PENETRATION TESTING REPORT

NEXT GEN

NEXT-GENERATION POWER AND ELECTRIC

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Executive Summary

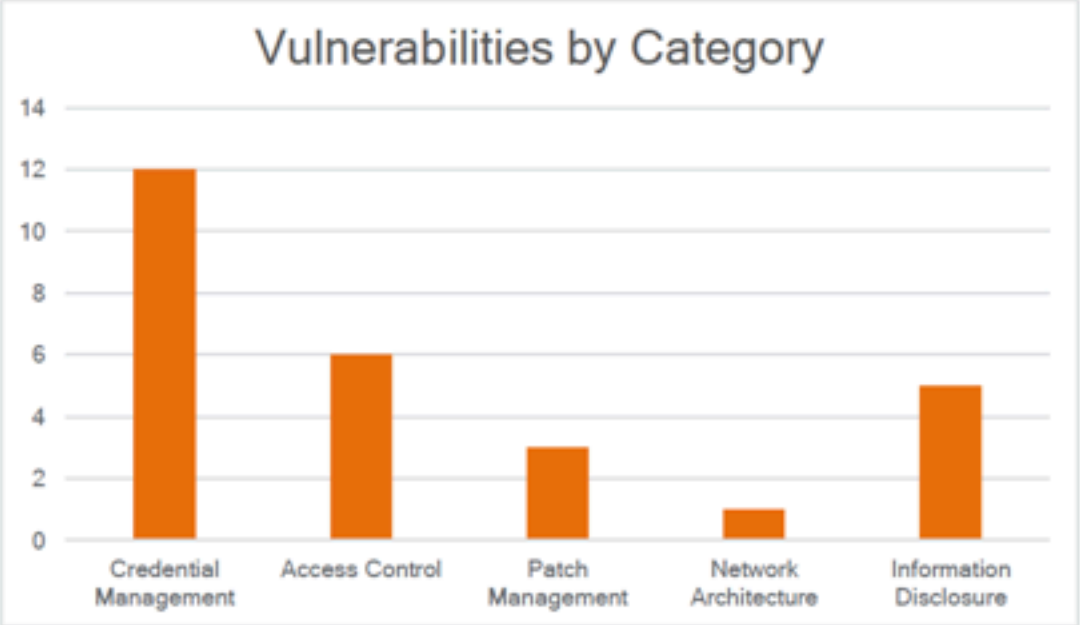
[redacted] was tasked to assess the security of Next Generation Power, Electric, and Water (NGPEW). The engagement's objective was to determine the company's overall exposure and the effectiveness of their current controls. Specifically, [redacted] was tasked to assess the security of the internal systems, the industrial control systems, and the client services. The scope of the assessment included 3 subnets given in the RFP. The assessment and report were compiled over a two-day period by NGPEW's request. Specifically, we were given instructions to not socially engineer during the assessment and be careful around the control systems for the dams. An expanded explanation of the scope and limitations is given later in the report.

During the assessment, several weaknesses were found in the NGPEW system and policies for the company. Most importantly, these included leaking confidential information, weak passwords, services that may be redundant for your organization, and unprotected parts of the system. These weaknesses allowed the assessment team to fully compromise the system and find severe flaws that allowed unauthorized user access to the entire organization. Due to these findings, the overall rating of CRITICAL was given to NGPEW. In addition, the vulnerabilities caused NGPEW to fall out of compliance with the Critical Infrastructure Protection standards (CIP) as defined by the North American Electric Reliability Corporation (NERC), which can result in a monetary fine of 1 million USD per violation per day. These are the baseline of practices for an organization in the energy critical infrastructure sector of the United States.

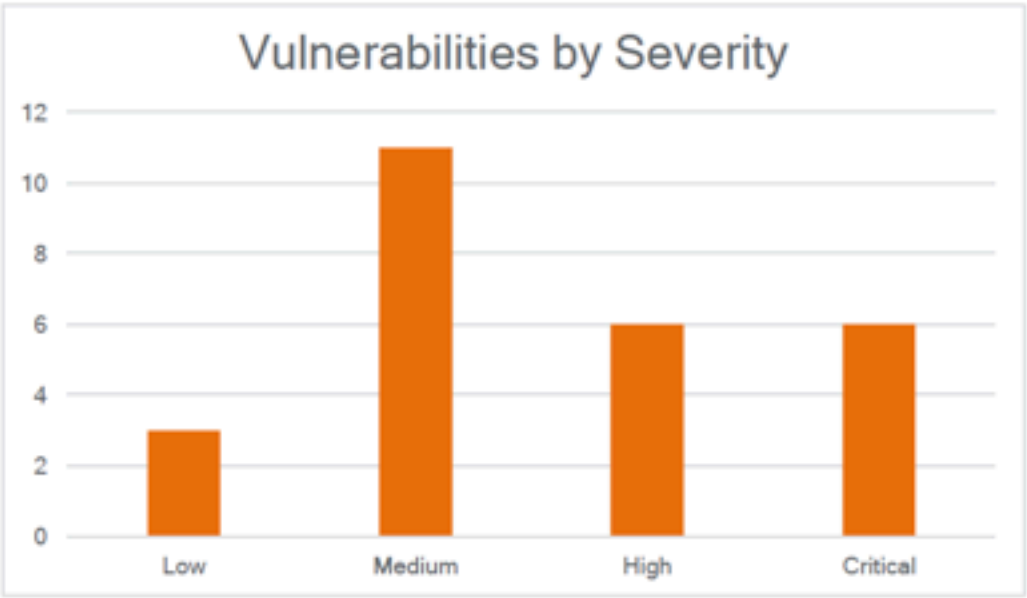
In order to secure the company and align the company with regulations, [redacted] recommends the following actions.

1. Reevaluate the credential management policy and consider implementing a password manager for the company.
2. Implement a training program for personnel on information security best practices.
3. Implement a multi-factor authentication program for employees.

Strategic Findings



1. Credential management includes the improper storage of passwords, weak passwords, and the reuse of passwords.
2. Information disclosure is the release of confidential or proprietary information that can potentially be harmful to the organization.
3. Patch management is keeping applications up to date with the latest version released by the vendor.
4. Network architecture includes vulnerabilities caused by the design and set up of the networks and externally facing machines.
5. Access control vulnerabilities are due to improper controls on user's permissions.



Strategic Recommendations

NGPEW has improved its security posture substantially since the last assessment, however, there are several areas that can still be improved to prevent a compromise similar to this assessment. The following is a list of the most critical areas to be addressed.

1. The passwords employees are using are still not secure and are easily guessable. Most passwords are weak and are reused by several users on different machines. It is recommended that password complexity requirements are changed to adhere to NIST best practices. It is in [redacted]'s opinion that a password manager be implemented where possible to securely store and create strong passwords.
2. During the assessment, [redacted] discovered that passwords and other sensitive information were being sent via chat or email in plaintext. [redacted] recommends that employees all undergo regular information security training to educate them on the proper ways to send sensitive information.
3. It is recommended that NGPEW implements a password lockout policy wherever possible. An example of a lockout policy is after five failed login attempts an account becomes locked. This deters adversaries from guessing or brute-forcing their way into NGPEW accounts.
4. NGPEW should wherever possible implement multifactor authentication. Our firm was able to gain access to various systems due to password reuse and weak passwords. Multifactor authentication is one method to further mitigate these risks, as it serves as a safeguard against employees being non-compliant with security policies.
5. NGPEW should wherever possible further segment the network by functional use. Workstations that are used by business employees should be segmented from SCADA devices. Furthermore, SCADA devices should be air gapped wherever possible.

Governance and Compliance

The North American Electric Reliability Corporation (NERC) created the Critical Infrastructure Protection (CIP) Standards to “advance the physical security and cybersecurity of the critical electricity infrastructure in North America” These standards were developed through a committee consisting of both “regional NERC-appointed representatives and technical subject matter experts.”

These standards serve as the baseline for cybersecurity in the community that NGPEW operates in. Therefore, our firm has aligned our technical findings with the CIP standards to provide a holistic view of the vulnerabilities noted. Additionally, we recommend that NGPEW joins the Electricity Information Sharing and Analysis Center (E-ISAC) to stay up to date on cyber threats and learn sector best practices.

Most notably, not complying with CIP standards can result in severe financial penalties for an organization, namely, up to 1 million USD per violation per day. [redacted] found that NGPEW was most often out of compliance with credential management (CIP-007-6 and CIP-011-2) and managing access to resources (CIP-005-6). Moreover, it was indicated by the assessment that NGPEW may be out of compliance with the personnel training standards. It is strongly recommended to implement a robust organization-wide training program to maintain compliance and protect the organization.

Assessment Metrics

The scoring of the findings in this report is based on the CVSS v3.1 metrics and standards maintained by NIST. A classification of the table can be found below. The two main categories in the calculation are exploitation and impact scores. The exploitation category is derived from the medium in which the vulnerability was exploited, the complexity of the attack, the level of privileges needed, and the level of user interaction. These are combined with the level of impact on confidentiality, integrity, and availability of the system to make up the majority of the score. The scope of the attack is also considered, to see if other resources are affected by the vulnerability. The score is output as a numerical value that corresponds to a level of impact.

Furthermore, our team has also included a business impact analysis for each finding. Our firm has chosen to add this metric to provide insight into the possible consequences of not remediating these findings. The combination of the quantitative scores provided by CVSS v3.1 metrics and the qualitative analysis provided by our firm's business impact analysis provides executive leadership and upper management with the information necessary to make informed decisions and determine priorities.

Rating	Numerical	Description
Critical	>= 9.0	Vulnerabilities that can cause large amounts of damage to an organization's assets if exploited with little effort by the responsible party. These vulnerabilities are recommended to be remediated immediately.
High	8.9 - 7.0	Vulnerabilities that can cause substantial disruptions or measurable damage to the assets of an organization. It is recommended that these vulnerabilities are remediated as soon as possible.
Medium	6.9 - 4.0	Vulnerabilities that can cause some disruption or damage to the assets of the organization. It is recommended that the vulnerabilities are scheduled for remediation soon.

Low	3.9 - 0.0	Vulnerabilities that put some of the assets at risk but result in minimum impact. Should be considered for remediation if time and resources allow.

Methodology

[redacted] leveraged prior knowledge about the security of NGPEW in addition to public information found prior to and during the assessment period. The public information ranged from company websites to social media profiles of different employees. This included information about the organization of the company that should not be publicly available and information about employees. It was noted that an attempt was made to remove some of this information by an employee, but it was unsuccessful.

Once the assessment period began, the assessment team began cataloging active hosts in the RFP's scope as a part of a reconnaissance phase. During this phase the hosts on the networks were noted along with the running services, leveraging scanning tools to do so. This led to an exploitation phase where the team manipulated service functions and information obtained to circumvent protection on the system. These phases were documented to accomplish the goal of the RFP of assessing the systems. All tools used during the assessment were either provided by NGPEW or publicly available.

Rules of Engagement and Limitations

The scope of this engagement was limited to the subnets 10.0.1.0/24, 10.0.5.0/24, and 10.0.10.0/24. All hosts and their services discovered within the subnets during the engagement were considered to be available for testing. These hosts included components of their client billing service, client database, SCADA and MODBUS industrial control systems, and their internal domains and workstations. It should be noted that special care was taken during the assessment to not harm the SCADA or MODBUS systems as to not endanger the lives of employees and to comply with the request from NGPEW. This did limit some of the methods used against those systems as one attack path has the potential to cause the dam to overflow. Information publicly available about the company and employees was in scope and allowed to be used during the assessment. However, social engineering was explicitly out of scope for the assessment. This limited the assessment as we could not assess the effectiveness of any information security training programs being implemented.

Attack Path to Compromise Subnets

The following is an attack narrative for the reproduction of the compromise of the subnets found on NGPEW during the assessment. It was noted that NGPEW had acted on previous recommendations to segment the network. [redacted] was able to circumvent this protection leading to access of the entire system where further exploits could be run.

Phase 1: Reconnaissance

1. An initial scan of the network revealed that the 10.0.1.0/24 subnet was publicly accessible as those were the only hosts responding to the scans. The one initial compromise was done on the address 10.0.1.11. The scan's results can be replicated through the following command: `nmap -Pn -sV -n -v -T4 -A 10.0.1.11`

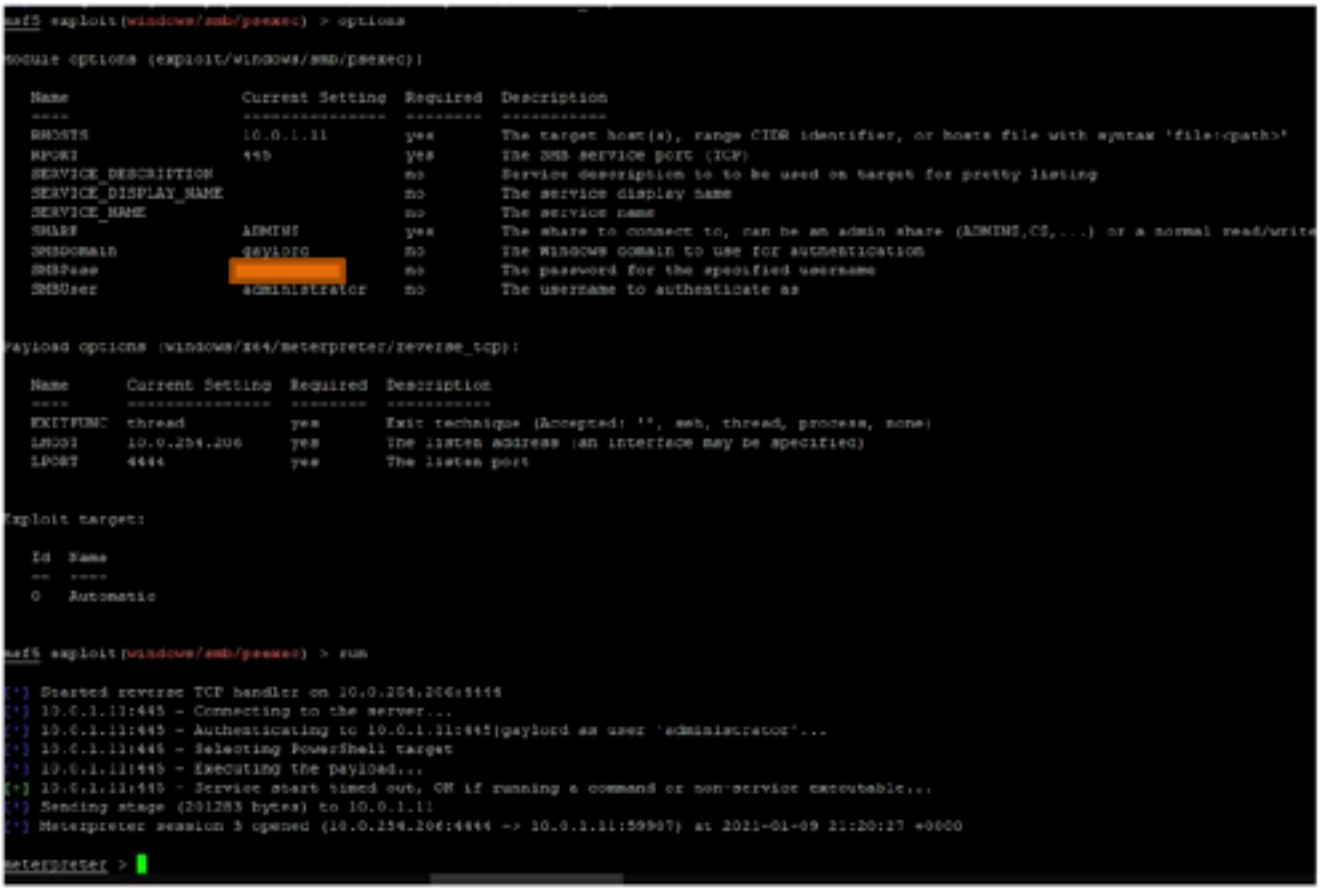
2. The scan revealed that the workstation used belonged to an employee of NGPEW giving us the domain, and that the SMB port was open (port 445), which was noted and used to move to the exploit phase.

```
Nmap scan report for 10.0.1.11
Host is up (0.019s latency).
Not shown: 65521 closed ports
PORT      STATE    SERVICE       VERSION
135/tcp   open     msrpc         Microsoft Windows RPC
139/tcp   open     netbios-ssn   Microsoft Windows netbios-ssn
445/tcp   open     microsoft-ds  Microsoft Windows Server 2008 R2 - 2012 microsoft-ds
3389/tcp  open     ms-wbt-server Microsoft Terminal Services
| rdp-ntlm-info:
|   Target_Name: GAYLORD
|   NetBIOS_Domain_Name: GAYLORD
|   NetBIOS_Computer_Name: GAYLORD
|   DNS_Domain_Name: gaylord
|   DNS_Computer_Name: gaylord
|   Product_Version: 10.0.14393
|_  System_Time: 2021-01-08T15:11:50+00:00
| ssl-cert: Subject: commonName=gaylord
| Issuer: commonName=gaylord
```

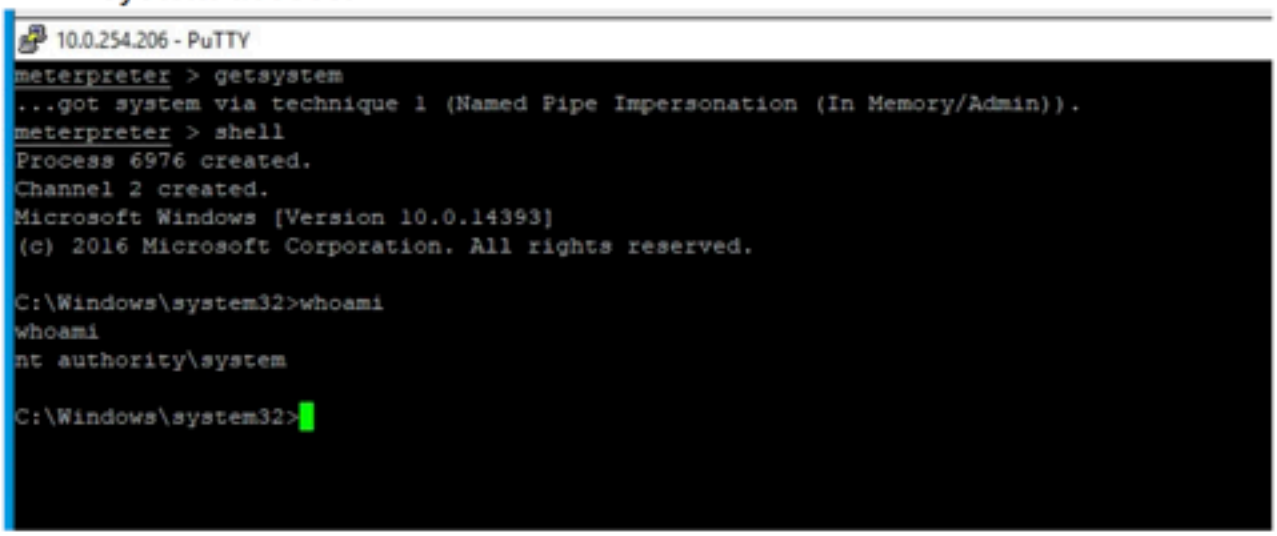
Phase 2: Initial Exploit

3. The user's workstation was recognized as having a weak password during the last assessment and there did not seem to be any lockout policy. Therefore, a Metasploit module was used to brute force the password using the 'rockyou' password list, which is publicly available.

4. When the Administrator credentials were found, another Metasploit module allowed the team to authenticate to the host, giving the team a shell.



5. The shell was upgraded using a Meterpreter module to give the team full system access.



Phase 3: Pivot Point

6. The next step was to route traffic through the compromised host to access the segmented subnets and PLCs. This was done using the auto route manager module in Metasploit and the existing session.

7. This only allows for the routing of Metasploit modules so no other tools could be used. To fix this, a SOCKS proxy was created and proxychains was used to route other command line traffic.
    a. First the proxy was started via a Metasploit module

```
msf5 auxiliary(server/socks5) > options

Module options (auxiliary/server/socks5):

   Name      Current Setting  Required  Description
   ----      ---------------  --------  -----------
   PASSWORD                   no        Proxy password for SOCKS5 listener
   SRVHOST   0.0.0.0          yes       The address to listen on
   SRVPORT   1080             yes       The port to listen on
   USERNAME                   no        Proxy username for SOCKS5 listener


Auxiliary action:

   Name   Description
   ----   -----------
   Proxy  Run SOCKS5 proxy


msf5 auxiliary(server/socks5) > run
[*] Auxiliary module running as background job 2.

[*] Starting the socks5 proxy server
msf5 auxiliary(server/socks5) >
```

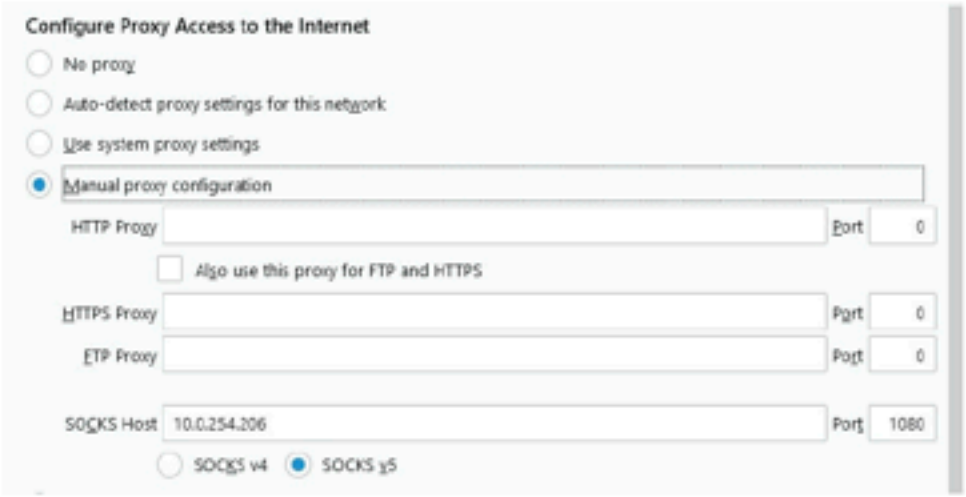
b. Then, the proxychains configuration file was changed to use the proxy by changing the last line of the file at `/etc/proxychains.conf`

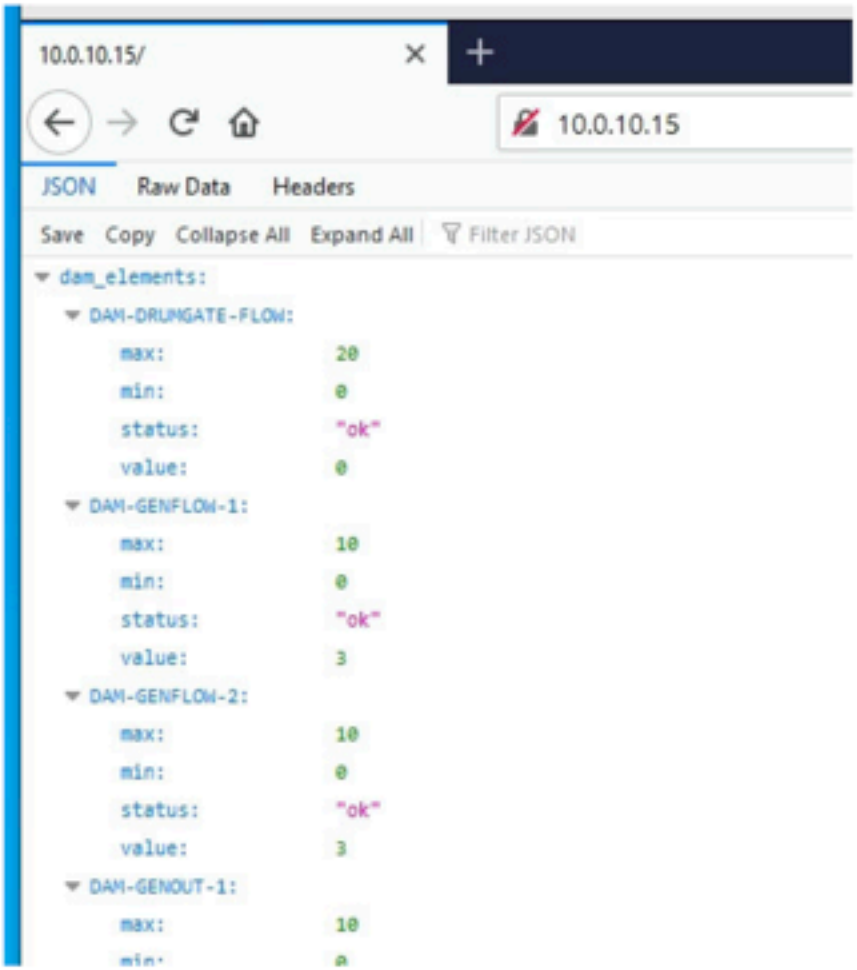
```
proxy_dns

tcp_read_time_out 15000
tcp_connect_time_out 8000

[ProxyList]
socks5 127.0.0.1 1080
```

8. Finally, the browser on the Windows host was used in conjunction with the proxy on the Linux machine to give the ability to browse internal sites.





Phase 4: Further Exploitation

9. Once access was obtained, the team was able to test the rest of the system while circumventing the firewall.

Improvements Since Last Assessment

Segmentation of Network (previously called SCADA System Protections)

Rating: Critical
Affected Hosts: 10.0.1.198-10.0.1.203, 10.0.5.0/24, 10.0.10.0/24
Score: 10.0 AV:N/AC:L/PR:N/UI:N/S:C/C:H/I:H/A:H
Business Impact: Critical Infrastructure could be exposed to the public internet which could damage or compromise the availability of NGPEW systems.

Vulnerability

Previously, all SCADA devices were directly accessible from the public internet. An attacker may be able to compromise the availability of these systems through the built-in terminals. Given that these devices are extremely sensitive and affect utilities, with potentially deadly consequences, the combination of ease to exploit and severe impact poses a very large threat to the NGPEW organization.

Evidence

When scanning from the public internet, 10.0.1.198-203 respond to ICMP pings but it seems their services are not accessible. All connections from the public internet should still be blocked. Subnets 10.0.5.0/24 and 10.0.10.0/24 hold critical functions that are segmented and inaccessible from the public internet.

Compliance

The changes made by NGPEW are an improvement to meet CIP-005-6 requirement #1.3 which states that inbound and outbound connections should be restricted.

Recommendations

NGPEW should consider moving the PLCs (10.0.1.198-203) from the 10.0.1.0/24 subnet to one of the segmented subnets to meet compliance and decrease attack surface.

Redis Authentication/Credential Management

Rating: High
Score: 7.3 AV:N/AC:L/PR:N/UI:N/S:U/C:L/:I:L/A:L
Affected Hosts: 10.0.10.31
Business Impact: A strong password reduces the chances of an attacker stealing sensitive information from the Redis database.

Vulnerability

The Redis server (10.0.10.31) was secured with a weak password, allowing an attacker to easily guess it to access sensitive information.

Reproduction

The previously found weak password no longer worked to authenticate the Redis server. Extensive brute force attempts were completed, and a valid password could not be found. Therefore, the Redis server is now secured with a secure password.

Compliance

This helps NGPEW start to comply with CIP-007-6: Cyber Security - Systems Security Management.

Slowloris

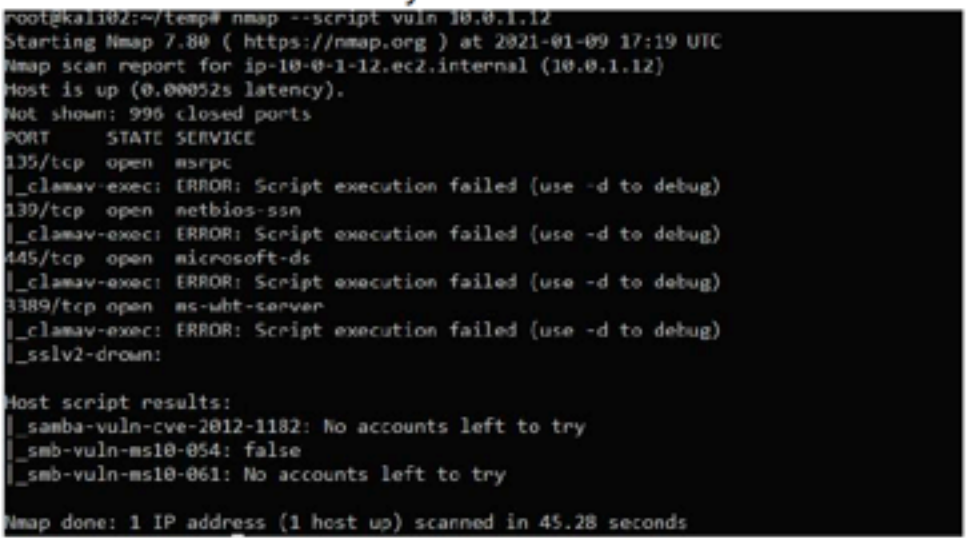
Rating: Medium
Score: 5.0 AV:N/AC:L/AU:N/C:N/I:N/A:P
Affected Hosts: 10.0.1.12, 10.0.1.152, 10.0.1.198, 10.0.1.199, 10.0.1.201
Business Impact: N/A

Vulnerability

Previously, a potential vulnerability to Denial-of-Service (DOS) attacks conducted with the Slowloris DOS tool was discovered on multiple hosts. The Slowloris tool allows an attacker to conduct a DOS attack from a single machine using minimal bandwidth. It operates by establishing multiple connections to a web server and holding them open as long as possible in order to starve the server of resources. Once all possible concurrent connections are established, new connection attempts from clients are prevented.

Reproduction

This issue was resolved. According to a scan, the host is no longer impacted by the Slowloris vulnerability:



Compliance

This improvement helps to bring NGPEW into compliance with CIP-005-6 requirement #1 that requires connections to a service or host are restricted.

RemoteMouse

Rating: Medium
Score: 5.3 AV:N/AC:L/PR:N/UI:N/S:U/C:N/I:L/A:N
Affected Hosts: 10.0.1.11
Business Impact: N/A

Vulnerability

Previously, the machine 10.0.1.11 had an open port (1987) which ran the RemoteMouse service without requiring authentication. An attacker could potentially use the service maliciously without any credentials. This could lead to a compromise of the machine if the attacker could use the mouse and keyboard to send arbitrary commands through the service.

Reproduction

This issue was resolved, there are no reproduction steps necessary.

Compliance

This improvement helps to align NGPEW with CIP-007-6 requirement #1.1 demands that unnecessary services should be disabled.

Findings

Weak/Reused Domain Administrator Password

Rating: Critical
Score: 10.0 AV:N/AC:L/PR:N/UI:N/S:C/C:H/I:H/A:H
Affected Hosts: 10.0.1.100
Business Impact: If discovered, adversaries can use these weak and reused passwords to compromise many NGPEW systems and get access to sensitive information. This can lead to a compromise of the confidentiality, integrity, and availability of NGPEW systems.

Vulnerability

The password for a domain administrator is weak and reused. Weak and reused passwords leave organizations at risk. This vulnerability presents a significant risk to NGPEW as in this case, the weak and reused password is that of the Domain Administrator.

Reproduction

Test the SPLASHY administrator password and database server root password on the domain administrator account to find that it is valid:

```
$ crackmapexec smb 10.0.1.100 -u administrator -p
[PASSWORD]
```

Compliance

This vulnerability is out of compliance CIP-007-6 requirement #5.5, passwords should be at least eight characters and contain at least
three different types of characters (lowercase, uppercase, numeric, non-alphabetic) as not all passwords comply. Additionally, CIP-007-6 requirement #5.6 which requires that passwords should be changed at least one every fifteen calendar months. Violating either of these requirements is a severe VSL.

Remediation

Use unique passwords for all administrator accounts. Additionally, it is recommended that passwords meet CIP standards outlined in CIP-007-6.

Credential Management

Rating: Critical
Score: 9.8 AV:N/AC:L/PR:N/UI:N/S:U/C:H/I:H/A:H
Affected Hosts: 10.0.1.10-13, 10.0.5.50
Business Impact: Attackers could steal sensitive information and pivot within the network causing fines as the result of data protection laws and the loss of business.

Vulnerability

Several of the workstation's administrator accounts are secured with weak passwords. This makes the credentials easily guessable by attacks. The passwords, along with knowing the username scheme of the company, can result in the account being compromised.

Reproduction

For 10.0.1.10-13, first the Administrator password is bruteforced using an extensive wordlist such as rockyou:

```
$ crackmapexec smb 10.0.1.1X -u administrator -p
rockyou.txt
```

Next, the found credentials can be used to RDP into the machine or a Meterpreter session can be created using the `exploit/windows/smb/psexec` module.

For 10.0.5.50, once on the machine using the VNC server, the following mimikatz command is run in a PowerShell session:

```
mimikatz # sekurlsa::logonpasswords
```

Next, the NTLM hash for SPLASHY\Administrator is inputted into https://crackstation.net/. Since it is a common password, the plaintext is returned from the public database.

Compliance

This vulnerability is out of compliance CIP-007-6 requirement #5.5 - passwords should be at least eight characters and contain at least three different types of characters (lowercase, uppercase, numeric, non-alphabetic). Additionally, CIP-007-6 requirement #5.6 which requires that passwords should be changed at least one every fifteen calendar months. Violating either of these requirements is a severe VSL.

Remediation

To remediate the vulnerability, implement a stronger password policy in which credentials cannot be reused and common, poor passwords cannot be used. Alternatively, implementing password managers can encourage employees to use stronger and more unique passwords. A resource for setting password policies can be found here: https://www.wikigain.com/configuring-password-policies-with-windows-server-2016/

Workstation Account Lockout Policy

Rating: Critical
Score: 9.8 AV:N/AC:L/PR:N/UI:N/S:U/C:H/I:H/A:H
Affected Hosts: 10.0.1.10-13, 10.0.5.50
Business Impact: Attackers could steal sensitive information and pivot within the network causing fines as the result of data protection laws as well as the loss of business.

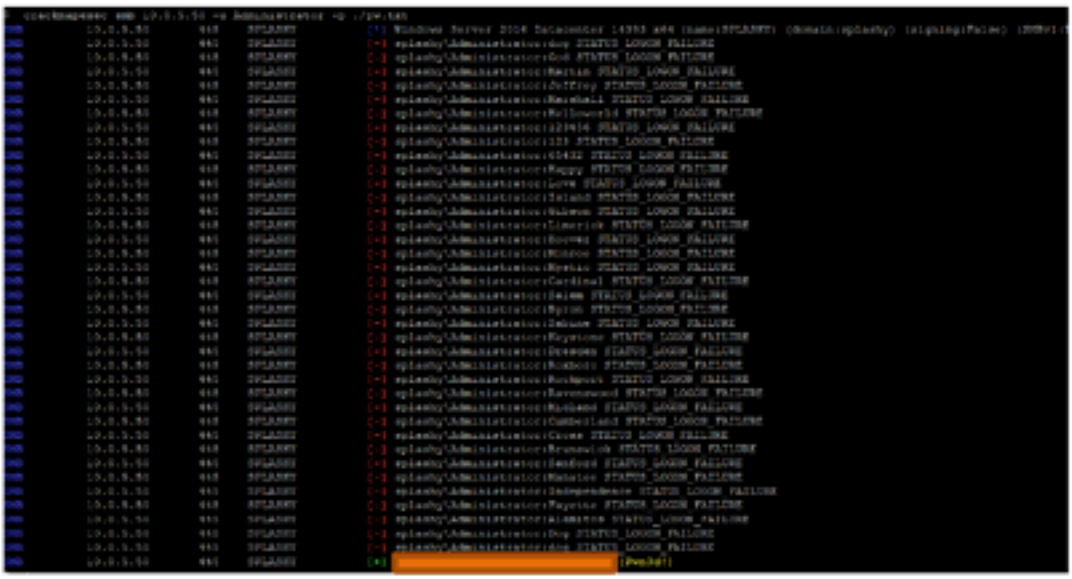
Vulnerability

The current password policy for the Windows workstation Administrator accounts does not implement any form of lockout after too many failed attempts to sign into an account. The vulnerability allows an attacker to brute force passwords of known accounts increasing the likelihood of a compromise.

Reproduction

Attempting a large list of passwords against the Administrator accounts results in the account not being locked out and eventually the password is discovered:

```
$ crackmapexec smb [IP ADDRESS] -u Administrator -p
rockyou.txt
```



Compliance

This vulnerability puts the organization out of compliance with CIP-007-6 requirement #5.7 which requires that login attempts should be restricted.

Remediation

Implement a lockout policy for accounts. After a certain number of attempts, the user account should be locked for a period of time. A tutorial can be found here: https://www.wikigain.com/configure-account-lockout-policy/.

Weak and Reused SSH Password

Rating: High
Score: 8.8 AV:A/AC:L/PR:N/UI:N/S:U/C:H/I:H/A:H
Affected Hosts: 10.0.5.151
Business Impact: Adversaries could guess the password to the database SSH Server.

Vulnerability

An internal attacker can easily guess the password for one of the SSH servers. This could lead to a compromise of confidentiality, integrity and availability.

Reproduction

Hydra was used to attempt the same password from the domain administrator and SPLASHY administrator:

```
$ hydra -l root -p [REDACTED] 10.0.5.151 ssh
[22][ssh] host: 10.0.5.151   login: root   password: [redacted]
```

Compliance

This vulnerability is out of compliance CIP-007-6 requirement #5.5, passwords should be at least eight characters and contain at least
three different types of characters (lowercase, uppercase, numeric, non-alphabetic) as not all passwords comply. Additionally, CIP-007-6 requirement #5.6 which requires that passwords should be changed at least one every fifteen calendar months. Violating either of these requirements is a severe VSL.

Remediation

Do not enable root login to the SSH server and do not reuse key pairs between SSH servers. This can be done by editing `/etc/ssh/sshd_config`.

Excessive Domain Administrators

Rating: Medium
Score: 8.8 AV:N/AC:L/PR:L/UI:N/S:U/C:H/I:H/A:H
Affected Hosts: 10.0.1.100
Business Impact: Too many domain administrators increase the attack surface of NGPEW.

Vulnerability

An excessive number of domain administrators were found.

Reproduction

The Windows Active Directory network had 24 administrators out of approximately 350 users:

```
$ crackmapexec smb 10.0.1.100 -u Adminstrator -p [REDACTED]
--groups
Domain Admins                                 membercount: 24
```

Compliance

CIP-007-6 requirement #2 requires that accounts are inventoried. Violating this would be a high VSL.

Remediation

Following the principle of least privilege, domain administrator rights should only be given to those that absolutely require those privileges. A resource to help with removing these privileges can be found here: https://community.expensify.com/discussion/5749/how-to-add-and-remove-domain-admins.

IIS-Password Brute Force and Policy Bypass

Rating: High
Score: 8.1 AV:A/AC:L/PR:N/UI:N/S:U/C:H/I:H/A:N
Affected Hosts: 10.0.5.152
Business Impact: An adversary could brute force, guess user credentials, or bypass account locking policies. This would allow adversaries to gain access to sensitive files compromising confidentiality and integrity. Adversaries could use these credentials to carry out further attacks.

Vulnerability

The file `aexp2.htr` is located at `10.0.5.152/iisadmpwd/`. An attacker can use this file to brute force usernames and passwords. A valid user with a locked account can bypass the password lockout policy by changing their password. This vulnerability applies to IIS 4.0.

Reproduction

1. Navigate to http://10.0.5.152/iisadmpwd/aexp2.htr
2. From here a valid user with a locked account can change their password or an attacker can brute force usernames and passwords.

Compliance

This finding may put NGPEW out of compliance with CIP-011-2: Cyber Security – Information Protection.

Remediation

To remediate this funding the following two steps should be followed:
1. Update IIS
2. Remove `aexp2.htr` file (as well as `aexp2b.htr`, `aexp3.htr`, `aexp4.htr`)

Our team also recommends implementing a robust patching program to avoid similar vulnerabilities in the future.

PLC Debug Mode

Rating: High
Score: 7.6 AV:N/AC:L/PR:L/UI:N/S:U/C:L/I:L/A:H
Affected Hosts: 10.0.1.198-203
Business Impact: The exploitation of the vulnerability can cause the control systems to shut down resulting in outages to customers and potentially loss of life to employees.

Vulnerability

While behind a firewall now, the PLCs could still be accessed by an authenticated user. The devices were shown to be very sensitive and could easily be shut down. A full exploitation of the devices was limited by the desire to not damage the customer's system as it was a point of concern.

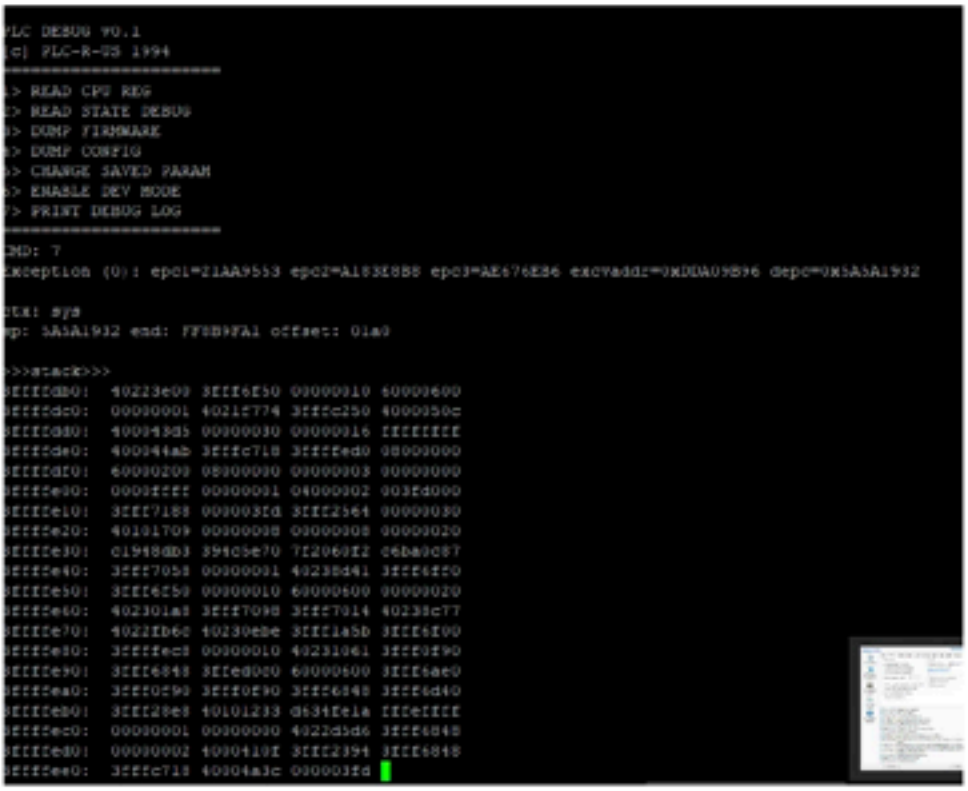
Reproduction

While authenticated to the subnet the PLCs could be accessed via port 8080 through netcat

1. `nc 10.0.1.198 8080`

Then the commands could be inputted to the debugger with the corresponding number. This revealed information about the PLC and could cause the device to crash.

2. `7`



Compliance

The vulnerability could put the organization out of compliance with CIP-007-6 requirement #1.1 that demands unnecessary services should be disabled. Violating this is at least a high VSL. If the PLC debugger is not needed, then it is a violation.

Remediation

Fully restrict access to the PLC by disabling the ports if able. Otherwise, it is suggested to add another layer of authentication to the devices.

Unauthenticated Service, RealVNC

Rating: High
Score: 7.6 AV:A/AC:L/PR:N/UI:N/S:U/C:H/I:L/A:L
Affected Hosts: 10.0.5.50
Business Impact: The vulnerability can lead to the theft of company data that could result in fines and loss of revenue if a breach occurs.

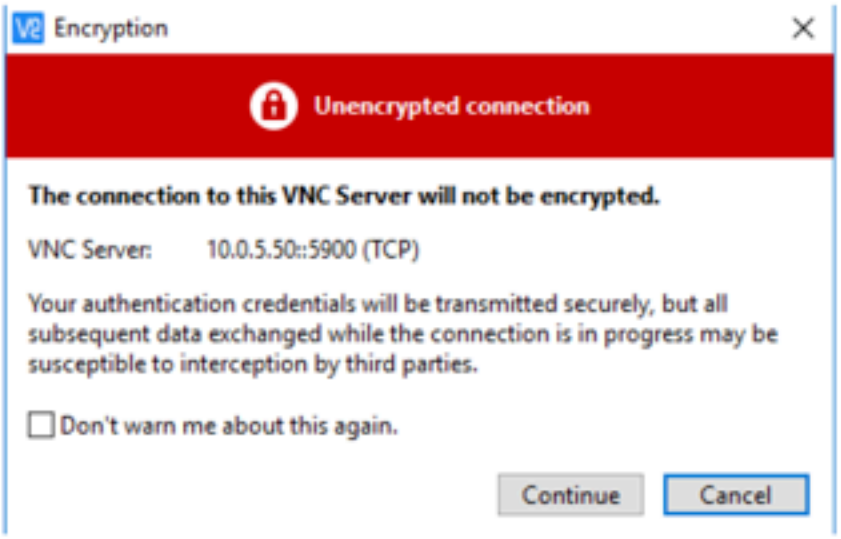
Vulnerability

The host was found running a VNC server that did not require authentication to access. Any user that had access to the host via the network could authenticate without any credentials giving them a session on the host. This could result in the theft of information or damage to assets.

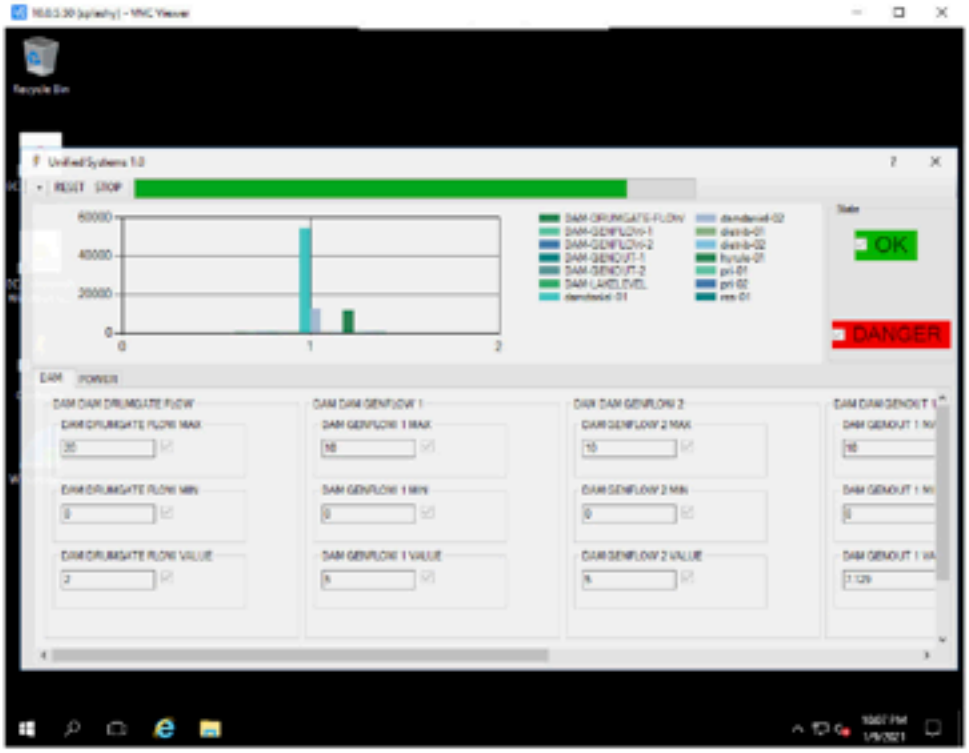
Reproduction

From an internal workstation, it was found that port 5900 was open on 10.0.5.50, a common VNC server port.

A VNC client can be used to connect to 10.0.5.50 without any credentials:



This gives the attacker a graphical interface to access the Windows workstation as an administrator and view the HMI:



An attacker would also be able to dump plaintext Windows account hashes using mimkatz. This workstation, contrary to the previous assessment, is no longer connected to the domain, so domain credentials cannot be dumped.

Compliance

This vulnerability puts the organization out of compliance with CIP-007-6 if the service is not considered necessary as the machine also has the remote desktop protocol enabled. Additionally, it is out of compliance with CIP-005-6 as the lack of authentication is considered a failure to restrict remote connections. These could result in severe penalties.

Remediation

Assess your organization's needs and if VNC is determined to not be needed for business operations consider removing the service. Alternatively, a level of authentication should be implemented if the service is determined to be necessary.

Disable Unnecessary Services

Rating: High
Score: 7.3 AV:N/AC:L/PR:N/UI:N/S:U/C:L/I:L/A:L
Affected Hosts: 10.0.1.10-13, 10.0.5.50
Business Impact: It allows for more attack avenues, putting the company at risk for a breach which can result in fines, reputational damage, and the loss of revenue.

Vulnerability

The SMB protocol is enabled on the Windows workstation in addition to a remote desktop access protocol. The combination of the two protocols is redundant and should be disabled if not absolutely necessary.

Reproduction

The services were found through an nmap scan of each affected host:

```
445/tcp   open  microsoft-ds  Microsoft Windows Server 2008
R2 - 2012 microsoft-ds
```

Compliance

This places the organization out of compliance with CIP-007-06 requirement #1.1, which requires that unnecessary services are restricted.

Remediation

The needs of the organization should be assessed and if at least one of the services can be disabled without affecting the organization. The service should then be disabled. Alternatively, if both services are considered necessary then more robust forms of authentication should be considered.

IIS Patch Management

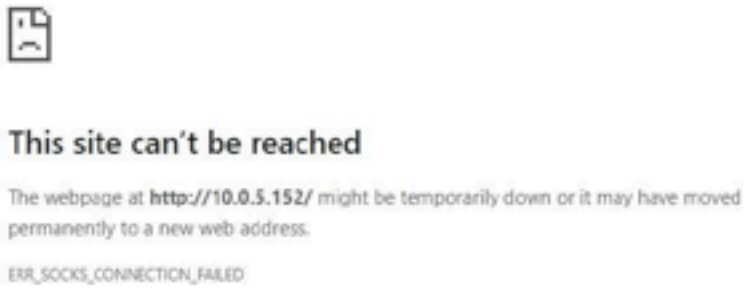
Rating: Medium
Score: 6.8 - AV:A/AC:L/PR:L/UI:N/S:C/C:N/I:N/A:H
Affected Hosts: 10.0.5.152
Business Impact:

Vulnerability

The version of IIS is vulnerable to a buffer overflow attack in the ism.dll. Execution of the proper exploit will result in the overflow of memory and give an attacker remote command execution to the server. Additionally, the vulnerability can create Denial of Service(DoS) conditions if the exploit is executed incorrectly.

Reproduction

1. `$ msfconsole`
2. `msf5> use exploit/windows/iis/ms02_018_htr`
3. `msf5> set RHOSTS 10.0.5.152`
4. `msf5> run`
5. The server is no longer online：



Compliance

CIP-007-6 requirement #2 requires that patches are updated within 35 days. Failing to update patches older than 65 days is a severe VSL.

Remediation

Contact the vendor about updating the IIS server to the latest version.

Weak Active Directory Passwords and Password Policy

Rating: High
Score: 6.5 AV:N/AC:H/PR:N/UI:N/S:C/C:L/I:L/A:L
Affected Hosts: 10.0.1.100
Business Impact: Adversaries can brute force or guess user passwords. This could lead to a loss of confidentiality and future attacks.

Vulnerability

Windows Active Directory passwords are weak and easily guessed due to a poor password policy implemented in group policy.

Reproduction

After gaining domain administration credentials, Impacket is used to dump all active directory hashes:

```
$ secretsdump.py
corp.millenialpower.us/administrator:[REDACTED]@10.0.1.100
--use-vss > hashes.txt
```

Next, John the Ripper is used to crack the passwords:

```
$ john hashes.txt --format=NT
```

The plaintext for over 75 user passwords was recovered. All passwords followed the same format: a word or common name with the first letter being capitalized. Many passwords were repeated, often up to four times. Additionally, the active directory password policy only enforced that passwords were at least four characters:

```
$ crackmapexec smb 10.0.1.100 -u administrator -p
[REDACTED] --pass-pol
```

```
[+] Dumping password info for domain: MPOWER
Minimum password length: 4
Password history length: None
Maximum password age:

Password Complexity Flags: 000000
    Domain Refuse Password Change: 0
    Domain Password Store Cleartext: 0
    Domain Password Lockout Admins: 0
    Domain Password No Clear Change: 0
    Domain Password No Anon Change: 0
    Domain Password Complex: 0

Minimum password age: None
Reset Account Lockout Counter: 5 minutes
Locked Account Duration: 5 minutes
Account Lockout Threshold: 10
Forced Log off Time: Not Set
```

Compliance

This finding puts NGPEW at risk of being out of compliance with CIP-007-6: Cyber Security - Systems Security Management. The passwords found did not meet the password complexity requirements defined by CIP.

Remediation

A password policy should be implemented in the active directory group policy with a longer minimum length and a complexity requirement. One resource to help with this remediation can be found here: http://woshub.com/password-policy-active-directory/.

Weak Credential Storage

Rating: Medium
Score: 6.5 AV:N/AC:L/PR:N/UI:N/S:U/C:L/I:L/A:N
Affected Hosts: 10.0.5.151
Business Impact: This can lead to full credentials being recovered. The server is no longer used, but the data still exists. If there is password reuse, this can lead to further account takeovers on the network.

Vulnerability

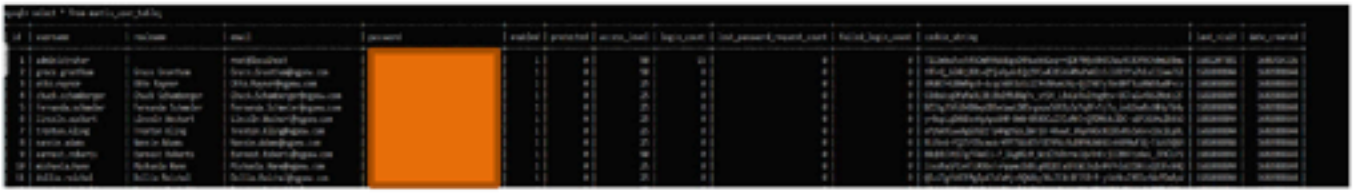
The hashes that were stored in the database where stored using a weak hashing algorithm. This allows the hashes to be cracked and recover the credentials.

Reproduction

With access to the server from the weak SSH credentials, it is possible to connect to the MySQL database by running

```
$ mysql
```

The screenshot below shows how to dump the mantis user table, which contains password hashes for all mantis users.



Compliance

This finding puts the company in violation of CIP-011-2, R2 in which encryption is required to protect information in transit and securely store credentials at rest which md5 is not considered.

Remediation

Consider using a more secure hashing algorithm or MD5 with a salt to make the hashes more difficult to crack.

Kill Bill Weak Passwords

Rating: Medium
Score: 6.5 AV:N/AC:L/PR:N/UI:N/S:U/C:L/I:L/A:N
Affected Hosts: 10.0.5.75
Business Impact: This server hosts two web applications that connect to a single database. While neither of these applications appear to be in use, the access that was gained would leak any future information that may be stored. An attacker with his level of network access could retrieve, modify, or delete any data for the applications.

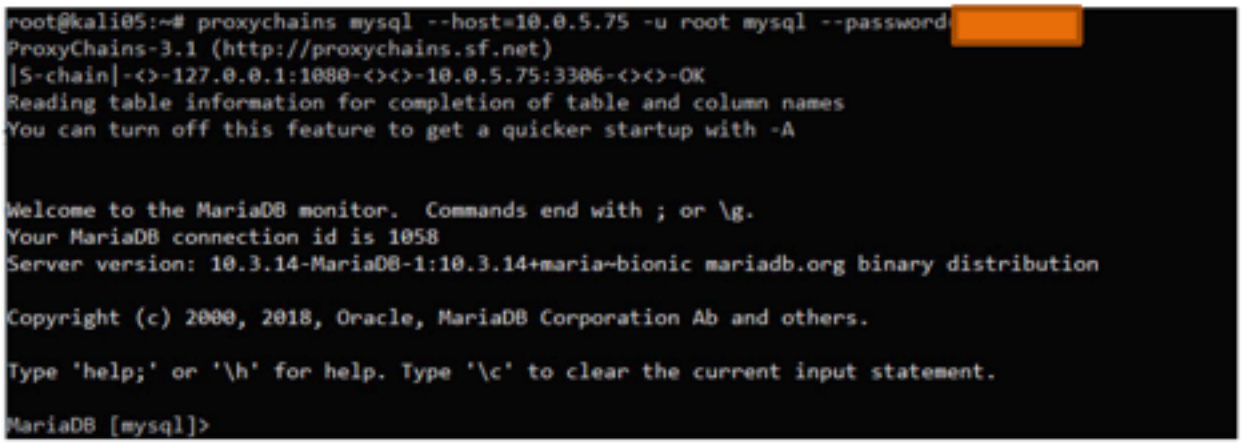
Vulnerability

The API for Kill Bill allows for an authenticated user to perform some elevated actions that provide information about the company's billing data. The password for this can be easily guessed. The database is accessible from any machine within the internal network. The credentials for this database are easily guessed.

Reproduction

The API can be accessed through a web browser and the Kill Bill client or from the command line. This makes it easy to perform password guessing and retrieve data from the service. The screenshot below shows an example command with valid API credentials.

The MySQL database can be accessed via the command line with the following command:



Compliance

This vulnerability is out of compliance CIP-007-6 requirement #5.5, passwords should be at least eight characters and contain at least three different types of characters (lowercase, uppercase, numeric, non-alphabetic) as not all passwords comply. Additionally, CIP-007-6 requirement #5.6 which requires that passwords should be changed at least one every fifteen calendar months. Violating either of these requirements is a severe VSL.

Remediation

A password policy should be implemented in the active directory group policy with a longer minimum length and a complexity requirement. One resource to help with this remediation can be found here: http://woshub.com/password-policy-active-directory/.

Sensitive Data Stored on Unused Service

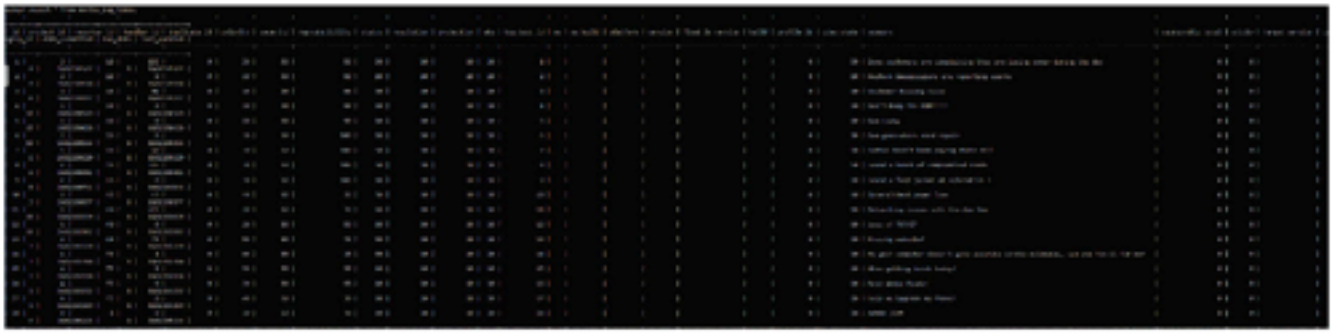
Rating: Medium
Score: 6.5 AV:N/AC:L/PR:N/UI:N/S:U/C:L/I:N/A:N
Affected Hosts: 10.0.5.151
Business Impact: Information about vulnerability within the network are useful information for an attacker that is looking to further pivot.

Vulnerability

Although the website is no longer running, the Mantis bug tracker data is still available in a database on one of the machines on the network. This data can be achieved with access to the system using a MySQL client.

Reproduction

From the server, use a MySQL client to enumerate the Mantis database.



Compliance

CIP-011-2 requires the protection of sensitive information in transit.

Remediation

This finding may put NGPEW in violation of the CIP-011-2: Cyber Security – Information Protection guidelines.

IIS 4.0 - Illegal Hex Encoding

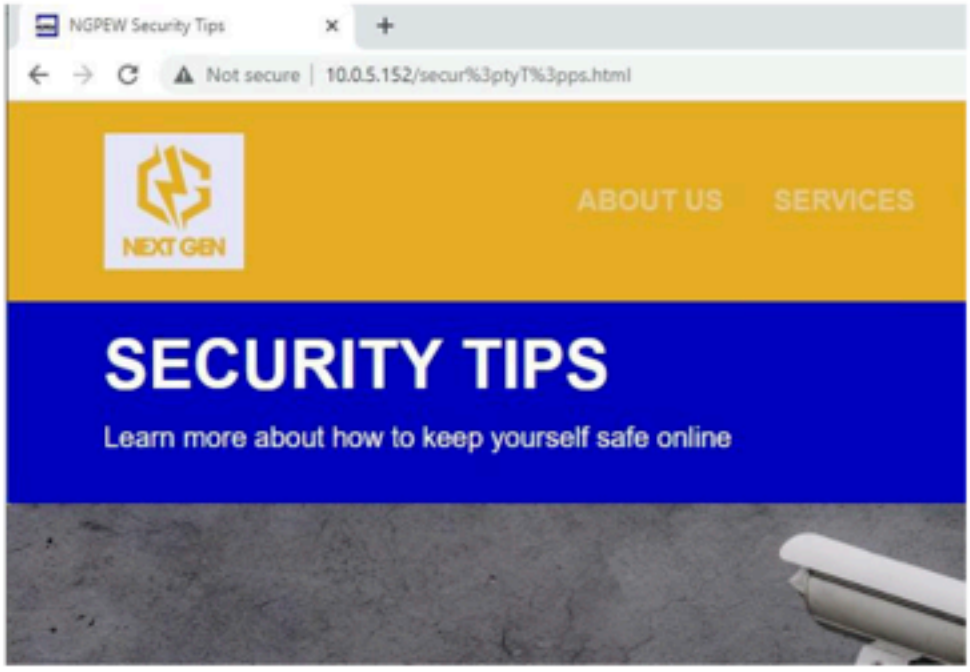
Rating: Medium
Score: 6.5 AV:A/AC:L/PR:N/UI:N/S:U/C:H/I:N/A:N
Affected Hosts: 10.0.5.152
Business Impact: This vulnerability discloses sensitive files and folders to malicious actors. This information could be used against NGPEW in future attacks.

Vulnerability

The IIS server processes illegal hex characters such as "0x3p" which it decodes as "I" even though "I" is "0x49." This could be used to bypass security systems that block certain expected URLs. An attacker could use this to access files that they are not authorized to.

Reproduction

It is possible to replace characters with illegal hex values as shown below.



Compliance

CIP-007-6 requirement #2 requires that patches are updated within 35 days. Failing to update patches older than 65 days is a severe VSL.

Remediation

Update IIS to the latest available version after thoroughly vetting its compatibility with your environment. Our firm also recommends that you consistently patch your systems when updates are available. Please remember to test all patches before introducing them into your production environment.

Modbus Disclosures

Rating: Medium
Score: 5.3 AV:N/AC:L/PR:N/UI:N/S:U/C:L/I:N/A:N
Affected Hosts: 10.0.10.50-65
Business Impact: Disrupt services to customer by overriding data.

Vulnerability

Modbus/TCP was used for communication between dam/power PLCs and the HMI. However, Modbus/TCP does not provide confidentiality or integrity because of a lack of encryption or authentication. An attacker would be able to intercept Modbus/TCP traffic to determine register addresses, then send commands to Modbus/TCP server to read or write to these registers. This can be done using a Modbus/TCP client, such as a Metasploit module (`auxiliary/scanner/scada/modbusclient`), a Python library (`PyModbus`), or the command line tool `modbus-cli`.

Reproduction

The `modbus-cli` tool was used to interact with the Modbus service and modify data on the coil without authentication. The tool must be run from a machine within the internal network.

```
1.proxychains modbus read 10.0.10.50 400101 20
2.proxychains modbus write 10.0.10.50 400101 2 2 2 2 2 2
  2
```

This will then overwrite the data in memory starting at address 400101:

Compliance

CIP-011-2 requires the protection of sensitive information in transit.

Remediation

The specification for Secure Modbus/TCP can be found here: https://modbus.org/docs/MB-TCP Security-v21_2018-07-24.pdf/. This version of Modbus uses port 802 and adds encryption and authentication using TLS, which will significantly reduce the chances of an attack compromising the PLCs' confidentiality or integrity.

Reused SSH Key Pair

Rating: Medium
Score: 5.0 AV:N/AC:H/PR:L/UI:N/S:U/C:L/I:L/A:L
Affected Hosts: 10.0.1.60, 10.0.1.151
Business Impact: An adversary that has compromised one SSH key pair would be able to compromise multiple SSH servers.

Vulnerability

Two SSH servers (and likely others) contain the same public key for root SSH login.

Reproduction

The files located at `/root/.ssh/authorized_keys` on the two servers are identical:

Compliance

This puts NGPEW at risk for being out of compliance with CIP-007-6: Cyber Security - Systems Security Management.

Remediation

Each SSH server should have a unique SSH key pair (https://www.ssh.com/ssh/keygen/). Additionally, the root user should not be allowed to login via SSH. This can be changed by modifying `/etc/ssh/sshd_config`.

Password Sharing

Rating: Medium
Score: 4.8 AV:L/AC:L/PR:L/UI:N/S:U/C:L/I:L/A:N
Affected Hosts: 10.0.1.154, 10.0.1.10-13
Business Impact: This further increases the chances of other compromises occurring if passwords are intercepted.

Vulnerability

Employee credentials were often shared in an insecure manner either via email or via a chat room where credentials were sent in plaintext. It allows for an attacker if intercepted to reuse the credentials across the system, increasing the risk of a negative business consequence.

Reproduction

Evidence of password sharing was found within the General channel in the RocketChat application. Log into the chat to see the messages transmitted:

This vulnerability also occurred via email as well, which was received via employee's Thunderbird emails.

```
From - Tue Sep 22 20:15:00 2020
Subject: Found VNC Password
From: Morfin6o
To: Tiny
Content-Type: multipart/alternative; boundary="000000000000054f85705aff3ec24"

           Content-Type: text/plain; charset="UTF-8"; format=flowed; delsp=yes

           --000000000000054f85705aff3ec24
           Content-Type: text/html; charset="UTF-8"
           Content-Transfer-Encoding: quoted-printable

           <!DOCTYPE html><html lang=3D"en"><head></head><body style=3D"margin: 0; padding: 0;" bgcolor=3D"#FFFFFF">
<table width=
           =3D"100%" height=3D"100%" style=3D"min-width: 348px;" border=3D"0" cellspacing=3D"0" cellpadding=3D"0"
lang=3D"en">Hey Tiny I found a VNC server listening internally that I think belongs to you? My team was able to
bruteforce the VNC password being [redacted] and got admin access to the system with the same password</body></html>
```

Compliance

This finding puts the company in violation of CIP-011-2 requirement #2 in which encryption is required to protect information in transit.

Remediation

It is recommended that NGPEW implement an information security training program for employees if not in place already. The program should emphasize that passwords should only be transmitted in a secure manner by the proper authorities.

Information Disclosure

Rating: Medium
Score: 4.8 AV:L/AC:L/PR:L/UI:N/S:U/C:L/I:L/A:N
Affected Hosts: 10.0.1.154, GitHub Repository
Business Impact: This further increases the chances of other compromises to occur if information about vulnerable parts of the company is shared.

Vulnerability

Employees shared sensitive company information in plaintext via insecure channels. Attackers that compromise the communication applications can then see the information in plaintext. In addition, sensitive company information could still be viewed via the commits on the company's GitHub repository, found here: https://github.com/Next-Generation-Power-and-Water/docs/blob/6cb3049ecc95c8ed55aa9b1c1d362e975b7d59f4/PowerBus-Overview.png.

Reproduction

When a user authenticates the RocketChat application, they could see the entirety of the chat history which included discussion of sensitive information relating to security flaws.

Information was also disclosed via the employee email accounts via the Thunderbird email application such as bugs and shared accounts.

From - Tue Sep 22 20:15:00 2020
Subject: Bug Bounty
From: Independent Researcher
To: Gaylord
Content-Type: multipart/alternative; boundary="0000000000004f8370faff1ac24"

Content-Type: text/plain; charset="UTF-8"; format=flowed; delsp=yes

--0000000000004f8370faff1ac24
Content-Type: text/html; charset="UTF-8"
Content-Transfer-Encoding: quoted-printable

<!DOCTYPE html><html lang=3D"en"><head></head><body style=3D"margin: 0; padding: 0;" bgcolor=3D"#FFFFFF"><table width=
=3D"100%" height=3D"100%" style=3D"min-width: 348px;" border=3D"0" cellspacing=3D"0" cellpadding=3D"0" lang=3D"en">there are a bunch of
vulnerabilities in the IIS server that is hosting the main website. Many of these can be exploited. Can you please provide me with the email address of
the appropriate person or team to send my proof of concept exploits and evidense to?</body></html>

From - Tue Sep 22 20:15:00 2020
Subject:
From: CIO
To: Gaylord
Content-Type: multipart/alternative; boundary="0000000000004f8370faff1ac24"

Content-Type: text/plain; charset="UTF-8"; format=flowed; delsp=yes

--0000000000004f8370faff1ac24
Content-Type: text/html; charset="UTF-8"
Content-Transfer-Encoding: quoted-printable

<!DOCTYPE html><html lang=3D"en"><head></head><body style=3D"margin: 0; padding: 0;" bgcolor=3D"#FFFFFF"><table width=
=3D"100%" height=3D"100%" style=3D"min-width: 348px;" border=3D"0" cellspacing=3D"0" cellpadding=3D"0" lang=3D"en">Gaylord
you missed our weekly meeting again. What is the status of implementation of privilege access controls for the upcoming audit? I see a finding in the
gap analysis that says we're using shared accounts. I am going to have to meet with your manager if this continues as this is vital for success as a
company. This level of communication is unacceptable.</body></html>

Compliance

This finding puts the company in violation of CIP-011-2, R2 in which encryption is required to protect information in transit as well as at rest with stored emails.

Remediation

Implement a company policy to restrict employees from transmitting sensitive information over insecure channels. Further, when possible implement an encryption scheme to guard against non-compliance.

Web API Service Authentication

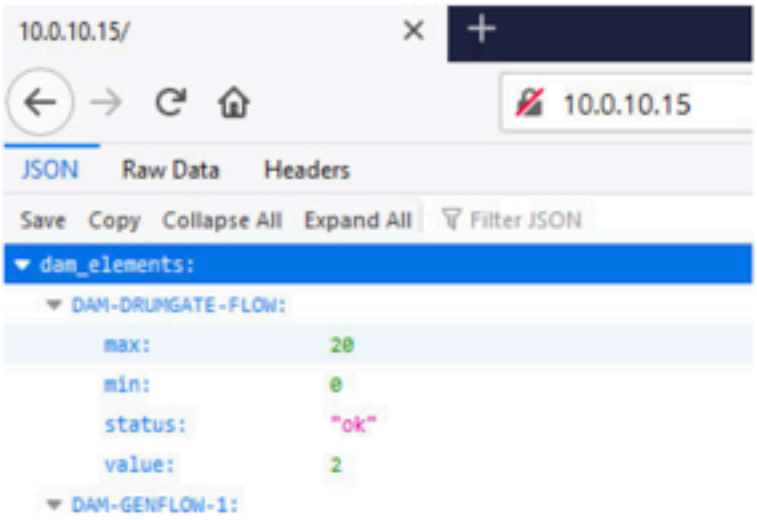
Rating: Medium
Score: 4.3 AV:A/AC:L/PR:N/UI:N/S:U/C:L/I:N/A:N
Affected Hosts: 10.0.1.15
Business Impact: Potential information disclosure about the NGPEW's Industrial Control Systems.

Vulnerability

The web server at 10.0.10.15 will respond to any request with critical ICS information without authentication. Malicious attackers can use the information disclosed to create more effective attacks against NGPEW.

Reproduction

Please note for reproduction that an adversary must be inside NGPEW's network to perform this attack.



Compliance

This vulnerability places NGPEW out of compliance with CIP-007-6: Cyber Security - Systems Security Management 5.1 which states that there must be methods to enforce authentication for interactive user access wherever technically feasible.

Remediation

The API should require authentication, such as a long and complex API key, to prevent any user within the network from accessing sensitive information.

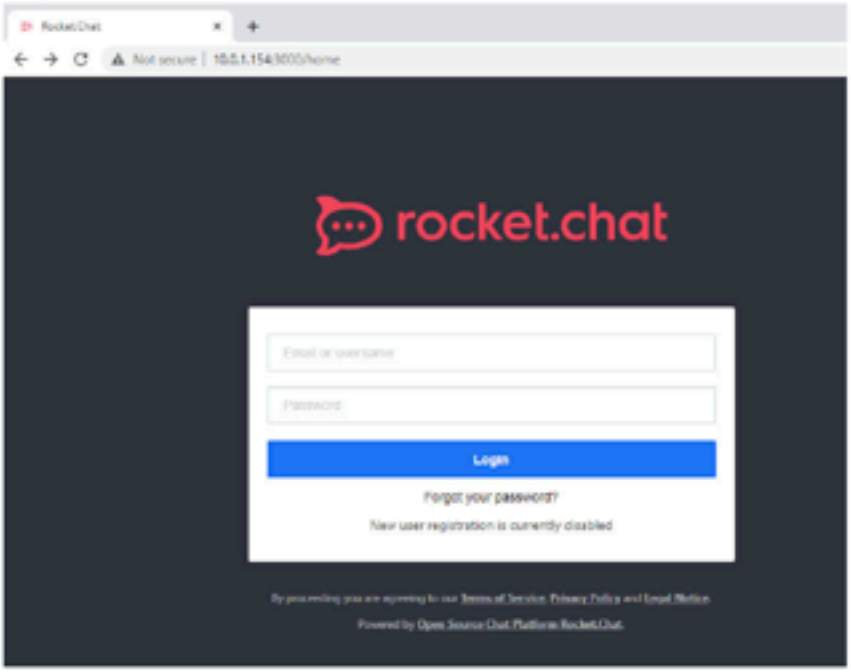
Encryption of Web Traffic

Rating: Medium
Score: 4.3 AV:L/AC:H/PR:H/UI:N/S:U/C:H/I:N/A:N
Affected Host(s): 10.0.1.154, 10.0.5.75, 10.0.5.152, 10.0.10.15

Vulnerability

The NGPEW network uses HTTP instead of HTTPS for all web applications, such as the online communication tool Rocket Chat. Much of the HTTP data contains sensitive information about SCADA systems, employees, or users. An attacker can capture the web traffic, which can lead to a possible information disclosure and a loss of integrity.

Reproduction



Compliance

The current storage mechanism being used does not provide any forms of protection for the information, making it a violation of CIP-011-2. Information has to be protected, this can be done by storing it securely.

Remediation

HTTPS should be the default for all NGPEW services and HTTP ports should redirect to the encrypted version of the respective application. The website https://letsencrypt.org/ provides free HTTPS certificates.

Weak Diffie-Hellman Key Exchange

Rating: Low
Score: 3.7 AV:N/AC:H/PR:N/UI:N/S:U/C:N/I:L/A:N
Affected Hosts: 10.0.1.100
Business Impact: Has the potential for an attacker to intercept sensitive information or command disrupting the flow of business.

Vulnerability

Diffie-Hellman Key Exchange is an algorithm used for secure communication on 10.0.1.100 port 3389 which hosts the Windows Remote Desktop (RDP) service. The Diffie-Hellman group used for the key exchange is weak which could allow an attacker to eavesdrop on connections. If exploited, this vulnerability could allow the execution of passive eavesdropping attacks. A Logjam man-in-the-middle attack could be used to downgrade TLS connections to a level in which the attacker can read and modify data passed over the connection.

Reproduction

The exploitation of this vulnerability fell out of the scope for the assessment as it would require an amount of interaction with employees. However, the vulnerability could be exploited and therefore was still documented.

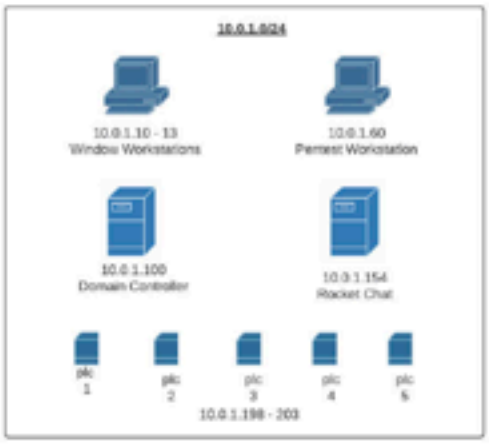
Compliance

CIP-005-6 requirement #2 requires that remote interactive sessions have a strong form of encryption. To maintain compliance, improve the strength of the encryption algorithm used.

Remediation

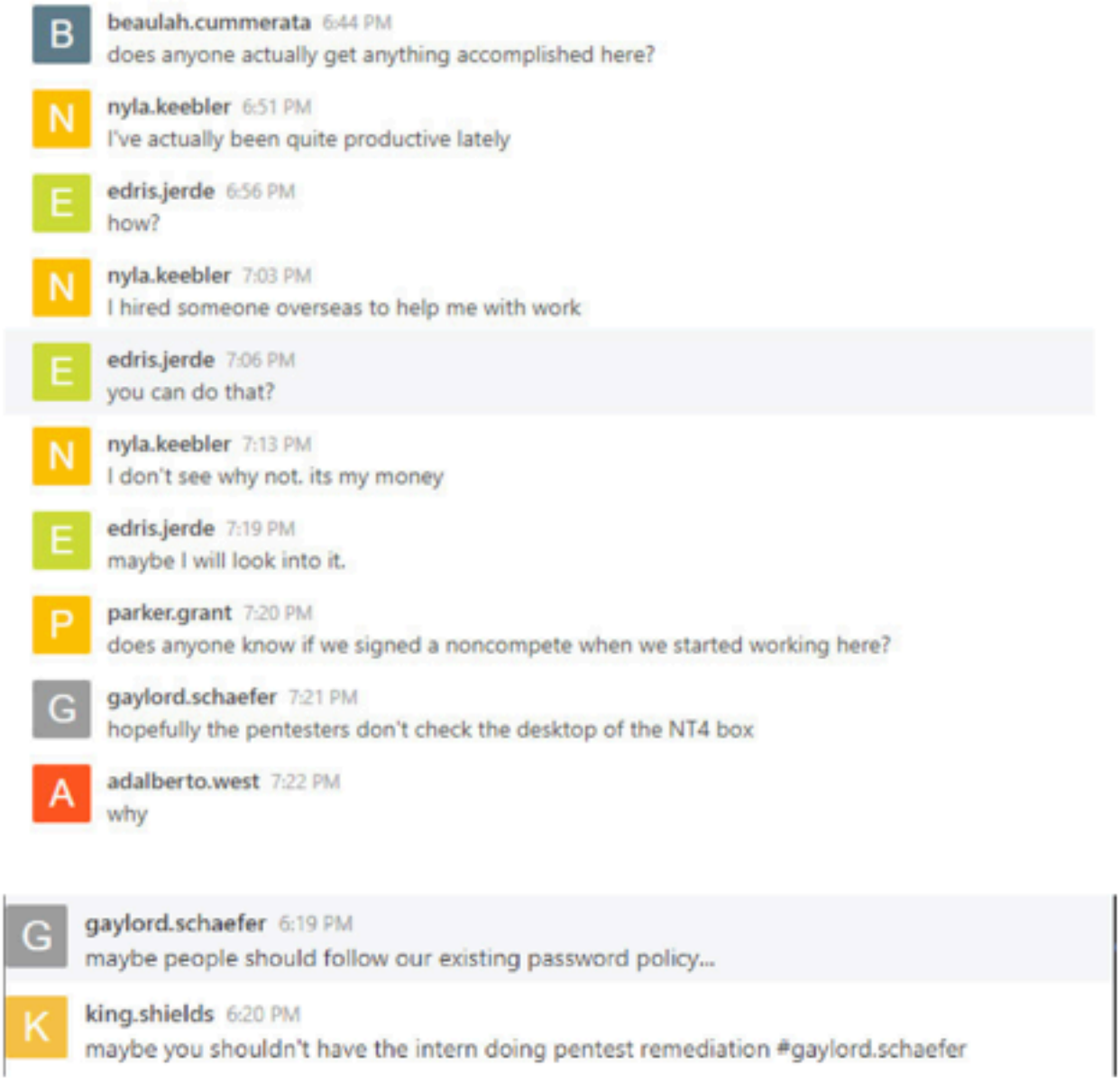
1. Disable outdated and insecure cipher suites.
2. Use Ephemeral Elliptic-Curve Diffie-Hellman.
3. Use a 2048-bit or stronger Diffie-Hellman Group.

Appendix A – Network Map



Appendix B –Other Violation s

Internal Employee may have violated security protocols by hiring an outside employee without approval. Also, employees are using post-it notes to store passwords. Intern was tasked to handle pentest remediation



Appendix C

The French Croissant

The Icelandic Croissant

The Japanese Croissant

The German Croissant

The American Croissant

The Russian Croissant

The Canadian Croissant

The British Croissant

The Australian Croissant