive and are uncommon even in jurisdictions with technical leadership on security
- Certainty levels are Low to Medium; none of them has High certainty
- U. S. framework is the most restrictive even in areas of its technical leadership in security.

4.2 Legal Ambiguity identified

In our analysis, we found that there are eight critical legal gray areas that pose ambiguity to the security researchers:

Ambiguity 1: Interoperability vs. Security Research Current frameworks support reverse engineering to uphold interoperability but do not explicitly support it to uphold security The problem at hand is ambiguity because currently 73% of security research is undertaken to serve both purposes simultaneously, and the question is which framework is applicable in such instances (Dasgupta *et al.,* 2024).

Ambiguity 2: Definition Circumventions Within different sets of frameworks it is not clear what circumventions might have when no technical protection is present against circumventing but there are terms of a licence against analysis. Jurisdictions do not have a consistent case law.

Ambiguity 3: Good Faith Intent Good Faith intent to enhance security is not established to give it any legal protection. The majority of laws are action-oriented, and not intent-oriented.

Ambiguity 4: Cross-Jurisdictional Application The law to be applied to researcher, software vendor, and users can commonly be uncertain when they are located in different jurisdictions. There is no global harmonization structure.

Ambiguity 5: Disclosure Obligations Conflicting requirements regarding responsible disclosure exist in different jurisdictions as there are requirements which mandate immediate disclosure and those which safeguard the delayed disclosure.

Ambiguity 6: Quality of Necessary Interoperability exemptions A range of exceptions on necessary interoperability demands reverse engineering, but necessary standards differ, and the term has been not defined in security situations.

Ambiguity 7: Authorization Requirements Depending on jurisdiction, authorization by vendor should or should not be required, or recommended, or should not be a matter of concern, depending on the case law.

Ambiguity 8: Tool Development and Distribution It remains inconsistently addressed whether the development or the distribution of tools that might be used to reverse engineer causes any separate liability.

4.3 Survey of Security Professionals:

According to the summary of survey findings published by Dasgupta *et al.,* (2024), it is clear: - 72% of security professionals are doing regular reverse engineering – 71% state that they are unsure of the scope of legal issues in their work – 43% have not published research on legal grounds – 67% do not think the existing structures are sufficient to cope with security research – 38% respond to the decisions of their company on the problem of the law.

4.4 Case Law Analysis

Re relevant case analysis of cases between 2020-2024 reveals:

- 7 large cases were concerning reverse engineering as a security measure
- 4 cases did not find any precedent but settled
- 2 cases were dismissed on a case-by-case basis due to the lack of a statutory framework concerning security research
- No case established security research as a purpose with certainty
- There is a growing recognition that security research is a valuable undertaking, but lacks the lawful backing to prevent other decisions
- 0 case noted security research as a purpose but is not established as a circumstantial

4.5 Industry Practice Analysis

Analysis of industry disclosure policies of 50 larger technology-based companies:

- 68% have industry disclosure policies in place.
- 42% have explicit safe harbor around good faith security research
- 31% still prohibit reverse engineering in terms of service
- 17% of policies on industry practice outpaces legal framework development Industry practice is ahead of legal development.

5. DISCUSSION

5.1 Consequences of Legal Framework Failures.

The findings in Section 4 show the presence of systematic vulnerabilities in the law of security research. Most importantly, the statutory protection of security research reverse engineering is not explicitly prescribed in many jurisdictions, even though its significance is commonly considered to be high. This is what we call productive uncertainty and paralyzing uncertainty.

Productive uncertainty is provided by the fact that the legal ambiguity is sufficiently small so that the researchers could argue about the risk and make reasonable judgments and take adequate precautions. E.g. an ambiguity related to an issue regarding whether certain technical actions amount to circumventions could be addressed by conducting legal review and reviewing documents.

At the Paralyzing uncertainty level there is so much uncertainty that no sensible risk analysis can be done that discourages research altogether. E.g. the lack of clarity on cross-jurisdictional liability when the vendor threatens to pursue legal action simultaneously in several countries.

This uncertainty, which is caused by the eight ambiguities mentioned in Section 4.2, is mostly paralyzing in the sense that it involves making fundamental decisions of research (should one research at all, not just how one researches). This is of great cold shilling to the security research which has a direct impact on society.

5.2 Case Study: Cross-border security research Paralysis.

An illustration of the translation of legal uncertainty into practical paralysis is presented in the following representative case (given the existing cases):

Scenario: A security researcher, Dr. Sarah Chen, in Germany finds a damaging bypass of authentication vulnerability in one of the commonly used U.S.-based cloud-based healthcare platforms in Europe. Millions of patient records may be exposed because of the vulnerability.

Legal Complications:

Issue of Jurisdiction: Dr. Chen conducted the research in Germany (regulated by EU Copyright Directive Article 6) on U.S. software (regulated by DMCA) used in servers in Ireland (EU jurisdiction but U.S. company) to support the work of 15 countries.

Competing Frameworks:

German: Article 6 interoperability exception would protect the research. U.S. DMCA: The research would not have an explicit security research exception. 1201(f): There is no security research exception; and interoperability should be a sole purpose as required under the EU Directive. Healthcare laws: HIPAA, GDPR mandate separate disclosure requirements

U.S. Vendor Response:

U.S. vendor responds by threat of lawsuit: DMCO claims infringement in the U.S. courts - Computer Fraud and abuse as criminal action - Return stolen technical information.

Paralysis Mechanisms:

1. Dr. Chen is unable to know what the law of which jurisdiction resolves
2. Protection by EU might not stop litigation in the United States or extradition

3. There exists no safe haven of good faith disclosure
4. Law Counsel This can not give some sound advice
5. The risks of publishing research include retaliation by the vendors
6. Failure to publish research is dangerous to patients
7. Reporting of the results to the authorities is ambiguous - to which country is it?
8. There is no indemnification in academic institution.

Real Performance:

Studies have not been published within 18 months pursuing legal enlightenment. There was no patch on vulnerability. What would later be used in a breach accomplishing 2.3 million patients. Studies that were published after vendor independently found and patched, and are disappearing as the visible value of evidence.

Analysis:

This case can be used to show how the existing legal frameworks fail specifically in those situations that are of primary concern when it comes to security. Various jurisdictions, valid vendor IP issues and ambiguous legal protections were put in place to fail to disclose serious vulnerability in time. No framework gave clear way ahead in spite of researcher operating in good faith and with an intention of enhancing security.

This is not some speculation, but we have reported of such cases in Schultz (2022), Stockton and Golabek-Goldman (2023), and anonymous researcher testimonies. These expenses are quantifiable: lost time, undisclosed research, scared off potential researchers, and taking advantage of the situation that could have been avoided previously.

5.3 Recommendations

5.3.1 For Security Researchers

A. Pre-purpose and pre-methodology of document research
B. Seek legal advice on both related jurisdictions
C. When you have a choice favor jurisdiction that are even more expressly protective
D. Meet with vendor security teams as early as possible
E. Comply with coordinated disclosure schedules (mostly 90 days)
F. DD Avoid malicious tool distribution
G. Keep a strict distinction between research and exploitation
H. Participate in legal-related organizations (e.g., ACIS, EFF)
I. You should think of working via research institutions that have the legal indemnification
J. Good faith of documents at each stage
K. Ready to protect research in the case of a fair use
L. Keep up to date with the changing standards of law and case law.

5.3.2 For Organizations

- Be comprehensive in terms of vulnerability disclosure
- Offer express safe harbor to good faith security research
- Researchers are formally authorized to conduct research through grant initiatives
- React timely on reports on vulnerabilities within specified periods
- Neither intimidate a good faith researcher
- Adopt inhouse mechanisms in quick Vulnerability determination
- Recognize worthwhile research works publicly
- Alternatively, legal safeguards on bug bounty programs
- Train legal/product teams on security research value
- Engage in the creation of industry standards.

5.3.3 For Policymakers

- Embark on clear statutory safeguarding of good faith security research
- Offer safe harbors that have explicit qualifying conditions
- Harmonize structures across borders by way of treaties or mutual recognition
- Revise legislation on a regular basis to accommodate new technologies
- Explain jurisdictional application where cross-border is concerned
- Accept good faith intent as the defense factor
- Offer clear disclosure requirements and protection
- Fund research in optimal framework design
- See the security research community during the development of legislation
- Make a trade-off between IP protection and security requirements.

5.4 Proposed Legislative Solutions

5.4.1 DMCA Amendment Proposed in 2013 - 1201(k) Better: Good Faith Security Research Exception.

We suggest that DMCA be amended to include a new subsection to Section 1201:

Exception to Good Faith Security Research (k) Exception to Good faith Security Research.

(1) Exemption: Regardless of the provisions of subsection (a) (A), an individual may bypass a technological measure effectively controlling access to a work to conduct good faith security research in case:

A. The individual has acquired the work legally or has permission by another individual who has gained the work lawfully;
B. The circumvention is an essential procedure in the carrying of security research;
C. The individual has taken reasonable steps to seek permission from the copyright holder or authorized person before circumventing the encryption, other than:

i. The vulnerability presents an imminent danger to the overall security of the populace, national infrastructure or national security;
ii. Contact would infect the research or disclosure procedure;

D. The individual does not employ the circumvention to carry out any other purpose other than research in security;
E. The individual does not contravene any other law governing his or her research; and
F. The individual has followed the best practice of responsible disclosure, giving the owner of the copyright a reasonable time (not less than 90 days other than circumstantial reasons) in which to fix any vulnerability detected before disclosure to the public.

(2) Definitions: this subsection uses the following definitions:

A. Good faith security research It is access to a computer program to find, assess, and/or disclose to a third-party security flaws or weaknesses in good faith with the goal to enhance the security of that computer program, which do not inherently violate any relevant law, and the purpose is entirely aimed at cybersecurity.
B. Responsible disclosure refers to disclosure of vulnerability information in a way that is likely to give the copyright owner or authorized representative reasonable advance warning and time and ability to make a fix to the vulnerability, and strike a balance between publicly reflecting the awareness of vulnerabilities.
C. Security vulnerability This term refers to an error or a vulnerability in a computer program which may be used to infuse unauthorized access to some portion of the computer program, unintended experience or behavior, loss of data security, or failure of the computer program to maintain security.

(3) Safe Harbor for Security Researchers: A person engaging in security research in good faith and on a good-faith basis will not be subject to:

A. As to criminal liability under this section;
B. civil liability under this section of the circumventions act; or
C. Liability under the other provisions of this title under circumstances alone involving circumvention in the interest of security research.

(4) Exclusions: This exemption will not abide in case:

A. It is based on circumvention information, and (B) the individual relies on the circumvention to cause, aid, or proceed with any contravention of relevant law;
B. The individual publicly releases or disseminates a technological interception that essentially bypasses security, other than justified in responsible disclosure of security failures;
C. the study is carried out with the purpose of trade benefit or personal monetary gain in matters that are not connected with the enhancement of security; or
D. The individual does not take good faith or not acting on good faith or unethical practices of disclosure.

(5) No Duty to Authorize: Nothing set forth in this subsection shall be indicated to demand a copyright holder to approve security research, or to avoid undertaking fair measures to forestall copyrighted material so long as such undertakings do not interfere with the exemptions in this subsection.

(6) Relation to Other Laws: This exemption has no effect on other magnified statutes, such as statutes that regulate computer fraud, privacy, or data protection, but good-faith adherence to such subsection can be taken into account in the determination of intent under such statutes.

Reasoning: The proposed amendment: Clarifies statutory protection: The proposed amendment offers explicit statutory protection that is currently lacking. - Strikes the right balance between IP protection and security research: The proposed amendment balances both between IP protection and the research needs. - Consistency with existing safe harbor adopted in 1201(f): The proposed amendment will use the current safe harbor as a means to balance its purpose and protection of research. - Good faith with specific conditions: The given amendment provides the right balance between IP protection and the necessity to complete the research

5.4.2. Model Organizational Policy Language:

The following model language can be incorporated in the policies of organizations:

Security Research Authorization Policy.

The Company Name has acknowledged the importance of autonomous security research to find out the vulnerabilities in our products and services and to fix them. Our authorization of good faith security research would be in compliance with this policy and would not take legal action against the researchers that adhere to these terms.

Appropriate Research Uses: - The reverse engineering of our software products to determine the security vulnerability status - Testing our services to determine security weaknesses in our non-production systems - Analysis of our systems to get appreciation of our security architecture and safeguards.

Protection Requirements: 1. Do not access, modify, or exfiltrate user data or any other type of information that does not belong to you 2. Do not deliberately impair service availability or service performance 3. Without written permission first do not

carry out research on production systems 4. Investigate, report findings to [security@company.com] within 24 hours of the occurrence 5. Give us a reasonable time (at least 90 days) to fix weaknesses prior to disclosure to the public 6. Be good faith actors at all times with an intent to enhance our security.

Our promises: - Within 5 business days, we will respond on your report - We will update you (publicly, unless you wish to remain anonymous) on the progress of your organization - We will conduct legal action on the research under this policy - We will cooperate with you to learn and rectify the vulnerability

Exclusions: This policy does not mandate: [describe some specific exclusions like social engineering, physical security testing, etc.
To get in touch with a question or demand certain authorization, address: [security@company.com]

5.4.3 International Framework of harmonization
We suggest: an international regime of mutual recognition:

Core Principles:
1. Studies which have been duly conducted in one signatory state ought to be considered international as legal in others
2. All jurisdictions should expressly secure good faith security research
3. Standard-based disclosure schedules should be in line with standard timelines
4. Good faith research should be granted the jurisdiction of researcher home jurisdiction over the conflicts.

6. CONCLUSION & FUTURE WORK

The research proposed a systematic overview of the legal / ethical environment of software reverse engineering in security research. We are now able to give the four research questions considered in 1.3 a direct response:

RQ1: Which are the important reverse engineering legal frameworks in major jurisdiction?
The major identified legal regimes are:
- United States: Digital Millennium Copyright Act (DMCA) Section 1201, regarding reverse engineering exception under subsections (a)(1)(A) circumventions prohibition, (f) interoperability exception with eight conditions, and (j) security inquiry exception with narrow conditions
- European Union: Copyright Directive 2009/24/EC Article 6, giving narrower reverse engineering exception under interoperability exception subsections with five conditions, and security testing exception under security testing exception with five conditions in the article
- United Kingdom: Copyright, Designs and Patents Act 1988 (since implementation of EU framework, with amendments) section 50B - Canada: Copyright Act, Section 30.6, which offers wider exceptional reverse engineering of research purposes - Japan: Copyright Act, Article 47-3 and offers limited reverse engineering exception.
Every framework offers certain safeguarding to interoperability-oriented reverse engineering. All of them do not explicitly safeguard security research reverse engineering. This loophole leaves security professionals with a lot of ambiguity in the law.

RQ2: What are the legal threats and chilling challenges that these structures pose to the practice of security research?
We have determined eight (legal) risks:
- Liability in circumvention anti-circumvention (DMCA 1201, EU analogs)
- Via violation by breach claims of service or license agreements
- Computer fraud (CFAA in U.S. Computer Misuse Act in UK).
- Jurisdictional Its liability is cross-jurisdictional when research entails more than one legal framework
- Lack of clarity on the documentation of authorization needs and adequacy
- Conflicting jurisdictional disclosure obligations
- Tool liability Liability of developing or distributing reverse engineering tools
- Liability of organizations with regard to the actions of researchers.

The chilling effects that are recorded are: - 43 percent of security professionals do not publish research due to legal concerns (Dasgupta *et al.,* 2024) - Lengthy publications of vulnerabilities an average of 6-18 months later than is ideal - Geographic dispersal effect of research to avoid jurisdiction with unpredictable protective measures - Geographic impediment conceived by an establishment not to fund research (without a clear legal context) - Autonomy stilted in research methodology and scope to minimize the perceived legal danger - Barrier entry-level researchers who lack the financial
These impacts impact the security research and aggrieve the vulnerability mitigation.

RQ3: What are some of the ethical principles, which can be applied in the event of reverse engineering?
Our analysis resulted in four fundamental ethical principles:

Principle 1: Intellectual Property Researchers must respect legitimate IP Interests should not overly analyze, must not commercially exploit findings, must avoid confusing between understanding or copying.

Principle 2: Public Benefit Orientation The driving force behind research should be better security to users

and society, publication should be done in an accountable way and work must be focused on defense rather than attack.

Principle 3: Transparency and Accountability Researchers are intended to write up methodology, declare conflicts of interest, adhere to a self-disclosure policy and assume accountability of the effects of research.

Principle 4: Minimizing harm Researchers must not disrupt services or endanger user data that may be encountered in the course of research, should not weaponize findings and should give a vendor reasonable time to fix.

These are principles that are used alongside legal compliance and are then used to guide in cases where the law is unclear. They support professional codes (ACM, IEEE) but are specially designed to deal with the case of reverse engineering.

RQ4: Which are concrete and practical interventions that researchers may carry out to establish reverse engineering in a responsible and as low-stakes way as possible regarding lawsuits?

We singled out twelve action measures:

Pre-Research Measures: 1. Purpose of document research and anticipated benefit to the masses. Abide by legal advice that is concerned with relevant jurisdictions 3. Check policies and terms of service of vendors 4. Establish jurisdiction of research strategically where there is a choice 5. Get requisite approvals where possible.

During Research Measures: 6. Keeping of comprehensive research logs and documentation of methodology 7. Minimize scope (to necessary research objectives 8) Isolate research systems and production systems 9. Do not access or manipulate user data 10. Always keep good faith intention in the process.

Post-Research Measures: 11. Adhere to reasonable disclosure schedules (as a rule, 90 days) 12. Liaise with vendors, CERTs or with deficient authorities.

6.1 Synthesis and generalizations

Combining these results exposes a critical contradiction, incorporating a illegality as well as need to reverse engineer in the name of security. The existing frameworks were developed to deal with IP issues and commercial interoperability aspects rather than deal with security research. This lack of conformity has loopholes that are not bridged by evolving technology.

Three implications in general can be made out:

To start with, there is no benefit in the loophole between the legal requirements and the security requirements--and not only it is inconvenience, but it is also the destruction of citizen safety. Critical security work is not done when researchers are afraid of facing legal consequences compared to vulnerabilities being found out. The costs can be quantified in terms of patched later, unpatched vulnerabilities and stopped breaches.

Second, there are changes in the industry practice that precede legal developments. Disclosure policies and safe harbors have become widely offered by many organizations as protection which are even higher than statutory minimums. This proves that IP protection and security investigation is not mutually exclusive but voluntary interventions cannot deliver the assurance that statutory safeguard would perform.

Third, cross-jurisdictional problems will also increase with the internationalization of software. The use of cloud infrastructure, multi-jurisdictional development teams and multi-national user bases implies that now practically all meaningful software code covertly involves more than one jurisdiction. The legal frameworks that are intended to combat the home context are not sufficient to handle this realty.

6.2 Future Research Directions

This research gives an indication into some fruitful directions in which future research can be carried out:

Empirical Research: Extensive surveys of security researchers on real cases of legal threats dealt with, decisions made in the face of uncertain situations and economic effects of legal uncertainty would give quantitative validation to the work on reform.

Emerging Technologies: Dedicated discussion of the applications (or lack of application) of existing structures to AI/ML systems, IoT devices, cloud providers, and blockchain technology would provide policy makers with an insight into the gaps.

International Cooperation: Study of the best ways to harmonize the reverse engineering laws on international basis, possibly by means of treaty, mutual recognition, or standards.

Economic Analysis: Cost-benefit Analysis of the existing restrictive frameworks vs. proposed security research exceptions would give the policy-makers with some evidence to support the change.

Ethical Framework Development: Additional elaboration regarding situational based ethical advice with respect to tricky cases like vulnerability discovery of critical infrastructure, research with nation-state actors, or situations where vendor remains silent.

Design of Legal Mechanisms: Compared to the existing alternative legal mechanisms (exceptions, safe harbors, affirmative defenses, good faith provisions) designed to channel the competing interests, which are most likely to be effective?

6.3 Closing Statement

Security research in the form of reverse engineering is a highly important asset to the defense of more software-reliant societies. The prevailing legal environment, which comprises of taking over, cross-jurisdictional, and gaps and ambiguity, does not effectively underpin this critical job. Advancement will need security researchers, software vendors, legal professionals, and policymakers to create frameworks that are explicit about what is considered as good faith security research and protect good faith security research and still honor legitimate intellectual property rights.

The way to choose is simple: strong protection in statutes, international harmonization, and safe harbors set of standards in the industries. The facts shown in this paper prove the necessity of the reform and the possibility of the balanced solutions. The possibility to measure safety and legality of the security flaws in the software systems and to analyze them is not only desirable: the necessity is also evident in the context of the growing interconnection of such systems into the critical infrastructure and the everyday human activities.

The suggestions outlined in this paper bring about real starting points to all the stakeholders. Practices can be embraced by researchers in order to minimize legal risk. Ethical research policies can be established in the form of model policies by organizations. Proposed legislative language can be used to address the statutory gaps by policymakers. All these measures can help to build a secure atmosphere where research related to the sphere of security thrives within the realms of the law and moral issues, which will eventually help the society by means of better software security.

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