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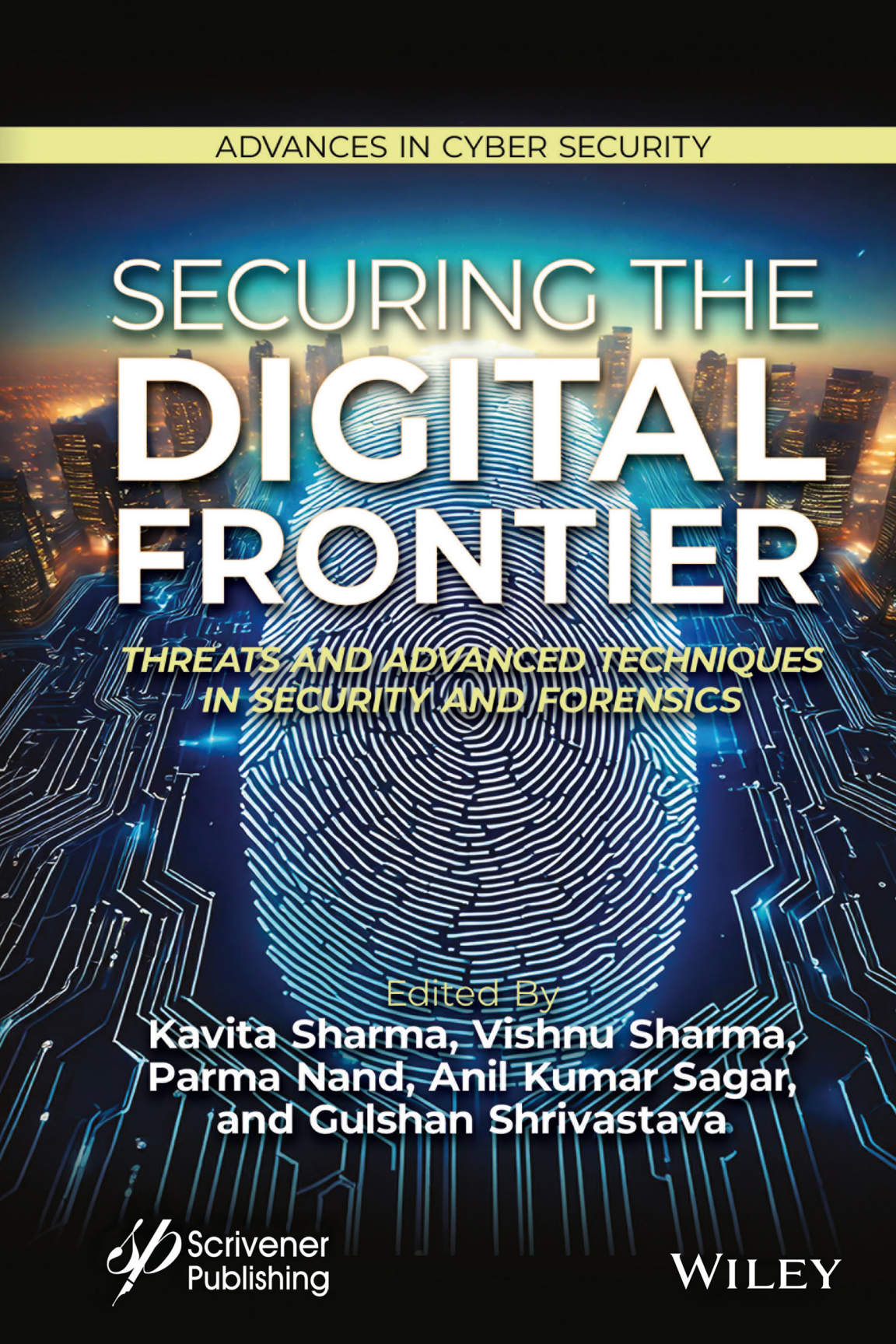

SECURING THE DIGITAL FRONTIER

THREATS AND ADVANCED TECHNIQUES IN SECURITY AND FORENSICS

Edited By
Kavita Sharma, Vishnu Sharma, Parma Nand, Anil Kumar Sagar, and Gulshan Shrivastava

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Securing the Digital Frontier

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Advances in Cyber Security

Series Editors: Rashmi Agrawal and D. Ganesh Gopal

Scope: The purpose of this book series is to present books that are specifically designed to address the critical security challenges in today's computing world including cloud and mobile environments and to discuss mechanisms for defending against those attacks by using classical and modern approaches of cryptography, blockchain and other defense mechanisms. The book series presents some of the state-of-the-art research work in the field of blockchain, cryptography and security in computing and communications. It is a valuable source of knowledge for researchers, engineers, practitioners, graduates, and doctoral students who are working in the field of blockchain, cryptography, network security, and security and privacy issues in the Internet of Things (IoT). It will also be useful for faculty members of graduate schools and universities. The book series provides a comprehensive look at the various facets of cloud security: infrastructure, network, services, compliance and users. It will provide real-world case studies to articulate the real and perceived risks and challenges in deploying and managing services in a cloud infrastructure from a security perspective. The book series will serve as a platform for books dealing with security concerns of decentralized applications (DApps) and smart contracts that operate on an open blockchain. The book series will be a comprehensive and up-to-date reference on information security and assurance. Bringing together the knowledge, skills, techniques, and tools required of IT security professionals, it facilitates the up-to-date understanding required to stay one step ahead of evolving threats, standards, and regulations.

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Preface

Welcome to *Securing the Digital Frontier: Threats and Advanced Techniques in Security and Forensics*. In today's interconnected world, where our lives are increasingly intertwined with technology, safeguarding our digital information cannot be overstated. This book is a comprehensive exploration of the evolving landscape of cybersecurity, offering insights into the latest threats, innovative techniques, and proactive measures employed to protect our digital assets.

Chapter 1, "Pegasus - A Menace to Privacy and Security," sheds light on the Pegasus spyware developed by the Israeli-based cyber group NSO. Authors Raunaq Khurana and Shilpa Mahajan examine the workings of this advanced spyware, which exploits zero-day vulnerabilities to access and collect data from target systems without user consent. Through detailed analysis and case studies, the chapter highlights Pegasus's challenges. It encourages using advanced technologies such as AI and ML/DL to develop effective countermeasures.

In Chapter 2, "Data Privacy and Compliance in Information Security," authors Rakesh Nayak, Umashankar Ghugar, Praveen Gupta, Satyabrata Dash, and Nishu Gupta explore the sophisticated relationship between data privacy and compliance in information security. They discuss the challenges, regulations, and best practices in protecting sensitive data in today's digital age, emphasizing the importance of implementing robust security measures and fostering privacy awareness within organizations.

Chapter 3, "Unveiling Cyber Threats: Exploring Crime, Security Techniques, and Digital Forensics," authored by Nidhi Gupta, Arpita Trivedi, Parveen P Terang, and Hasmat Malik, delves into the escalating landscape of cybercrimes and the various advanced techniques used to protect devices from cyberattacks. The chapter also highlights the importance of digital forensics in investigating cybercrimes and identifying perpetrators.

In Chapter 4, "A Customised Privacy Preservation Mechanism for Cyber-Physical Systems," authors Manas Kumar Yogi and A.S.N. Chakravarthy advocate for a novel privacy approach for cyber-physical systems, allowing users to customize their privacy settings based on their usage. The chapter explores the trade-off between privacy and utility in CPS entities and presents a provisional privacy-preserving method designed to enhance data utility while maintaining user privacy.

Chapter 5, "Securing the Future: Emerging Threats and Countermeasures in Cryptography," authored by Debosree Ghosh, Kishore Ghosh, Chandrima Chakraborty, Atanu Datta, and Somsubhra Gupta, focuses on emerging threats to cryptographic systems and innovative countermeasures. The chapter highlights the importance of post-quantum cryptography and secure implementation practices in safeguarding data security in an evolving digital landscape.

In Chapter 6, "Cyber Threats and its Impact on Electronic Transactions," authors Ramalingam Dharmalingam and Vaishnavi Dharmalingam explore the impact of cyber threats on electronic transactions, particularly during the COVID-19 pandemic. The chapter discusses the growth of digital transformation, current cyberattacks, and frameworks for combating cyber threats, emphasizing the need for collaborative efforts to secure future transactions.

Chapter 7, "A Robust Model for Enabling Insider Threat Detection and Prevention: Techniques, Tools, and Applications," authored by A Sheik Abdullah, Shivansh Dhiman, and Arif Ansari, addresses the growing threat of insider threats in organizations. The chapter explores techniques and tools for accurately detecting and mitigating insider threats, leveraging machine learning, artificial intelligence, and behavioral analytics.

In Chapter 8, "Digital Vulnerabilities Unveiled: A Multidisciplinary Exploration of Emerging Threats to Security and Privacy in the Age of Networked Communication," authors Priya Sachdeva and Archan Mitra offer a multidisciplinary analysis of digital vulnerabilities, highlighting the interplay between socio-technical factors underlying security issues. The chapter emphasizes the value of interdisciplinary approaches in comprehending and solving complex security challenges.

Chapter 9, "Tools of Emancipation as Global Web and its Digital Ecosystem: Steering IoT Landscape, Cloud Computing Unravel Safe Spaces Lensing New Cyber Risks and Emerging Threats," authored by Bhupinder Singh and Christian Kaunert, explores the symbiosis of tools of emancipation, the global web, and the digital ecosystem in navigating cybersecurity challenges. The chapter discusses the role of IoT and cloud computing in

mitigating cyber risks and proposes strategies for fortifying safe spaces in the digital realm.

Chapter 10, "IoT and Smart Device Security: Emerging Threats and Countermeasures," authored by Geo Francis E, S. Sheeja, Anotony Johen E.F., and Jismy Joseph, delves into the security challenges posed by IoT devices and explores emerging threats and countermeasures. The chapter emphasizes the importance of addressing IoT vulnerabilities and implementing robust security measures to safeguard data privacy and integrity.

In Chapter 11, "Secured IoT with LWC and Blockchain," authors Srishti Priya Chaturvedi, Ajay Yadav, Santosh Kumar, and Rahul Mukherjee discuss lightweight encryption and blockchain solutions for securing the Internet of Things. The chapter explores using lightweight cryptographic algorithms and decentralized blockchain structures to protect IoT ecosystems from cyber threats.

Chapter 12, "Social Engineering Attacks: Detection and Prevention," authored by Rajat Singh, Priyanka Soni, and Animaw Kerie, focuses on social engineering attacks and proposes detection and prevention techniques. The chapter discusses various social engineering attack models and preventive measures, including security information and event management (SIEM) systems and human-as-a-security-sensor frameworks.

In Chapter 13, "Multilayer Perceptron of Occlusion and Pose-Sensitive Ear Attributes for Social Engineering Attack Mitigation," authors O. Taiwo Olaleye, Oluwasefunmi Arogundade, Adebayo Abayomi-Alli, Wilson Ahiara, Temitope Ogunbiyi, Segun Akintunde, Segun Dada, and Olalekan Okewale explore the use of multilayer perceptron for detecting social engineering attacks. The chapter investigates the effectiveness of MLP in handling occlusion and pose variations, offering insights into its potential applications in digital forensics.

Chapter 14, "Study and Analysis of Cyberbullying Message Detection and Prevention Using Machine Learning Techniques," authored by Dr. S. Gunasekaran, Dr. S. Shanmugam, and Dr. N. Anusha, focuses on detecting and preventing cyberbullying using machine learning techniques. The chapter compares different machine-learning approaches for cyberbullying detection and proposes future research directions for improving detection accuracy.

Chapter 15, "Future Directions in Digital Forensics and Cybersecurity," authored by Elipe Arjun and Priyanka Singh, offers insights into the future trends and challenges in digital forensics and cybersecurity. The chapter explores the potential impact of emerging technologies like quantum computing and AI on cybersecurity practices, emphasizing the need for interdisciplinary collaboration and ethical considerations.

In Chapter 16, "Tomorrow's Shields: Exploring Future Trends in Cyber Security and Forensics," authors M. Sharma, R.K. Kohli, and K. Sharma provide a holistic perspective on future trends in security and forensics. The chapter discusses emerging technologies, regulatory frameworks, and industry trends shaping the future of cybersecurity, highlighting the importance of proactive measures and continuous learning in combating evolving threats.

We extend our sincere gratitude to all the authors who contributed their expertise & insights to this book. Their dedication and passion for advancing cybersecurity knowledge have made this book a valuable resource for researchers, practitioners, and students alike.

We hope that *Securing the Digital Frontier: Threats and Advanced Techniques in Security and Forensics* catalyzes ongoing discussions & collaborative efforts to fortify our digital defenses and navigate the ever-changing cybersecurity landscape.

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Pegasus—A Menace to Privacy and Security

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Abstract

The Israeli-based cyber group NSO developed Pegasus, a spyware that can access and collect data from a target system without the user's consent. Pegasus commonly exploits zero-day vulnerabilities, which are system weaknesses that the manufacturer has not addressed or is unaware of. This chapter thoroughly examines the Pegasus spyware, highlighting its unique features that pose significant challenges in its detection as compared to other malicious software. It presents an extensive analysis of Pegasus on both iOS and Android operating systems, with the intention of educating readers about its capabilities and advocating for the use of advanced technologies such as AI, ML/DL to develop effective countermeasures against spyware, malware, and adware. The chapter also includes various case studies that illustrate the transformation of Pegasus over time and the measures taken to prevent its infiltration into user devices. To facilitate reader's understanding, the chapter provides essential security checklists that help identify Pegasus's monitoring mechanisms.

***Keywords*:** Malware/spyware, encryption, vulnerability, vishing

1.1 Introduction

Spyware is harmful software made with the intention of stealing data from a system and sharing it with unidentified outside third parties. Pegasus is a sophisticated programme that can break into mobile devices like smartphones and tablets and eventually go over security precautions like internal

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encryption and two-factor authentication to allow hackers complete access to the targeted device once it is plugged in. If that is the case, Pegasus can control all communication between devices, including calls, messages, emails, microphone and camera providers, location data, contacts and calendars [1]. The memory consumption can be discovered using covert methods, CPU cycles, and network traffic monitoring, despite the fact that the Pegasus file store was initially intended to target officials, politicians, journalists, and influencers.

Pegasus tool is produced by the Israeli company NSO Group. This surveillance tool is designed purposely to monitor specific individuals for national security. Although this tool is developed to be used by the government agencies but it has been a subject of significant controversies. These controversies arises as they are considered to be threat to human privacy, an abuse to human rights and potential misuse of surveillance technologies.

The allegation involves that government is spying on its officials and political opponents and even individuals or not even legitimate targets for surveillance. NSO group gave his assurance that their tool is used for legitimate purposes like for frightening crimes and terrorism. However, number of evidences and investigations have suggested that Pegasus has been used for questionable purposes by some people.

The way that this tool operates is by taking advantage of flaws in mobile devices, especially smartphones, to access personal data, including calls, texts, emails, and other communications. It may also be used to activate the camera and microphone, monitor the device's position, and do a variety of other things, thereby transforming it into a robust surveillance tool.

The properties of Pegasus are thoroughly covered in this chapter, with special emphasis placed on those aspects that set it isolated from different spyware and malware in terms of difficulty in detection [2]. It also explains how Pegasus operates on both iOS and Android operating systems and suggests using advanced technologies like machine learning and AI to develop systems that can identify and prevent Pegasus, safeguarding devices from adware, malware, or spyware. Additionally, the chapter presents case studies demonstrating Pegasus's evolution over time and proposes methods to prevent spyware from infiltrating and spreading on user devices. By following the practical safety guidelines outlined in this chapter, readers can learn how to protect themselves from Pegasus's surveillance tool.

- Investigating the market origins and distribution of Pegasus.
- Examining how Pegasus operates and its ability to turn smartphones into listening devices by exploiting multiple vulnerabilities.

- Proposing various techniques to detect potential Pegasus attacks.
- Sharing advice on how to recognize the presence of Pegasus spyware on a device.
- Suggesting the utilization of command-line or terminal utilities to lower the likelihood of being affected by the Pegasus spyware.
- Providing practical recommendations to enhance awareness and protect devices from Pegasus spyware.

Spyware attacks have become increasingly sophisticated in recent years. In the past, malicious software could be installed by opening a suspicious email as early as a decade ago [3]. However, Pegasus spyware has now adopted a "mobile first" strategy, whereby it impersonates its users by sending links in text messages that appear to be from trusted sources. Clicking on these links gives Pegasus access to sensitive information, such as location data and financial information. From 2016 to 2021, Pegasus has become even more advanced and now uses "zero-click" technology, which relies on zero-day threats that are unknown to the user and remain unpatched [4]. To limit the success of Pegasus on user devices, the research paper titled "Pegasus: A Privacy Killer" recommends adopting basic precautions, like avoid unknown links, categorization of devices, and using reliable VPNs for all devices [5, 6]. Pegasus uses complex zero-day infection vectors to infiltrate devices. Once installed, try different ways to get access to victim's data and transmits it to the server [7]. The way how Pegasus can attack and exploit your phone can be seen in Figure 1.1.

1) It uses GPS information to identify and differentiate targets and obtain precise information
2) The Pegasus spyware does not require coordination with local Mobile Network Operators (MNOs), making it independent of service providers.
3) It control both the content and devices it infects by utilizing proprietary protocols and SSL, commonly used in complex communications, which allows it to surpass encrypted information.
4) The surveillance includes monitoring various applications, such as Instagram, Twitter, WhatsApp, Skype, Viber etc.
5) Monitor VoIP and voice calls in real time (call interception).
6) Pegasus can recognize operational identities without the need for regularly switching virtual identities or while continuously surveilling/observing the device.

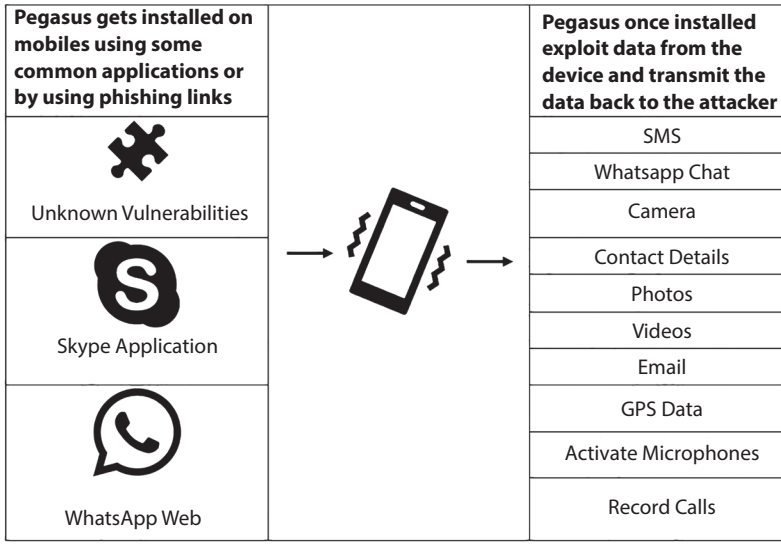

Figure 1.1 Pegasus impact.

1.2 Working of Pegasus

This spyware name Pegasus is a highly advance and dangerous tool that exploits "Zero-day Vulnerability," a security weakness for which no patch or update is available or known by the manufacturer. Pegasus can silently infiltrate various Android and iOS devices and covertly monitor all device activities. By exploiting vulnerabilities in third-party spyware, Pegasus can take complete control of the device, allowing the attacker to perform various actions. To protect against such attacks, users must take proactive measures, such as installing antivirus software, regularly updating device firmware, and being vigilant when clicking on links from unknown sources.

Pegasus can access data like access your messages, location tracking, content surfing, can make calls from compromised phones, call logs can be accessed, access to photo, camera and Microphone can be accessed and an delete data and even retrieve the deleted files from the mobiles. Pegasus spyware directly transmit the data obtained from target's phone straight to the data server of NSO group [8].

Pegasus spyware is a highly advanced malware that can be installed easily through physical contact, text or email and through calls and messages. It exploits vulnerabilities that have not been updated with a patch or are not known to the relevant parties. It can infiltrate a device through a missed call on WhatsApp or an iMessage on iPhones [9]. The Pegasus spyware utilizes a zero-click method that does not require any user interaction, making it challenging to detect. Even if a user tries to delete a suspicious message, the spyware can persist on the device and infect it [10].

Pegasus spyware is a highly sophisticated tool that can decrypt end-to-end encrypted messages and files, making it a potent weapon in espionage [11, 12]. Recent findings indicate that the latest versions of Pegasus can infiltrate devices through missed calls and delete the call logs to cover up the attack, making it harder to detect and track its actions. This poses a significant challenge for users who may not even be aware that their devices have been compromised [13].

A diagram depicting the general workflow of Pegasus can be seen in Figure 1.2.

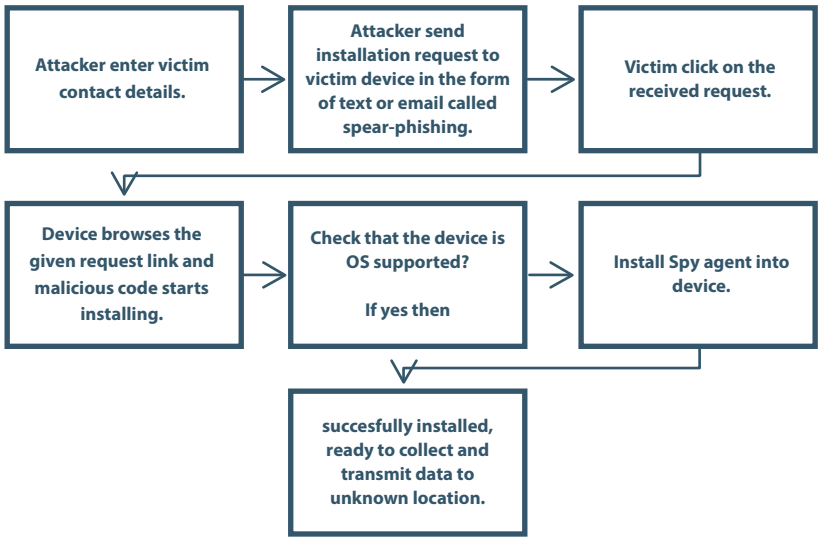

Figure 1.2 Pegasus workflow.

The workflow of Pegasus on a normal device vs. an infected device can be seen in Figure 1.3. It is interesting to find how an infected device behave differently from the normal device. In normal device, the common phasis include

Device Setup	*The user purchases a new mobile device and goes through the initial setup process, which typically includes connecting to Wi-Fi, signing in with their Apple ID or Google Account, and configuring settings.*
App Installation	*Users can install applications from authorized application marketplaces such as the Apple App Store or Google Play Store. These apps undergo a vetting process to ensure they do not contain malicious code.*
Regular Usage	*The individual utilizes the device for a multitude of functions, including placing calls, sending messages, surfing the web, and accessing applications. The device operates normally without any unexpected behavior.*

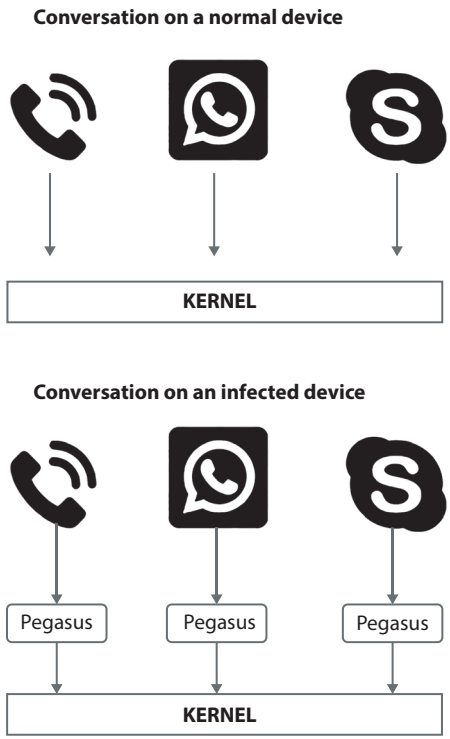

Figure 1.3 Work-flow of normal device vs infected device.