Analyzing the Ransomware Attack on D.C. Metropolitan Police Department by Babuk

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Abstract—Ransomware attacks are a fast-growing cybercrime that pose a large threat to society. These attacks can result in losing significant amounts of data and money for their victims. Many industries such as aerospace, governmental organizations, etc., have been targeted in the last couple of years. This paper examines the recent attack incidents by one of the famous ransomware groups, Babuk, on the aerospace industry and a police department. It provides an in-depth analysis of the methodology of the attack and examines the impact at a local and global level. A total of 250 gigabytes of data were stolen from one of the victims, the D.C. Metropolitan Police Department. Babuk first had to gain access by infiltrating the system to attack the victims successfully; however, there is no clear evidence on how this was specifically done. Babuk likely gained access by scanning for vulnerable ports in the victim’s system, sending employees a phishing email with a malicious link, or cracking passwords that the victim used for admins in their system. After gaining access, Babuk had to maintain access while stealing and encrypting files. Finally, they demanded ransom from the victims and threatened to post the sensitive data if the ransom was not paid. The attack has impacted not only specific organizations but also public security officials. This paper provides an in-depth analysis of the possible attack methodologies and defense strategies against such ransomware attacks. The defense strategies may include changing government policies, regulating cryptocurrency, and adhering to FBI-listed advice.

Index Terms—Ransomware, Attack, Zurich Airport, Serco, Police, Babuk, Cybercrime, Data Breach, Cybersecurity

I. INTRODUCTION

Cybercriminals across the globe can attack vulnerable organizations with great ease using malicious software. By doing so, criminals impact the confidentiality, integrity, and availability of sensitive data that businesses and governments use in their day-to-day operations. One of the most common forms of malicious software is known as ransomware. Ransomware can be used to steal and encrypt data from a victim, essentially holding it “hostage” until the victim pays the attacker for it to be decrypted [1]. Most ransomware programs operate by using some form of asymmetric cryptography scheme to encrypt data in ciphertext. These schemes generate public/private key pairs that are unique for both the victim and the attacker. The pairs are set up in such a way that only the attacker is able to generate a decryption key to unencrypt the victim’s data. Ransomware groups typically threaten their victims into paying for the decryption key in Bitcoin, thus completing their malign intentions [1].

On a yearly basis, ransomware continues to affect industries as one of the fastest growing forms of cybercrime in the world. Within the first half of 2021 alone, there were 121 reported ransomware attacks, up 64% from the year before [2]. In 2020, ransomware was a $20 billion industry, and it continues to grow on a daily basis; average ransomware payments rose 82% in 2021 to $570,000. One reason for ransomware’s massive popularity as of late is its ease of use against any organization in any industry. On the dark web, ransomware kits are sold for as little as $175 USD, and typically require no technology background to deploy against a target [2]. Ransomware attacks have become so popular that some experts estimate that a ransomware attack occurs once every 14 seconds around the world. Organizations within all industries are vulnerable to attack, especially those in government and the aerospace and aviation industries.

On January 31st, 2021, Serco revealed to the press that they had been subjected to a large ransomware attack. Serco is a massive contract organization that operates within a variety of industries including defense and aerospace, healthcare, and government. Just a few months later, on April 26th, the D.C. Metropolitan Police Department (DCMPD) confirmed they were subject to a massive ransomware attack. The DCMPD is one of the largest and most important police departments in the United States. The attackers were allegedly a foreign-based group named Babuk. In 2021, Babuk was also allegedly responsible for attacks on at least five other major organizations [3]. Some of Babuk’s targets within the aerospace and aviation industry include Serco, PDI Group, and the Zurich Airport [4]–[6].

When an organization becomes victim to a ransomware attack, the U.S. Cybersecurity and Infrastructure Security Agency (CISA) requests they contact the U.S. Department of the Treasury’s Office of Foreign Assets Control (OFAC) immediately. The CISA and FBI say paying the ransom may enable cybercriminals to continue attacking, and in some cases paying the ransom is illegal [7]. Another reason they insist not to pay the ransom is because the attacker may not end up giving the decryption key anyway. In Babuk’s case, the decryption key may be faulty and not work.

As shown in Figure 1, Babuk’s ransomware strategy takes on a similar structure to many other ransomware groups. After targeting the DCMPD, the group used their ransomware to infiltrate the DCMPD’s systems. Once they had gained
II. VICTIM AND THE ATTACKER

Babuk’s attack on Serco occurred in February 2021. As previously stated and outlined in Fig. 2, DCMPD first notified the press of their attack in late April 2021. In this section, we study the background of Serco, the DCMPD and the ransomware group Babuk.

A. Serco Aerospace Contractor

Serco is a British contracting company that operates in many different industries, specifically those within the public sector. Their worldwide contract work within the aerospace and defense industry is one of the largest facets of their work. This work includes base management and aircraft modernization and maintenance. In 2018, Serco’s revenue from contracts within this industry totaled £947 million, making them one of the largest contractors for the aerospace industry worldwide [9].

B. D.C. Metropolitan Police Department Data

The DCMPD is one of the most prominent police departments in the U.S. The department is one of the largest in the nation, and serves greater metropolitan area of the District of Columbia [10]. Because the department is located in the capital of the United States of America, they carry out work more important than a typical police department. In fact, officers from the DCMPD were called in to help control the crowd at the U.S. Capitol during President Joe Biden’s inauguration on January 6th, 2021 [11]. The heightened responsibility that the DCMPD handles on a daily basis is one of the many reasons why they are such an important police department in the U.S.

In their normal operations, police departments typically deal with various types of data. This includes criminal history records, law enforcement incident reports, records of judicial actions and decisions, and watch lists of known and suspected terrorists [12]. Not only does this data help law enforcement and government agencies detect and prevent crime before it occurs, but it also allows them to share data with different policing agencies. Police departments also store information relevant to their officers, including personal and employment data, as well as important information about their general operations. These copious amounts of sensitive data make police departments more vulnerable than ever to cyberattacks.

This was certainly the case for the DCMPD when they were targeted by Babuk [8], [13], [14].

C. Babuk Hacker Group

There is ongoing research about the alleged attackers, who are known as Babuk. The foreign-based group thinks of themselves as “security auditors” who request payments from the companies they “provide their services” to [3]. On their forums, Babuk tells victims that they would be much worse off if their data were in more villainous possession. In other purported attacks, Babuk have operated by using
Fig. 2: Timeline of Babuk’s attacks

...a “ransomware-as-a-service” model. That being said, it is believed the group have become more focused on data extortion after the DCMPD attack. As seen in the timeline (Fig. 2), Babuk was first detected in early 2021. Babuk’s ransomware uses similar operating methods compared to many other ransomware groups, and a technical analysis of their ransomware found it shared extreme similarities to another type of ransomware named Vasa Locker [15].

In a public post from the group’s data leak site, Babuk describes their intentions as “network testers” with “non-malicious software”. While Babuk does force victims into negotiation to decrypt their data, the group does have several types of organizations they do not attack. These include hospitals, non-profit organizations, schools, or companies with an average revenue of less than $4 million [15].

The group uses a series of English-speaking and Russian-speaking forums for operations [3]. The English-speaking forums are used primarily for leaking certain amounts of victim data and for communicating messages to the general public, while the Russian-speaking forums are used for communication between members and advertising recruitment to the group.

D. Babuk’s Ransomware Attacks Strategies

The group uses their ransomware to meticulously attack enterprises in the aerospace, transportation, healthcare, plastic, electronics, and agricultural industries. Before the attack on the DCMPD, Babuk had already used their ransomware to target at least five victims in these sectors in the first half of 2021 [15]. The group has been successful in at least one of these attacks, as one company paid them $85,000 to decrypt data stolen by Babuk’s ransomware.

Babuk’s attacks also varied in geography, with major attacks occurring in the United States, Spain, Italy, India, and China [15]. According to cybersecurity experts, their continued success is a result of operating out of jurisdictions which provide them protection from international law. This is due to iniquity or indifference from countries that they operate out of. [13]. Additionally, when Babuk threatens victims that sensitive information will be posted online, they request payment in Bitcoin in order to recover the data. Because the sending and receiving of Bitcoin is not overseen by one government or organization, this makes it much easier for Babuk to avoid international authorities [16].

One specific instance of Babuk’s ransomware attacks occurred to the Houston Rockets, a professional basketball club in the NBA. Babuk used ransomware to steal and encrypt 500 gigabytes of the organization’s data [17]. The data stolen were all important documents to the organization and included third-party contracts as well as corporate, customer, employee and financial information. This information was highly sensitive and was not meant to be seen by the general public. For example, one leaked document, titled “Team Sale”, led many to speculate whether the team’s owner was looking into selling the team or not. This attack bore many similarities to the attack against the DCMPD and Serco attacks that Babuk undertook.

III. Ransomware Attacks on Aerospace Industry

Within the aerospace industry specifically, ransomware attacks can have massive repercussions on an organization. A recent threat analysis by FireEye shows that cyberattacks on companies in this industry aim to steal intellectual property from aerospace and defense companies and use it against them by developing countermeasures or working to monitor and subvert a nations’ aerospace and defense systems [18]. Information stolen from aerospace and defense companies can include budget information, product designs and blueprints, research reports, and testing reports/results.

A. Recent Ransomware Impacts on Aerospace Industry

Recent attacks on the aerospace industry target the many vulnerabilities which different types of aerospace software contain. Specifically, increasing amounts of software and hardware integration leave vulnerabilities for malicious hackers to exploit [19]. Other research has shown that attacks on aerospace software can also originate from lower layers including the OS kernel. Purposes for these attacks are usually to corrupt core data and failure-tolerant systems within aerospace software [19]. Failures in either of these systems create massive ramifications for the overall safety of an aircraft.

B. Ransomware Attacks on Airports

Although Babuk has conducted an attack in this domain, it is also being targeted by other groups with higher stakes. In February 2022, there was a ransomware attack by an unknown group at the Zurich Airport which caused 22 flights to be delayed [6]. Swissport, the main ground services and air cargo operator at the Zurich Airport, had their IT systems subjected to a ransomware attack from an anonymous group. No critical systems were subjected to attack, and Swissport operators were quick to respond to the attack once it had been detected. When aerospace systems are targeted, more than just data can be affected, as attacks on critical systems can affect the integrity of an airport’s security as well as the safety of an aircraft for passengers and pilots. Some known named Cybercrime groups are Maze and Netwalker. In June 2020, there was an attack on ST Engineering, where 1.5TB of sensitive aerospace data was...
Victim
Attacker
Gain
Access
Command line
arguments
Terminate services and
running processes
Encryption
Key
Generation
Folder Traversing
Create ransomware note
.exe file
Figure 4: Attack Methodology Breakdown, specifically how they maintained access after compromising DCMPD system [24]

they attempt to find as much information they can about the DCMPD, including what types of software’s they use. Babuk then needed to scan the system for vulnerabilities to see where they could enter the system. There are three possibilities for how Babuk gained this initial access to the DCMPD’s system.

The information about how access was actually gained was not released by the police department. The first possible way would have been to exploit a vulnerability that may have been found during scanning and enumeration [22]. There are tools to do this and Babuk had done it before by exploiting a public-facing application, in the specific case the application had been Microsoft. Another possibility to gain access to the system would be via phishing email. If Babuk sent a fake email with a malicious link or attachment and that was clicked on or downloaded, they could get initial access. Phishing emails are sometimes hard to spot because they can be made to look very legitimate. The last possibility is that Babuk found a vulnerable password and could gain remote access into the system by guessing this password [22]. Babuk’s ransomware is programmed in an open source language called Golang. In a McAfee technical analysis, it is mentioned that Golang written on a Linux system can run on either Windows or Mac [22].

B. Maintain Access

Figure 4 shows the life-cycle of the malware after Babuk has successfully gained access into the DCMPD system. They terminate databases, office applications, and anti-malware services in order to further avoid detection [3]. Examples of the main services Babuk will terminate

<table>
<thead>
<tr>
<th>Version</th>
<th>Source</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version 1 (v1)</td>
<td>[15], [24]</td>
<td>This version analyzed was the first version of the ransomware detected.</td>
</tr>
<tr>
<td>‘DoYouWantToHaveSexWithCuong-Dong’ version</td>
<td>[3]</td>
<td>This version is believed to be used in the DCMPD attack and talks about the new updates to the encryption.</td>
</tr>
<tr>
<td>April 2021 Version (babuk_v2)</td>
<td>[22]</td>
<td>This version was analyzed from April 2021 and talks about some changes from the original version.</td>
</tr>
</tbody>
</table>

Figure 3: Ransomware attack phases that Babuk typically uses on their victims, including the DCMPD [22].

stolen [20]. In another attack targeting the aerospace industry, the malware had gone undetected for at least two years just being discovered in September 2021 [21].

C. Babuk’s Ransomware Attacks on Aerospace Industry

Babuk’s unsophisticated malware attacked Serco in February 2021. Babuk gained access to Serco’s systems and claimed to have stolen more than 1TB of data from them [4]. The specific systems that were under attack and impact the attack had on the company are unknown [4]. Another company in the defense and aerospace industry, PDI Group, was also attacked by Babuk in 2021 [5]. During this attack, 700GB of data ranging from contracts and customer payment information to personal information of employees and non-disclosure agreements regarding intellectual property were stolen from PDI Group. Similarly to the DCMPD attack, Babuk leaked sensitive documents online in order to pressure the victim to pay the ransom [5].

IV. ATTACK METHODOLOGY

In every cybercrime there is a set of phases used by the attackers in order to successfully infiltrate and attack a system. Malicious software, often referred to as “malware” is software purposefully designed to cause harm to computers and/or users in order to gain access to sensitive information. When cybercriminals use malware, there are a variety of different techniques that can be used to attack a victim. One common attack technique is a form of malware called ransomware [1], [23]. The specific attack that the Babuk group used was the ransomware-as-a-service model. Figure 3 shows the three main phases of a Babuk Ransomware attack. All of the following information is based off of three main technical analyses of source code from this Babuk attack and prior ones. Two of the analyses were done by McAfee [15], [22] and the other by Chuong Dong on his security blog [24].

The source code used throughout different Babuk attacks had evolved into different mutexes and the ones discussed in this paper are shown in Table I. The rest of this section discusses possible points of gaining access, what happened when access ultimately was gained, and how ransom was demanded from the victim.

A. Gain Access

The first phase for this attack was to gain initial access into the DCMPD’s system. To successfully have done this the attackers first had to complete reconnaissance. This means
Table II: Shell functions used by Babuk ransomware for lateral propagation after gaining access to the DCMPD network [24], [25].

<table>
<thead>
<tr>
<th>Shell Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ShellExecuteW</td>
<td>Executes cmd.exe /c vssadmin.exe delete shadows /all /quiet to delete shadow volumes</td>
</tr>
<tr>
<td>SHEmptyRecycleBinA</td>
<td>Empties the recycle bin of victim’s machine</td>
</tr>
<tr>
<td>FindFirstFileW, FindNextFileW</td>
<td>Recursively uses these methods calls to traverse through directories and subdirectories of a system</td>
</tr>
<tr>
<td>SetFileAttributesW, lstrlenW, lstrcpyW, lstrcatW, MoveFileExW</td>
<td>Functions used to append the .babyk extension to encrypted files.</td>
</tr>
<tr>
<td>QueryServiceStatusEx, EnumDependentServicesA, CloseServiceHandle, GetLastError</td>
<td>Functions used to terminate certain processes (mostly database and office applications) to avoid alerts</td>
</tr>
<tr>
<td>CreateToolhelp32Snapshot, lstrcmpw, OpenProcess, TerminateProcess, CloseHandle</td>
<td>Functions used to terminate the services if found are QueryServiceStatusEx, OpenServiceA, EnumDependentServicesA, CloseServiceHandle and GetLastError. The functions used to terminate processes if found are CreateToolhelp32Snapshot, lstrcmpw, OpenProcess, TerminateProcess and CloseHandle. The ransomware runs commands and destroys the “shadow volumes” of the victim machine which covers the tracks of the commands being ran [15]. The function used is ShellExecuteW, which deletes these shadow copies. Then the command SHEmptyRecycleBinA is used to empty the recycle bin of the victims machine to prevent any possibility to regain and recover data [25]. This ensures that the victim needs the decryption key from the attacker in order to have the files back.</td>
</tr>
</tbody>
</table>

C. Demand Ransom

After the Babuk ransomware had infiltrated the system, the last step was to demand ransom from their victim. They left a file titled “How to Restore Your Files.txt” with a ransom note on the system that has contact information and proof that the files have been taken [3]. In the case of DCMPD, the department did not find out their systems had been compromised until it was posted on the Babuk forum. The instructions to contact the attacker are listed and state to download the Onion Router from a dark-web repository1, then open it and follow a link in the browser2. Babuk changes these links for each specific attack. The note also provided a link to where the information will be leaked to the public on the Dark Web [3].

V. IMPACT

As previously stated, Babuk had claimed to have stolen in total 250 gigabytes of data from the DCMPD [14]. The data stolen was compromised of both sensitive information on individuals as well as larger federal documents. More specifically, sensitive documents pertaining to individual police officers were leaked to the public. Social security numbers, marriage history, financial details, criminal history, employment history, answers to polygraph tests, and social media activity of officers were all included in the leak. Documents leaked concerning the DCMPD included psychiatric evaluations, details of past drug use, finances, backgrounds checks, sexual abuse, disciplinary actions, and other confidential documents.

A. Impact on DCMPD and Public

As shown in Figure 5, data leaks released by Babuk on the DCMPD had a very damaging impact on the officers involved as well as the department itself. After the data was leaked, D.C. Police Union chairman Gregg Pemberton stated, “How we will ever hire anyone to work here is beyond me” [8]. Ransomware expert and threat analyst Brett Callow explained that because of the risks that officers and civilians faced from

1https://www.torproject.org/download/  
2http://babukq4e2p4wu4iq.onion/login.php?
Individual Officers

DC Metro Police

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packages have increased by 200% between 2016 and 2017.

supply chain attacks having implanted malware on software

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data breaches from 2020 [27]. A cybersecurity firm named

documents that could threaten public security, the attitudes

outside of the DCMPD. Since many individuals have had

their private information released to the public along with

documents that could threaten public security, the attitudes

regarding cybersecurity in the DCMPD have shifted.

B. Broad Impact of Ransomware

Babuk’s attack on the DCMPD was only a single attack

that represents a larger and growing problem. The impact

of ransomware attacks has grown massively in the past few

years. In October 2021, the number of publicly reported
data breaches had already surpassed the total number of
data breaches from 2020 [27]. A cybersecurity firm named
Cybersecurity Ventures estimates that costs associated with
damage from ransomware will amount to $265 billion dollars
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However, ransomware is not the only form of cybercrime
that is increasing. Mobile devices being attacked with malware
have increased 54% across the globe, and software update
supply chain attacks having implanted malware on software
packages have increased by 200% between 2016 and 2017.
The costs of these attacks are growing to tremendous amounts
as well. It is estimated that financial costs incurred by entities

hacking US companies, most of whom are foreign-based, are

between $225 billion to $600 billion annually [29].

One reason why ransomware and other cybercrimes have

been able to increase so greatly is due to low enforcement rates for cybercrimes. Table III shows the rate of enforcement of cybercrime compared to other forms of crime in the U.S.

It is incredibly difficult for federal authorities such as the FBI and NSA to track down and charge cybercriminals with criminal charges for their actions. This low enforcement rate when compared to other crimes makes cybercrime a “low-risk, high-reward” option for criminals who have the know-how to carry out these types of attacks.

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VI. POSSIBLE COUNTERMEASURES

Figure 6 outlines several key areas that could act as possible defense strategies against ransomware attacks. When it comes to cybersecurity, several government agencies such as the FBI and CISA offer general tips on how an organization can protect itself. These tips include using strong passwords, ensuring that an organization is using the most current versions of software, conducting regular virus scans, backing up data consistently, and making members aware of phishing scams [23].

A. CONTINUOUS PENETRATION TESTING OF SYSTEM

Frequent penetration testing of a system should be carried out to discover the attack surface and vulnerabilities in systems. More specifically, Antivirus company, McAfee offers suggestions on how to defend against Babuk themselves [15]. McAfee states that defenders should look out for behaviors with correlation to open source penetration testing tools or hacking frameworks such as winPEAS, SharpHound, Cobalt-Strike, Metaspliot, or Covenant because Babuk has posted that they recruit individuals with penetration testing skills [15].

Table IV outlines how each out these tools are normally used for ethical hackers to legally test organizations for vulnerabilities. Indicators of Compromise, also known as IoC’s, can help indicate when a cybersecurity attack has occurred. You can use IoC’s during response to an attack to prevent that specific attack from occurring again [31]. Monitoring traffic on a Companies system can help locate any suspicious activity and to act early in the case that malicious access was gained.
B. Organizational Policies

Another method of defence against cyberattacks such as this is changing government policies. As illustrated in Table III, there is a large enforcement gap when dealing with cybercrimes. One suggestion is to build better cyber defences but also increase effort into pursuing human attackers. It argues that this strategy could both decrease the finite amount of hackers nation wide, discourage others from pursuing cybercrime, and makes sense given the estimated $225 billion to $600 billion annual cost to US companies in 2017 [29]. However, despite the tremendous cost caused to the US economy by cybercrime the Department of Defense had only spent $7.2 billion on broad cybersecurity measures in the same year [29]. Though there have been some recent policy changes, such as a recent Executive Order from US President on cybersecurity that requires companies to report specific information about data breaches and establishes the Cybersecurity Safety Review Board, there are still many more defence methods that can be put into place [32].

C. Cryptocurrency Regulation

Cryptocurrency is widely used in ransomware attacks. This is due to that fact that cryptocurrency is easy to use and hard to trace when dealing with amounts of money. The regulation of cryptocurrencies both nationally and internationally could aim in investigations of cybercrime. Specifically, one study found that regulating Bitcoin globally that is done clearly, consistently, and cost effectively could help target malicious Bitcoin users [33]. Increasing global regulations for Bitcoin exchanges can help increase transparency between senders and receivers, especially malicious ones. Because Bitcoin uses blockchain for operations, none of its transactions are truly anonymous. Bitcoin exchanges use identifying documents to accurately trace the sender and receiver of the exchange [16]. These documents contain “know-your-customer” IDs, which can be used by law enforcement or government agencies to help track malicious Bitcoin traders and bring them to the justice system.

D. Community Awareness for Social Engineering and Phishing Attacks

Phishing is one of the most common ways that malicious actors are able to gain access to a system in a ransomware attack. Nearly one quarter of ransomware victims report that phishing was how attackers initially penetrated their system, and of those victims, over one half had conducted anti-phishing training in their organization to some degree [34]. Teaching employees about what phishing is and how to detect it within their system is a crucial step to preventing large-scale ransomware attacks in an organization. Microsoft lists calls to action or threats, poor spelling and grammar, unexpected links and/or attachments, and mismatched email domains as common hallmarks of phishing messages [35]. If an employee receives a phishing email, they should never open any links or download any attachments from the email. Reporting and deleting the email is the easiest way to prevent it from propagating ransomware onto a company’s network. Keeping an organization’s members knowledgeable about their security policies and practices is a major defense against ransomware attacks.

It is important to stay up to date on emerging cybercrime trends. Many attacks target software that is out-of-date or needs newer security patches. If the current trends are being researched this will help to keep any company’s cybersecurity up to par and be one step ahead of the hacker groups. This especially matters when software being used is old or outdated. Police computers are vulnerable for this exact reason, as they have older software with vulnerabilities that are typically targeted by ransomware groups [36].

VII. Conclusion

Babuk’s targeted attacks should serve as an example that no organization should take the ever-present threat of ransomware lightly. The pivotal attacks of Babuk’s ransomware show the wide range of organizations vulnerable. The data encrypted by the group could result in much more damage to not only to affected organizations like the DCMPD and Serco, but also the industries in which they operate. Babuk’s strategy of data encryption during the ransomware attack also shows how important it is for systems to better protect their data before it is stolen. In the case of DCMPD’s attack, the stolen data was actually leaked and Babuk likely could have made far more important information available on the dark web had they been less resistant to their ransomware process. It is important for organizations especially in the industries with

<table>
<thead>
<tr>
<th>Penetration Testing Tools/Hacking Frameworks</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>winPEAS</td>
<td>Used for privilege escalation on Windows hosts.</td>
</tr>
<tr>
<td>SharpHound</td>
<td>Collects data from domain joined Windows systems as well as domain controllers.</td>
</tr>
<tr>
<td>CobaltStrike</td>
<td>A software which emulates threats for penetration testing.</td>
</tr>
<tr>
<td>Metasploit</td>
<td>An open source penetration testing framework that is used to improve security.</td>
</tr>
<tr>
<td>Covenant</td>
<td>A control framework and a .NET command that detects attacks.</td>
</tr>
</tbody>
</table>
highly sensitive data to re-evaluate their ransomware prevention strategies and be wary of the constantly evolving threats that ransomware groups pose to their data. Only through constant and effective prevention strategies can organizations discourage hacker activities and prevent data breaches like the ones Babuk has perpetrated against. Using strategies such as increasing awareness of phishing attacks, implementing a solid incident response plan to combat ransomware and other forms of malware, updating or patching legacy software, and following the latest government regulations are all safe and effective ways that large organizations can use to increase their ransomware awareness. Research areas for future ransomware prevention include malware mutex detection through techniques like YARA rules and safer decryption methods for ECDH encryption and other similar encryption techniques. Additionally, research into global regulation of bitcoin transactions is another strategy to help deter cybercriminals using ransomware to profit off of vulnerable businesses.

REFERENCES