SMACK-BASED APPLICATION WHITELISTING ON AGL

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WHO AM I ?

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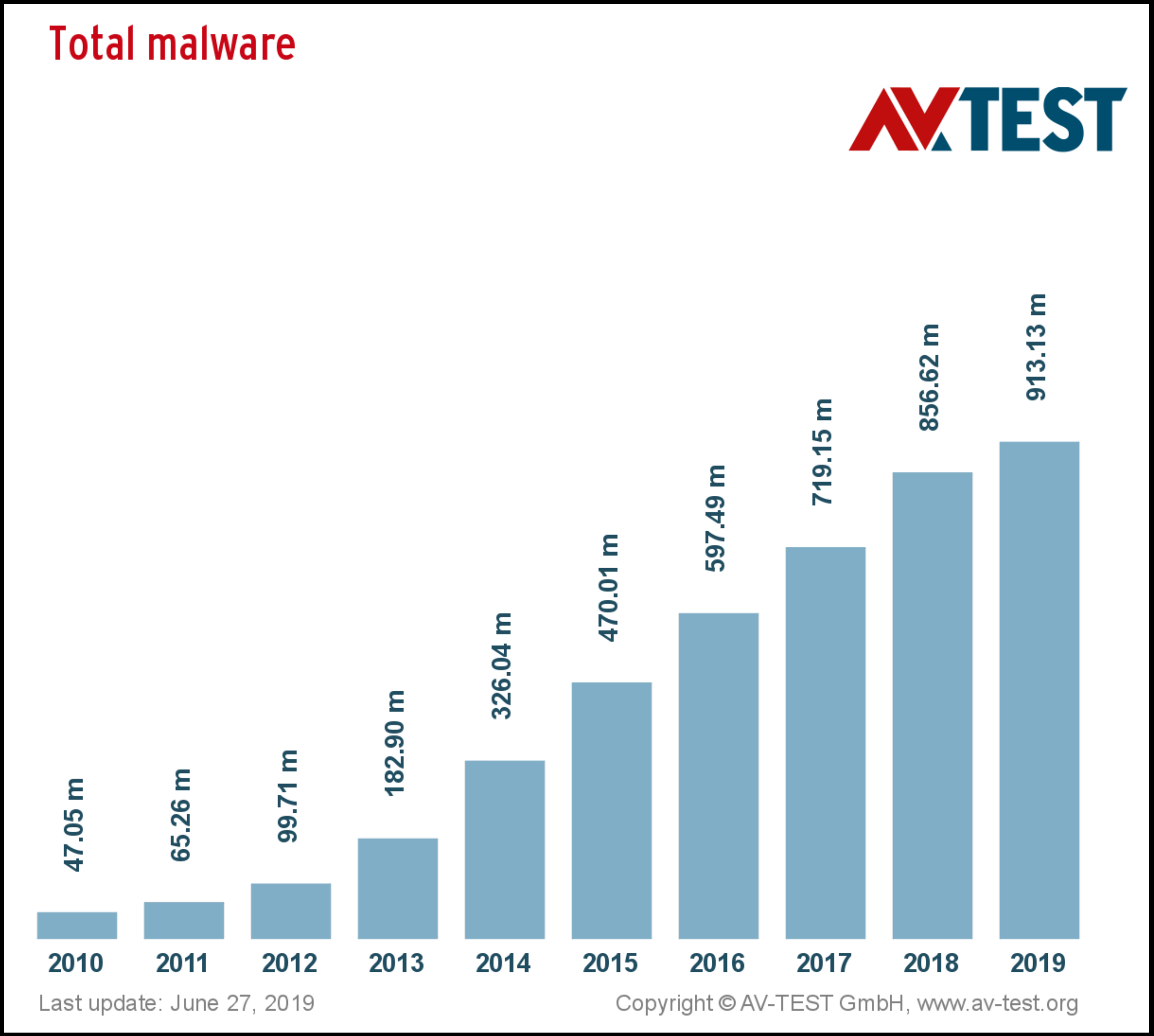
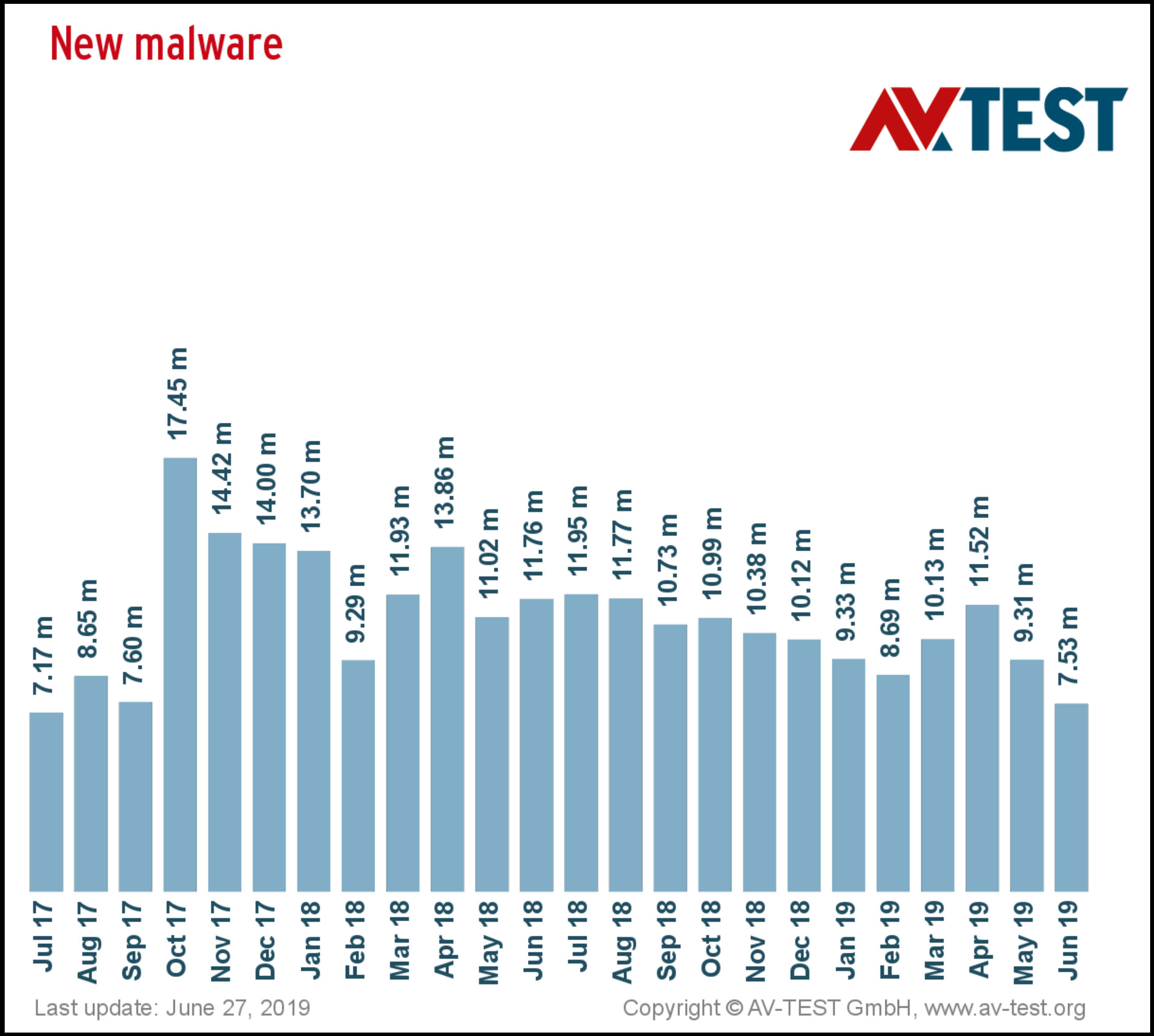
- Engineer at Industrial Technology Research Institute (ITRI) in Taiwan
- Security team focus on system security
- PhD candidate at Advanced Defense Lab in National Central University in Taiwan
- 2018 HITCON CTF second place in Taiwan

WHAT IS APPLICATION WHITELIST ?

- Kind of access control policy
- Opposite of blacklist
- Only allow applications listed in whitelist executed
- Deny applications not in whitelist executed

WHY NEED APPLICATION WHITELIST ?





https://www.av-test.org/en/statistics/malware/

- Application whitelisting is one of the most effective strategies in ensuring the security of systems

  – Implementing Application Whitelisting, Australian Cyber Security Centre

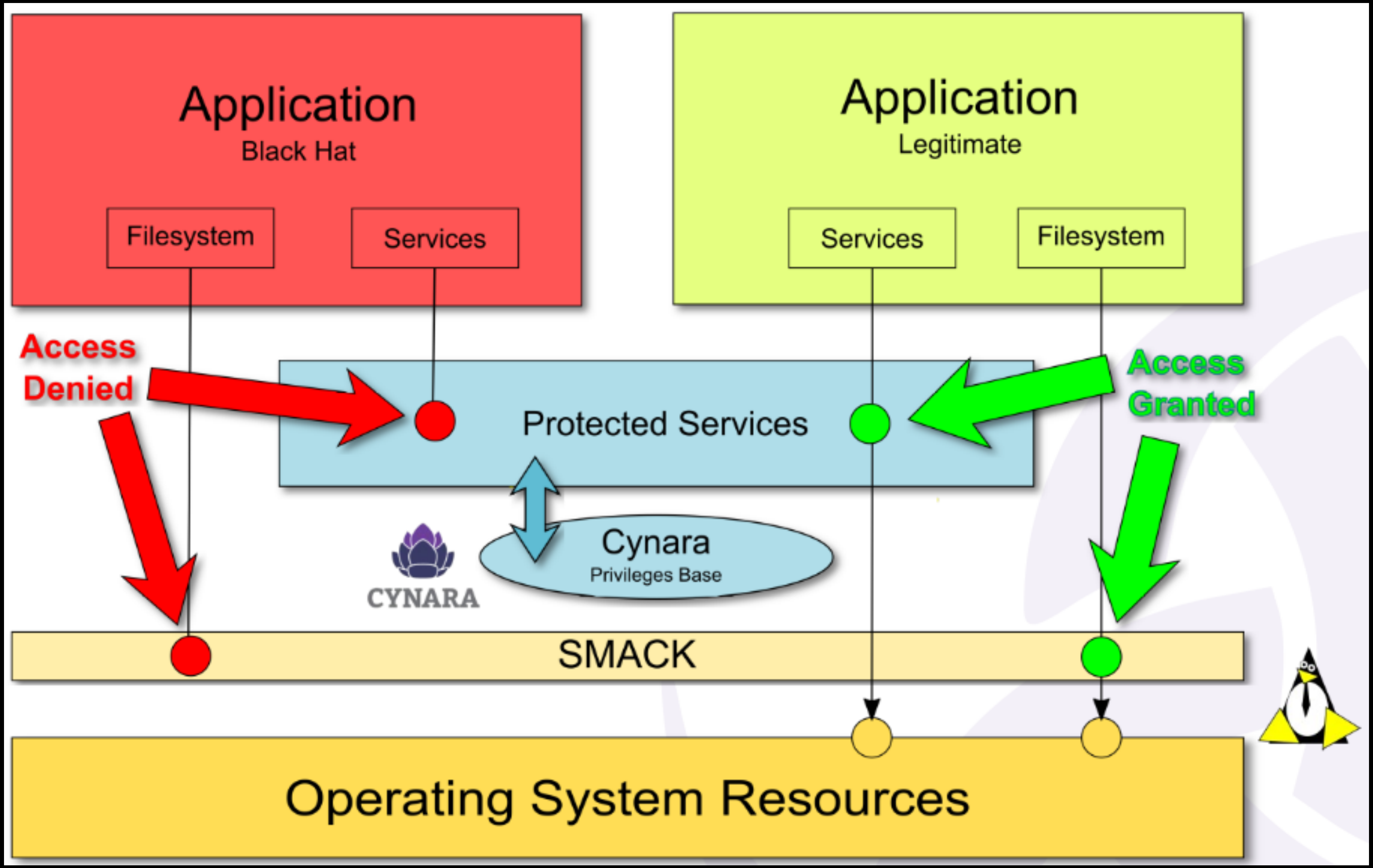
- Application whitelisting is most readily used to stop threats on managed hosts where users are not able to install or run applications without authorization

  – Guide to Application Whitelisting, National Institute of Standards and Technology

GOAL

- Propose an application whitelist prototype on AGL
- 4 features:
  - Block binary execute
  - Block library load
  - Block interpreter script
  - Block kernel module load

AGL SECURITY ARCHITECTURE



https://iot.bzh/download/public/2016/genivi/CyberSecurity-Genivi-2016-IOT-BZH-Fulup.pdf

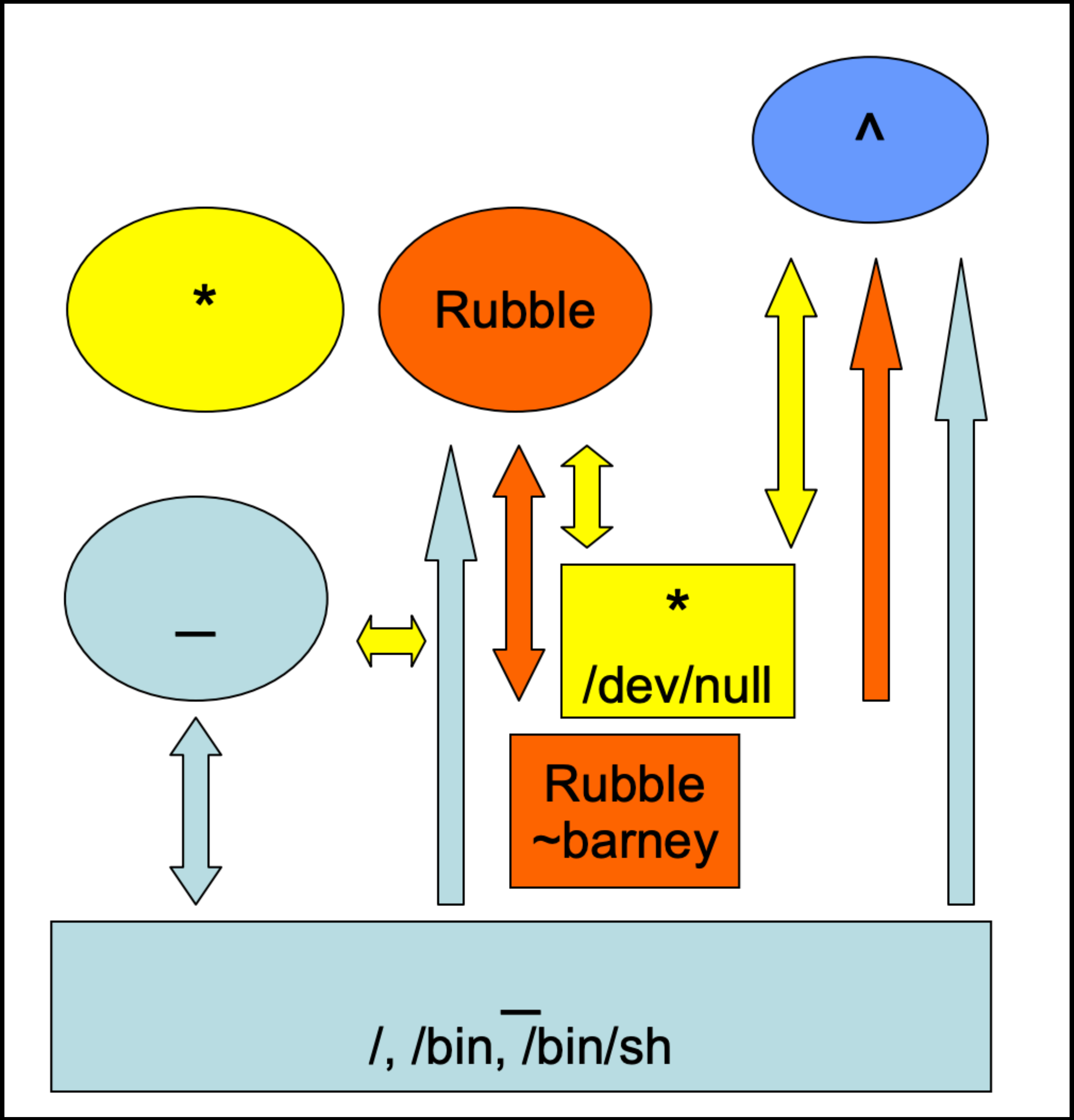
SMACK

- What is SMACK ?
  - Simplified Mandatory Access Control Kernel
  - Linux Security Modules
  - MAC model

SMACK

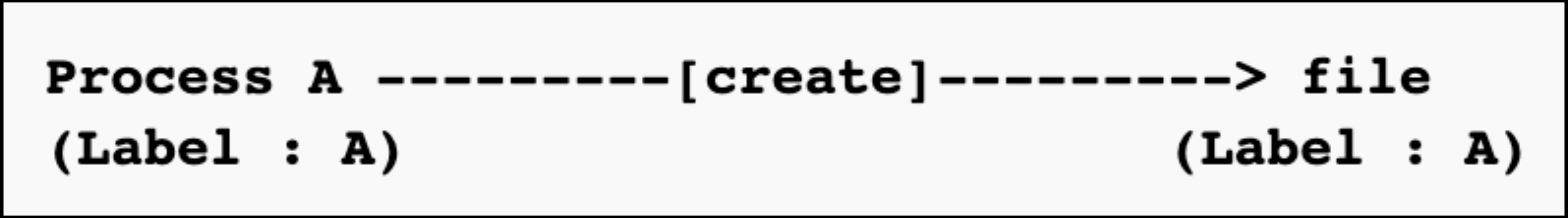
- Use extended attributes to store label
- Use label as identity
  - 6 extended attributes use to store label
    - e.g. SMACK64, SMACK64MMAP…
  - Subject Object rwxat
- There are predefine labels and rules written in kernel code

- SMACK default label & default rules



http://schaufler-ca.com/yahoo_site_admin/assets/docs/SmackWhitePaper.257153003.pdf

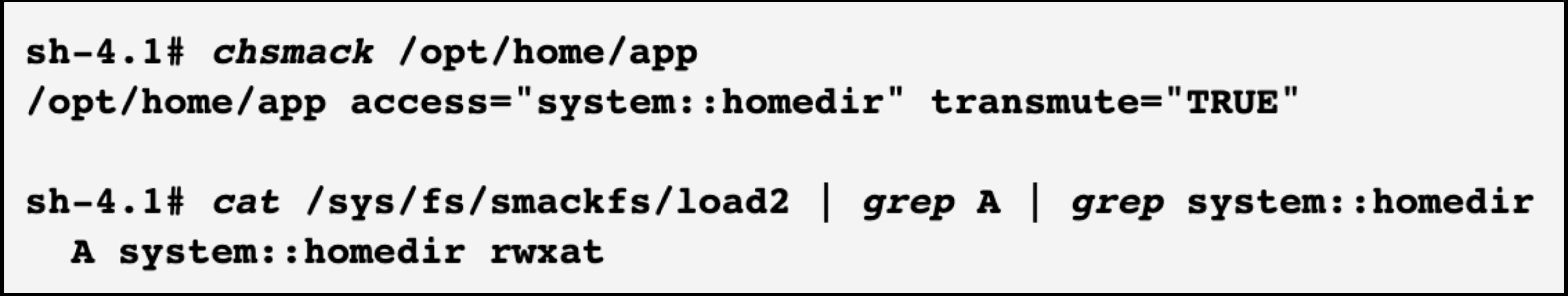
- What label will be set when create new file?
  - Without transmute



```
Process A ----------[create]----------> file
(Label : A)                            (Label : A)
```

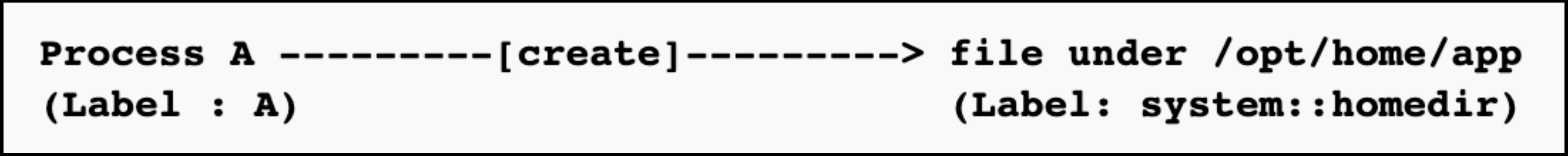
https://wiki.tizen.org/Security/Tizen_2.X_Smack_Developer_Guide

- What label will be set when create new file?
  - With transmute



```
sh-4.1# chsmack /opt/home/app
/opt/home/app access="system::homedir" transmute="TRUE"

sh-4.1# cat /sys/fs/smackfs/load2 | grep A | grep system::homedir
  A system::homedir rwxat
```

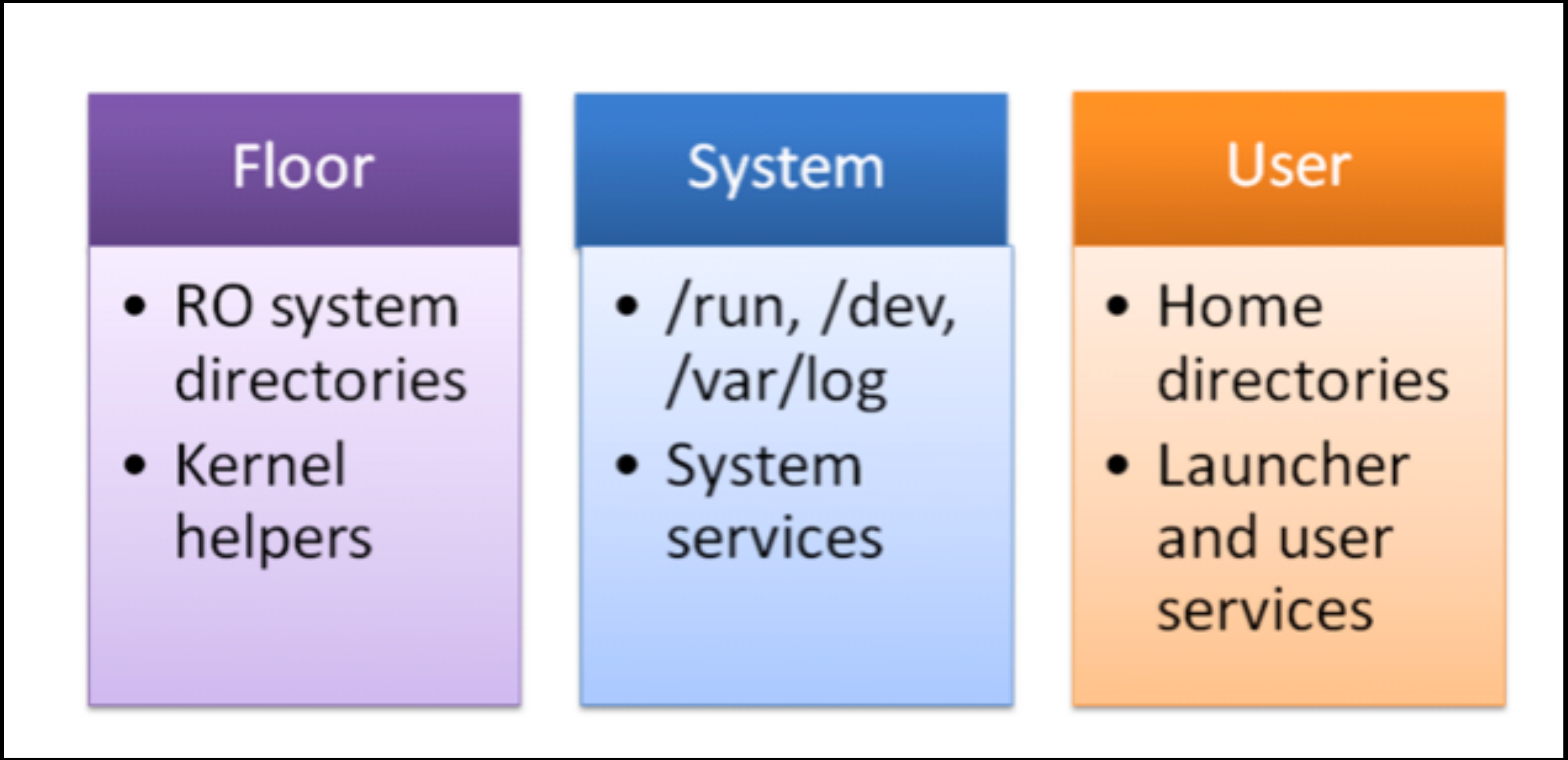


```
Process A ---------[create]---------> file under /opt/home/app
(Label : A)                           (Label: system::homedir)
```

https://wiki.tizen.org/Security/Tizen_2.X_Smack_Developer_Guide

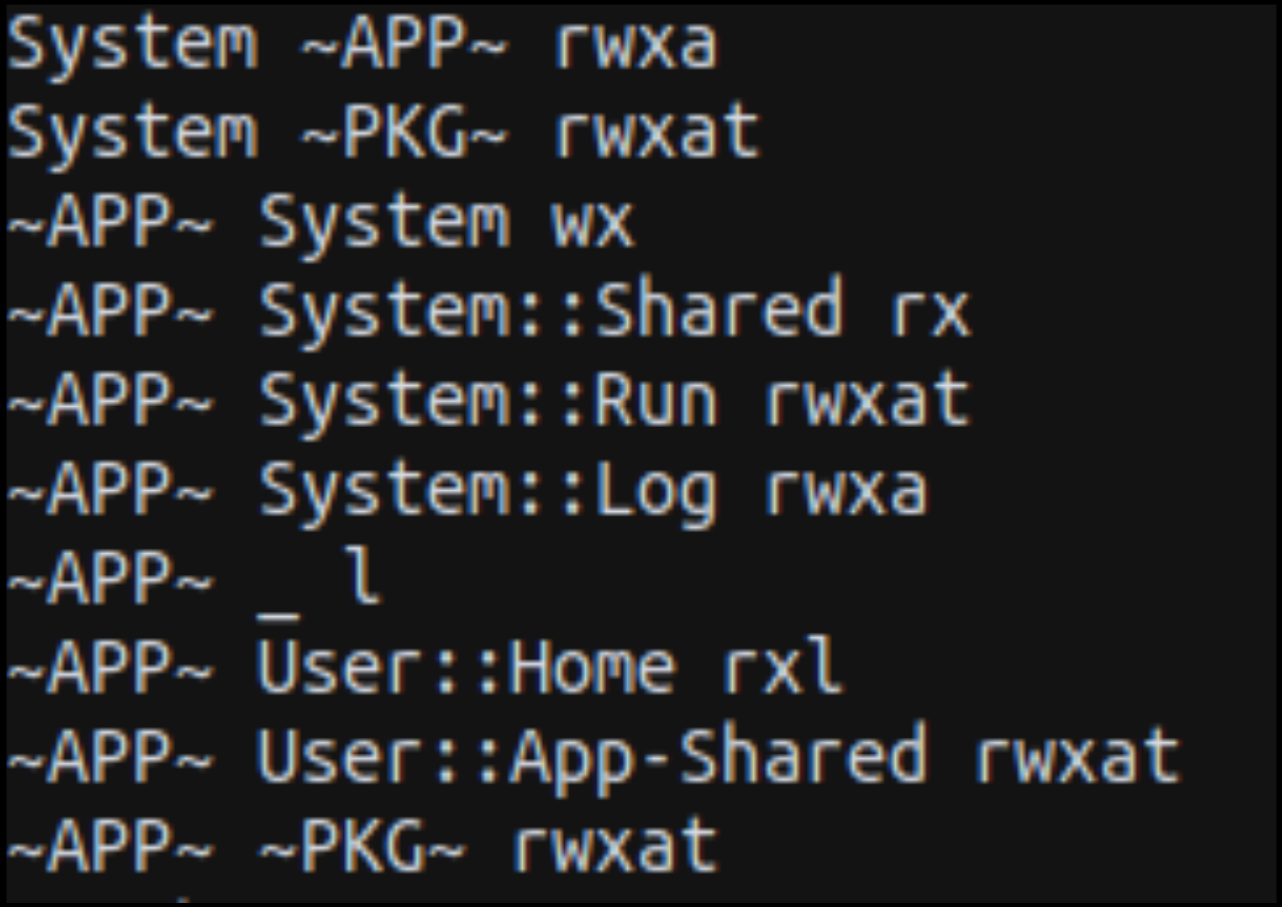
SMACK ON AGL

- Three domain model
  - Floor
  - System
  - User



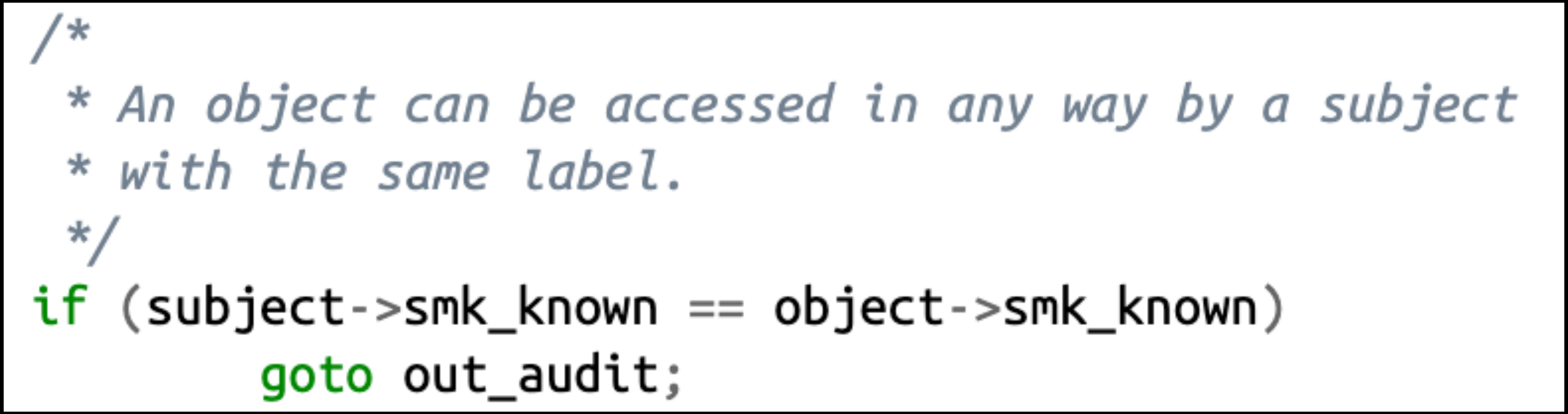
https://wiki.tizen.org/Security/Tizen_3.X_Overview

- SMACK rule template of APP in AGL
  - ~APP~ according to APP id
  - e.g. User::APP::my_app



```
System ~APP~ rwxa
System ~PKG~ rwxat
~APP~ System wx
~APP~ System::Shared rx
~APP~ System::Run rwxat
~APP~ System::Log rwxa
~APP~ _ l
~APP~ User::Home rxl
~APP~ User::App-Shared rwxat
~APP~ ~PKG~ rwxat
```

- Limitation of SMACK based application whitelist
    - Subject has full access to object with same label
    - Could not change by setting rule



```
/*
 * An object can be accessed in any way by a subject
 * with the same label.
 */
if (subject->smk_known == object->smk_known)
        goto out_audit;
```

- Limitation of SMACK based application whitelist
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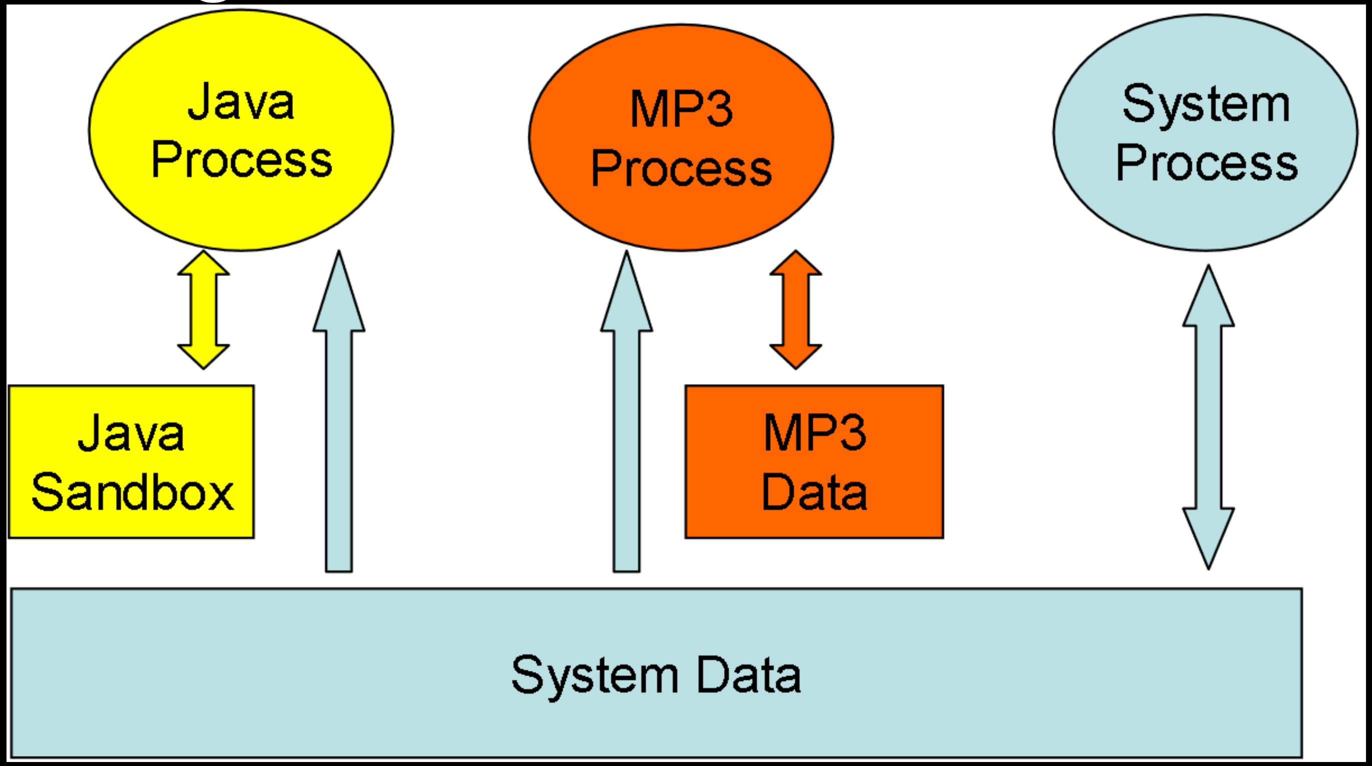

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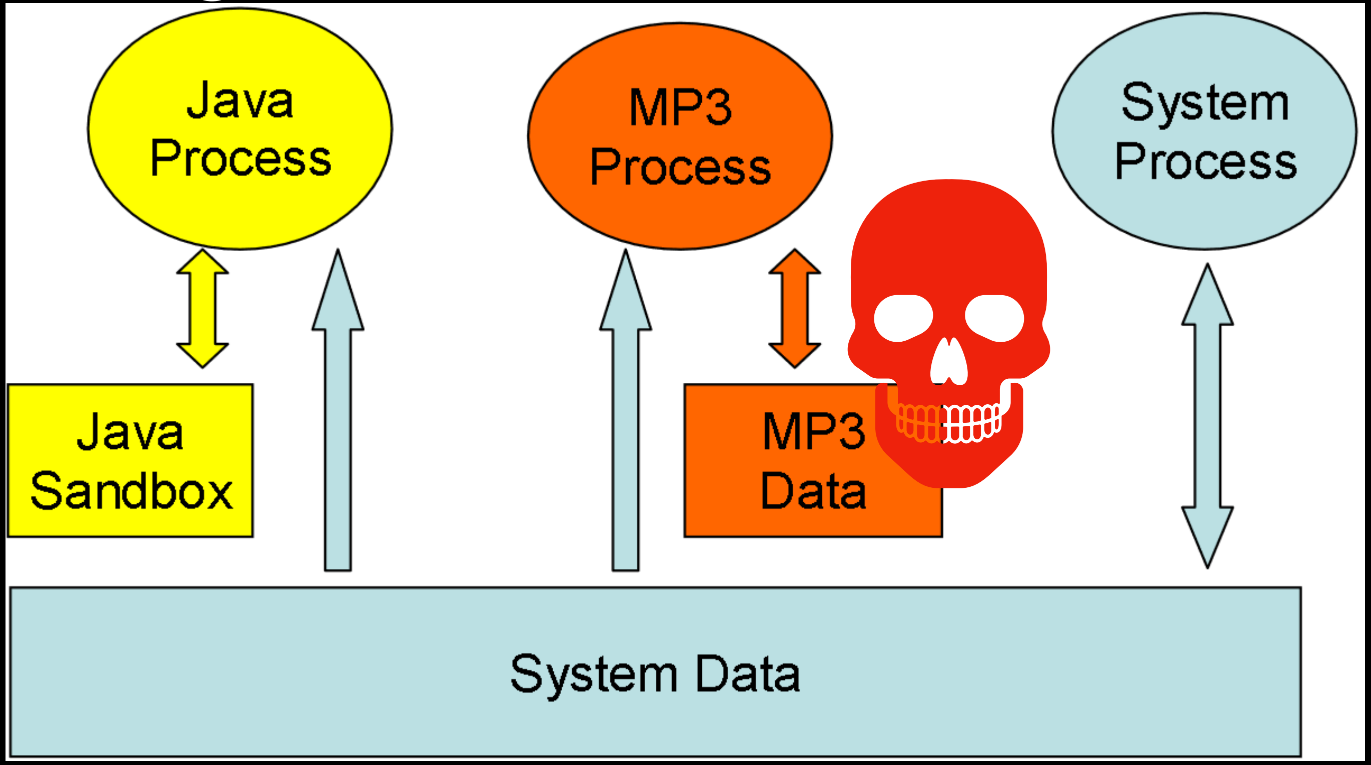

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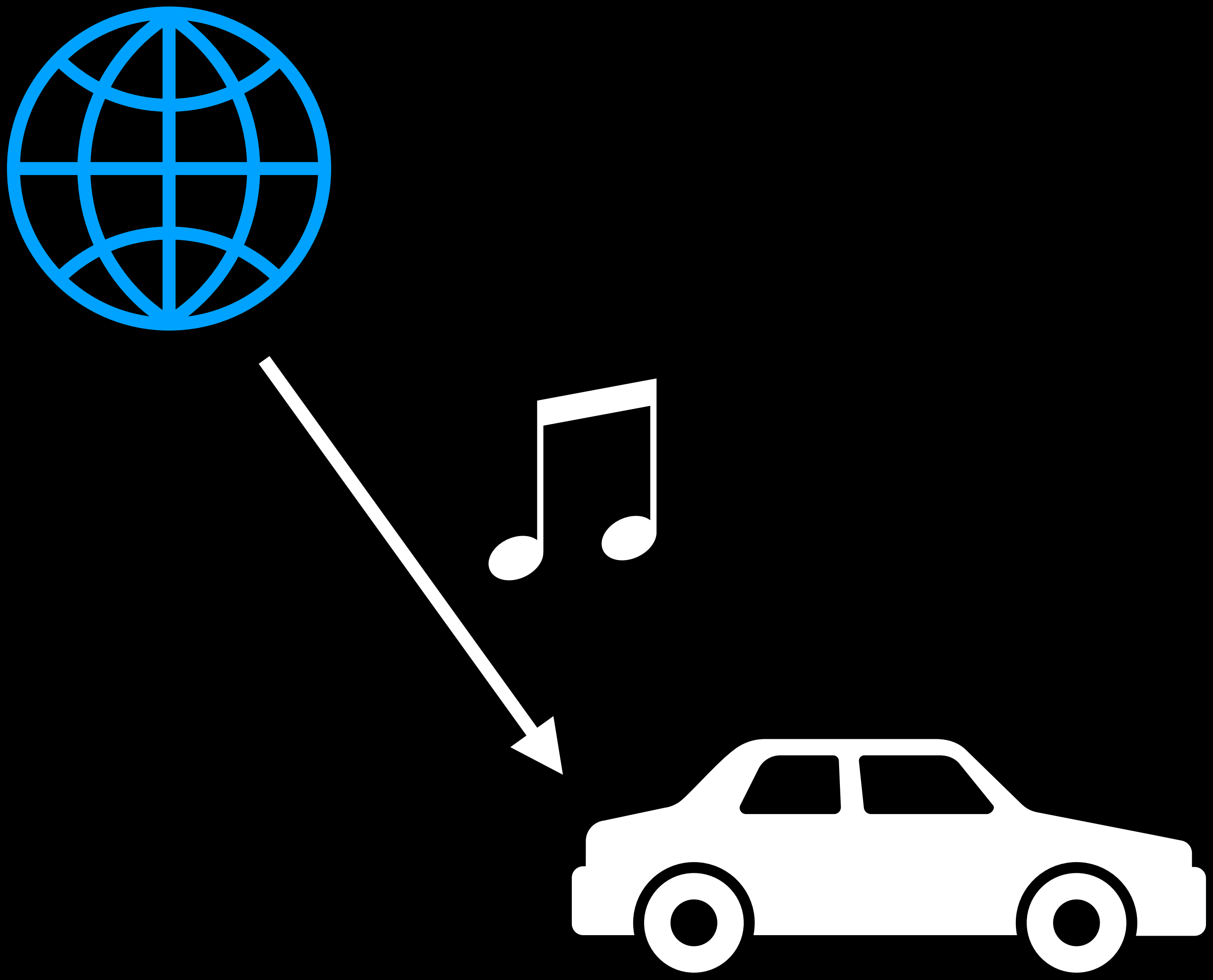

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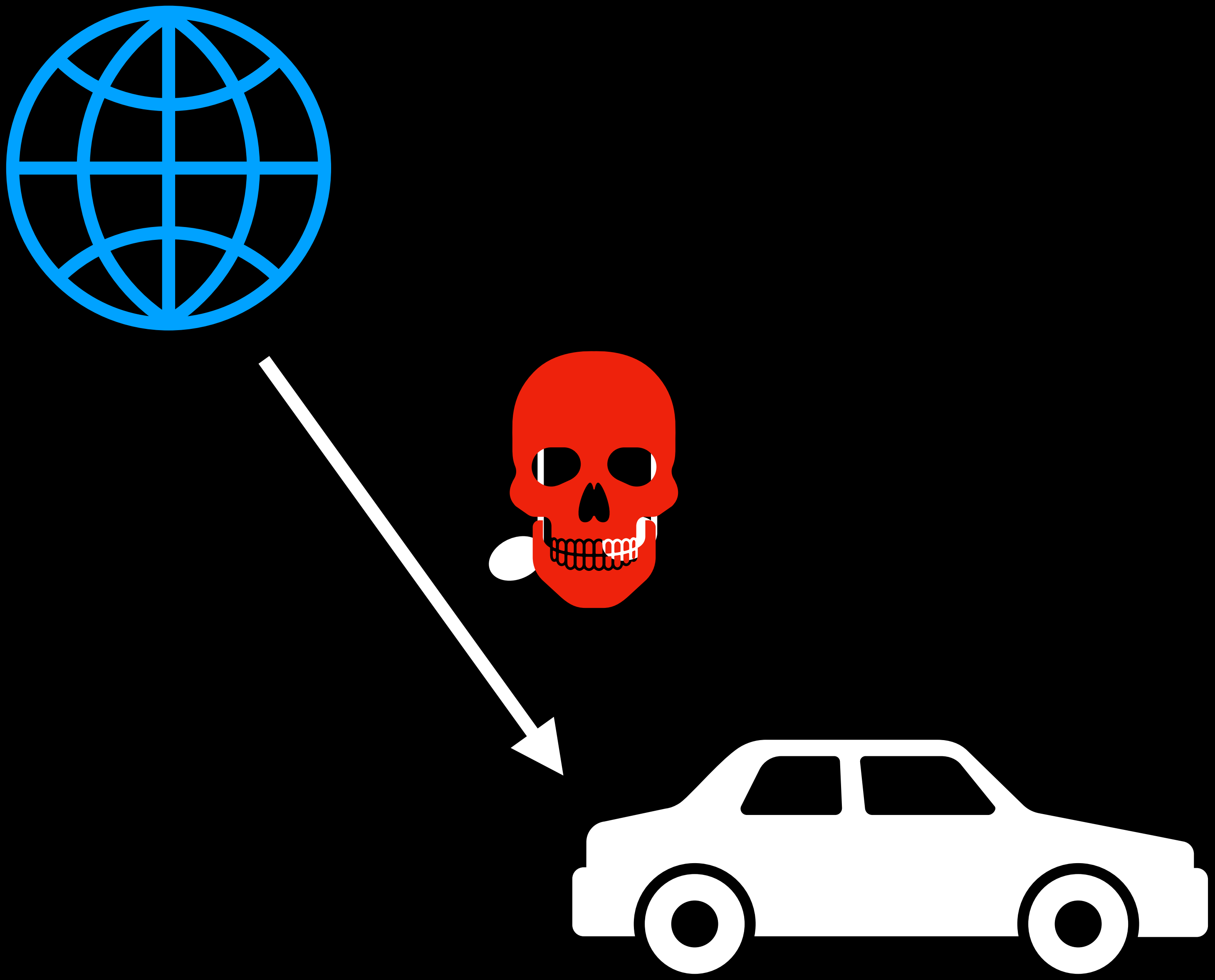

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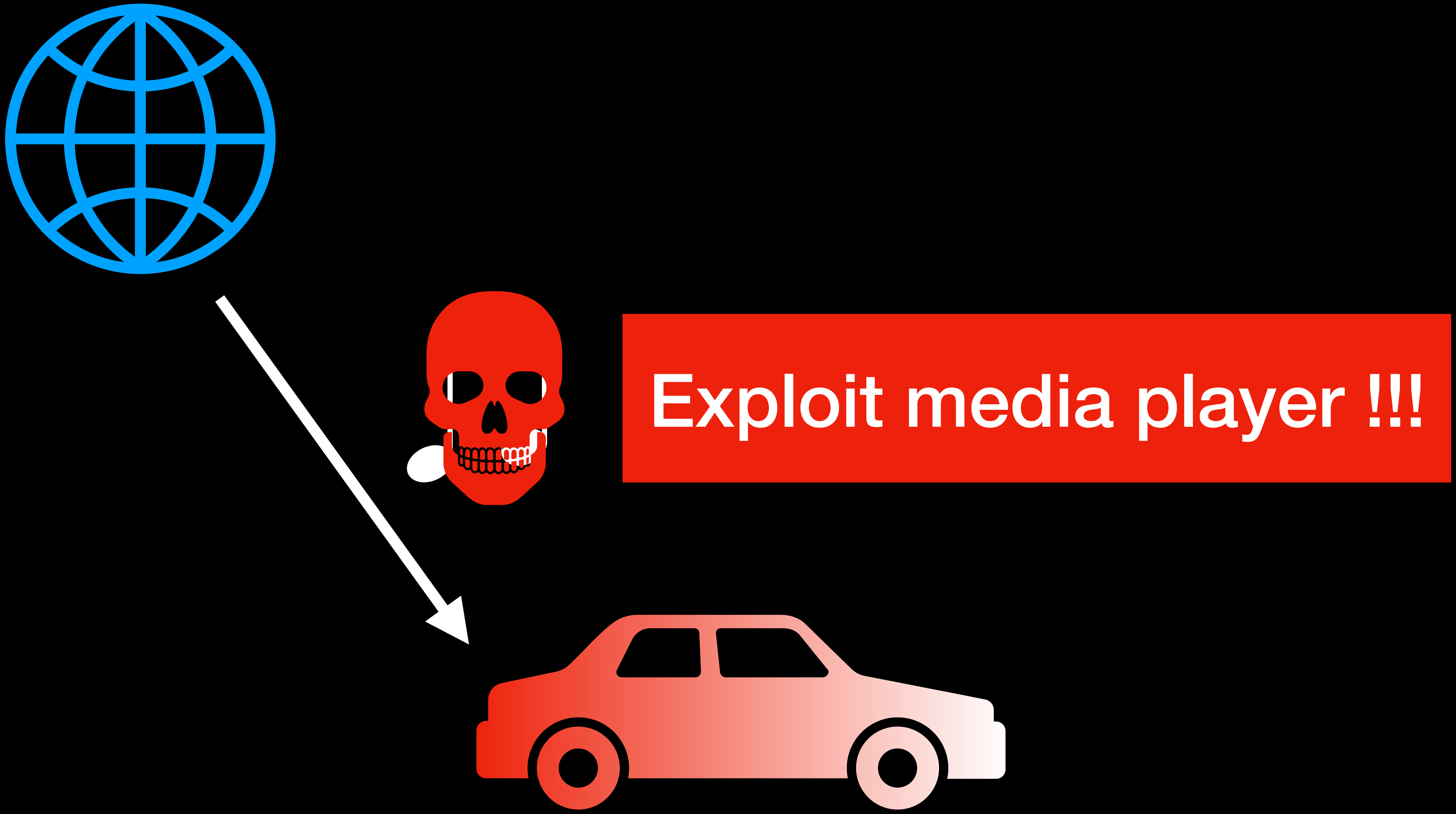

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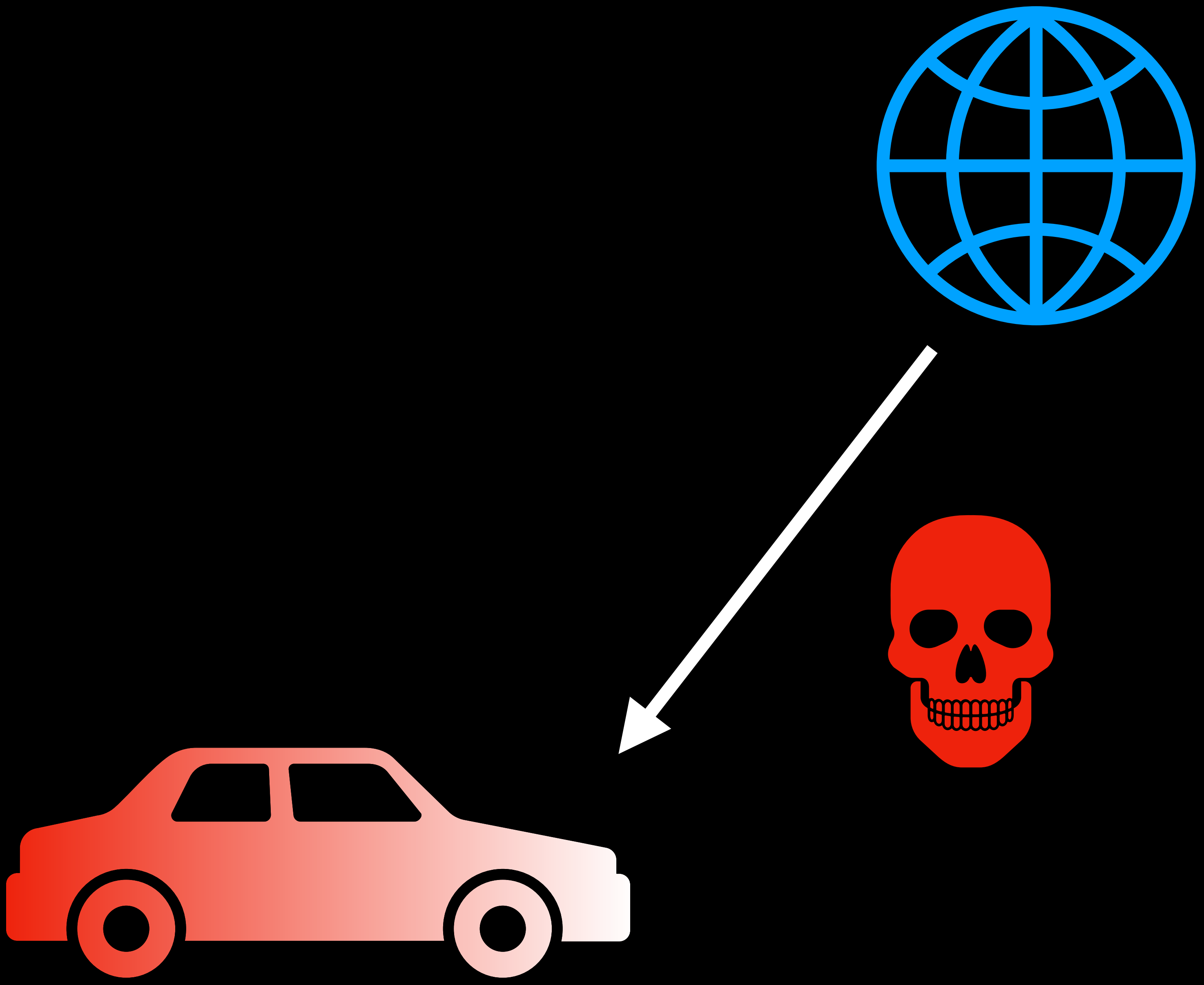

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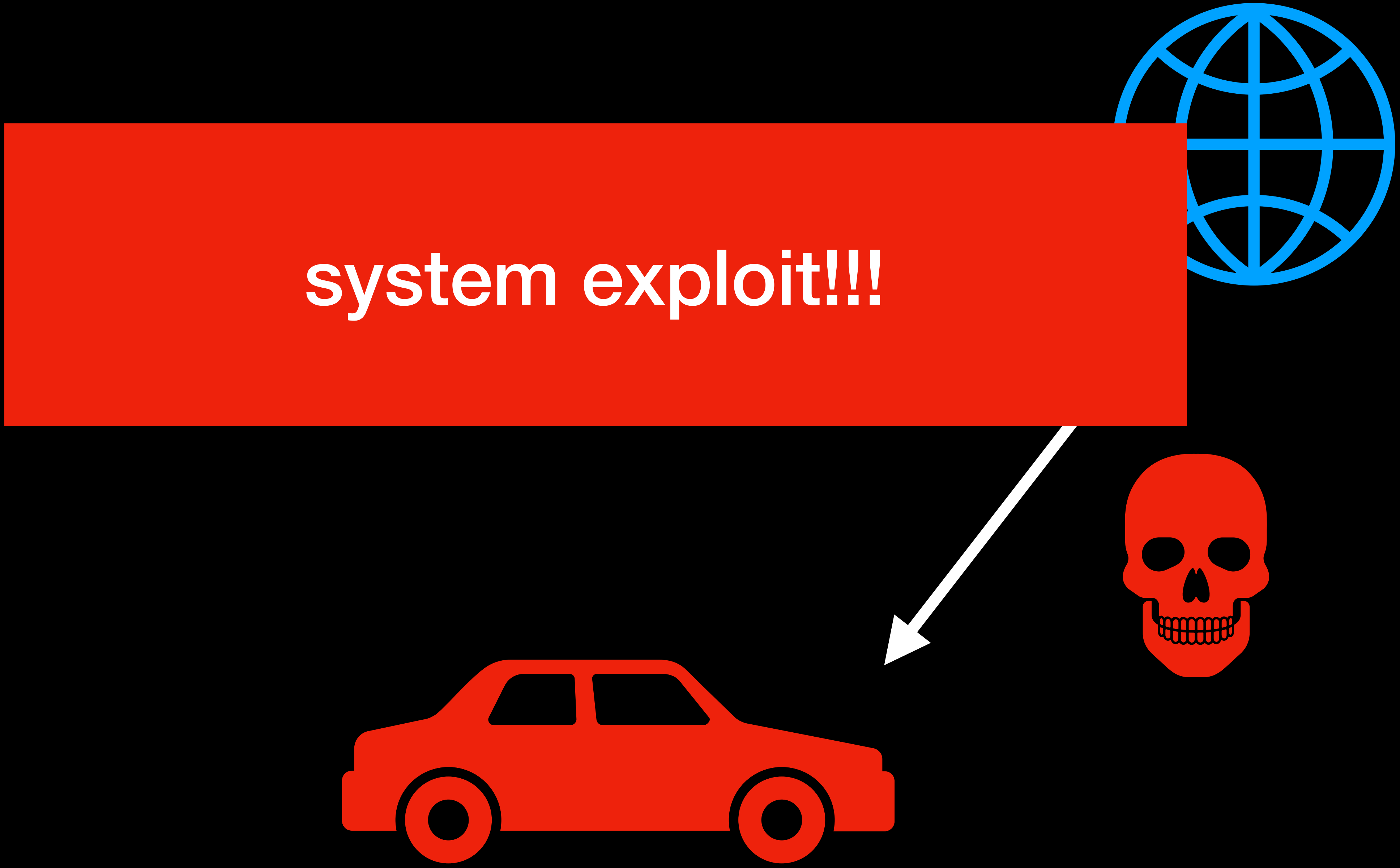


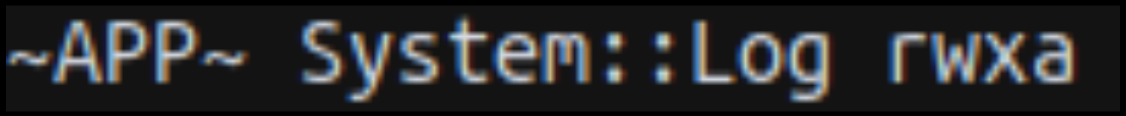
SMACK BASED WHITELIST ON AGL

- Some proposes
  - Not using root permission to run application
    - SMACK rule not effective in root privilege
  - No offline attack
    - May change smack label
  - We suppose not to change code and architecture

- 4 features:
    - **Block binary execute**
    - Block library load
    - Block interpreter script
    - Block kernel module load

BLOCK BINARY EXECUTION

- First try
  - Reference to DEP
    - Could not execute when it could write
    - Could not write when it could execute
  - e.g.

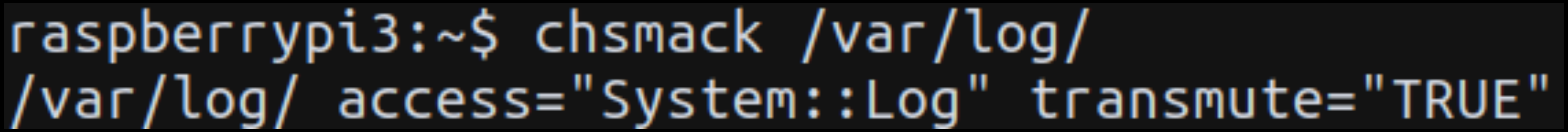


```
~APP~ System::Log rwxa
```

$\Rightarrow$

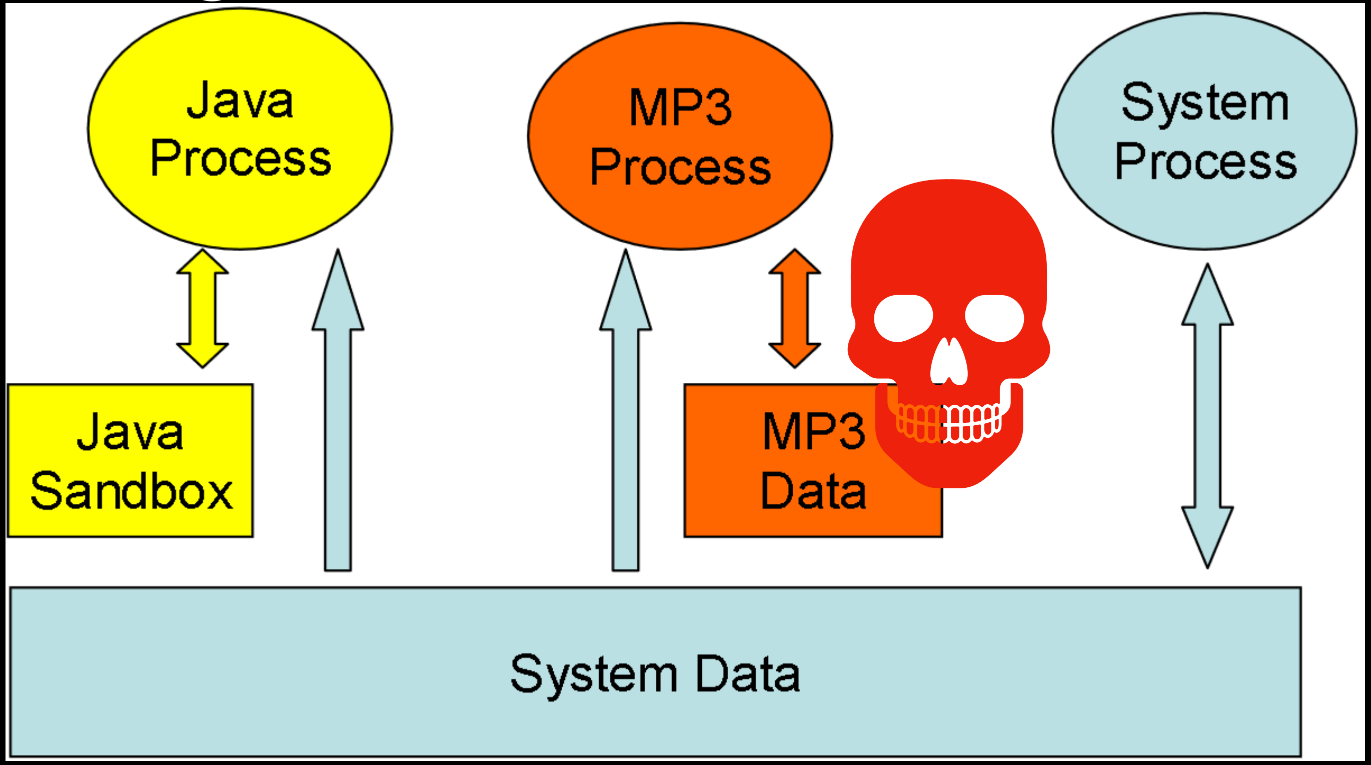
```
~APP~ System::Log rw-a
```

- Problems about our try
  - x permission on directory means permission for access file
  - If we unset x permission, then process cannot access file in the directory.



```
raspberrypi3:~$ chsmack /var/log/
/var/log/ access="System::Log" transmute="TRUE"
```

- Problems about our try
  - Subject have full access to object with same label
  - Could not change by setting rule



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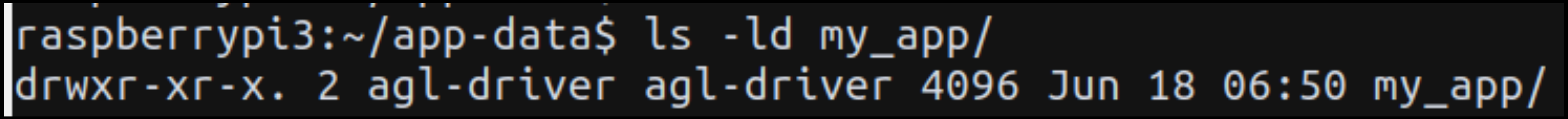
- How to solve?
    - Extend SMACK default rule
    - Let SMACK check rules when process access same label object

- How to solve?
    - ~~Extend SMACK default rule~~
    - ~~Let SMACK check rules when process access same label object~~

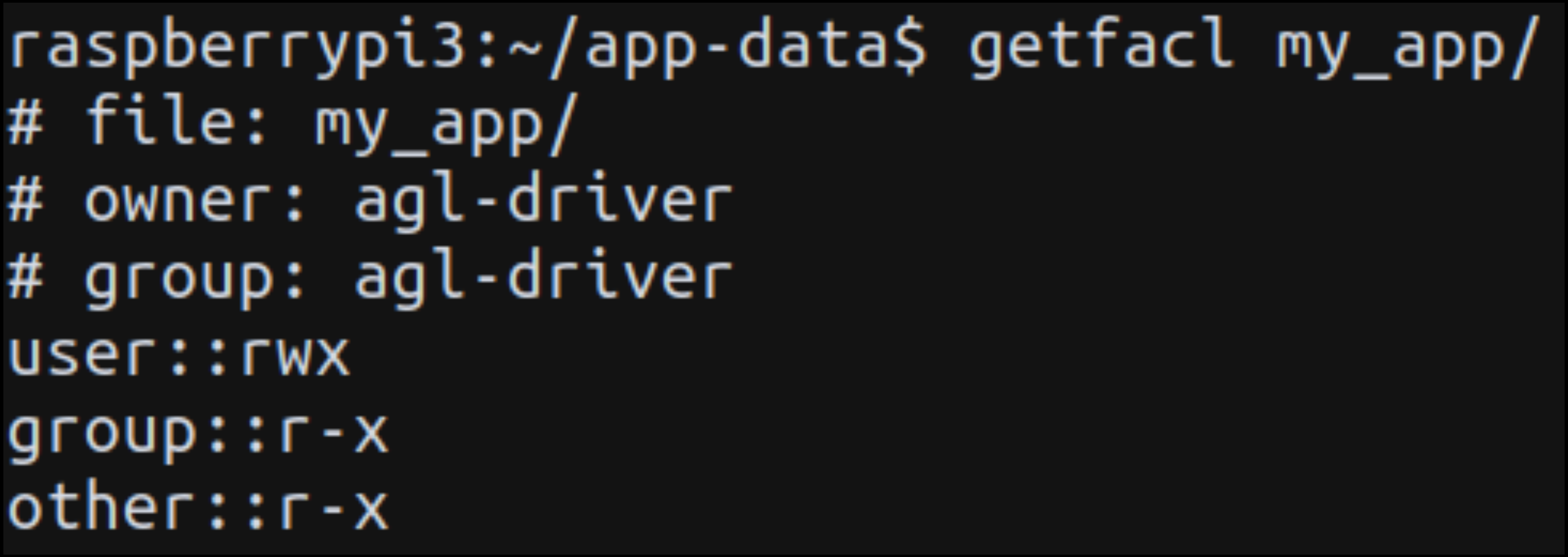
We suppose not to change code !!!!

- What about adding other feature?
  - Use access control list (ACL) to limit permissions
  - A list of permissions attached to an object.
  - Set default DAC permission to directory
  - When create new file, file will apply default permission

- Without ACL

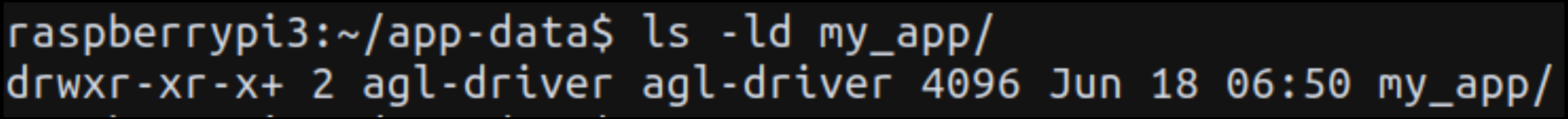


```
raspberrypi3:~/app-data$ ls -ld my_app/
drwxr-xr-x. 2 agl-driver agl-driver 4096 Jun 18 06:50 my_app/
```

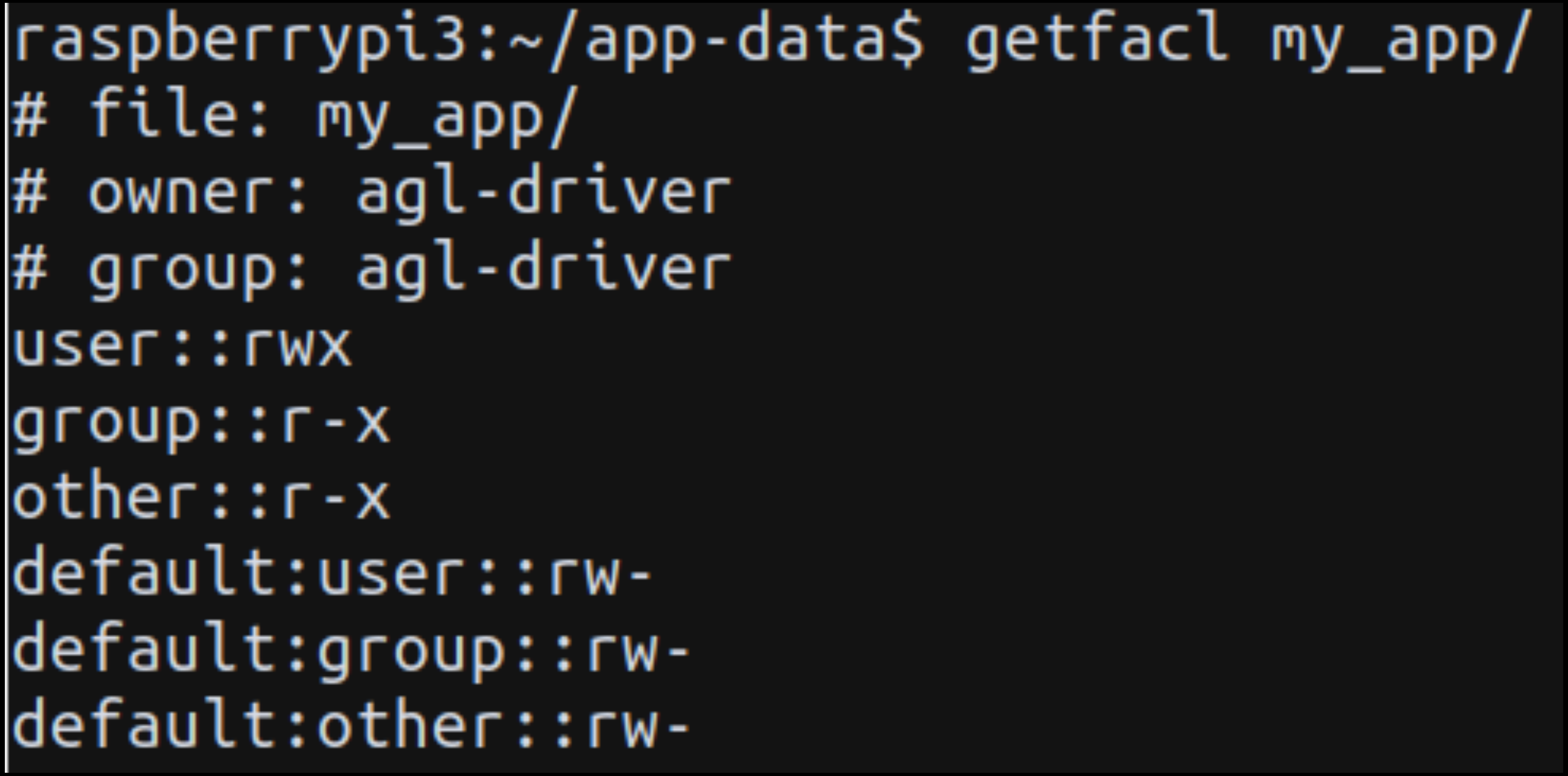


```
raspberrypi3:~/app-data$ getfacl my_app/
# file: my_app/
# owner: agl-driver
# group: agl-driver
user::rwx
group::r-x
other::r-x
```

- With ACL

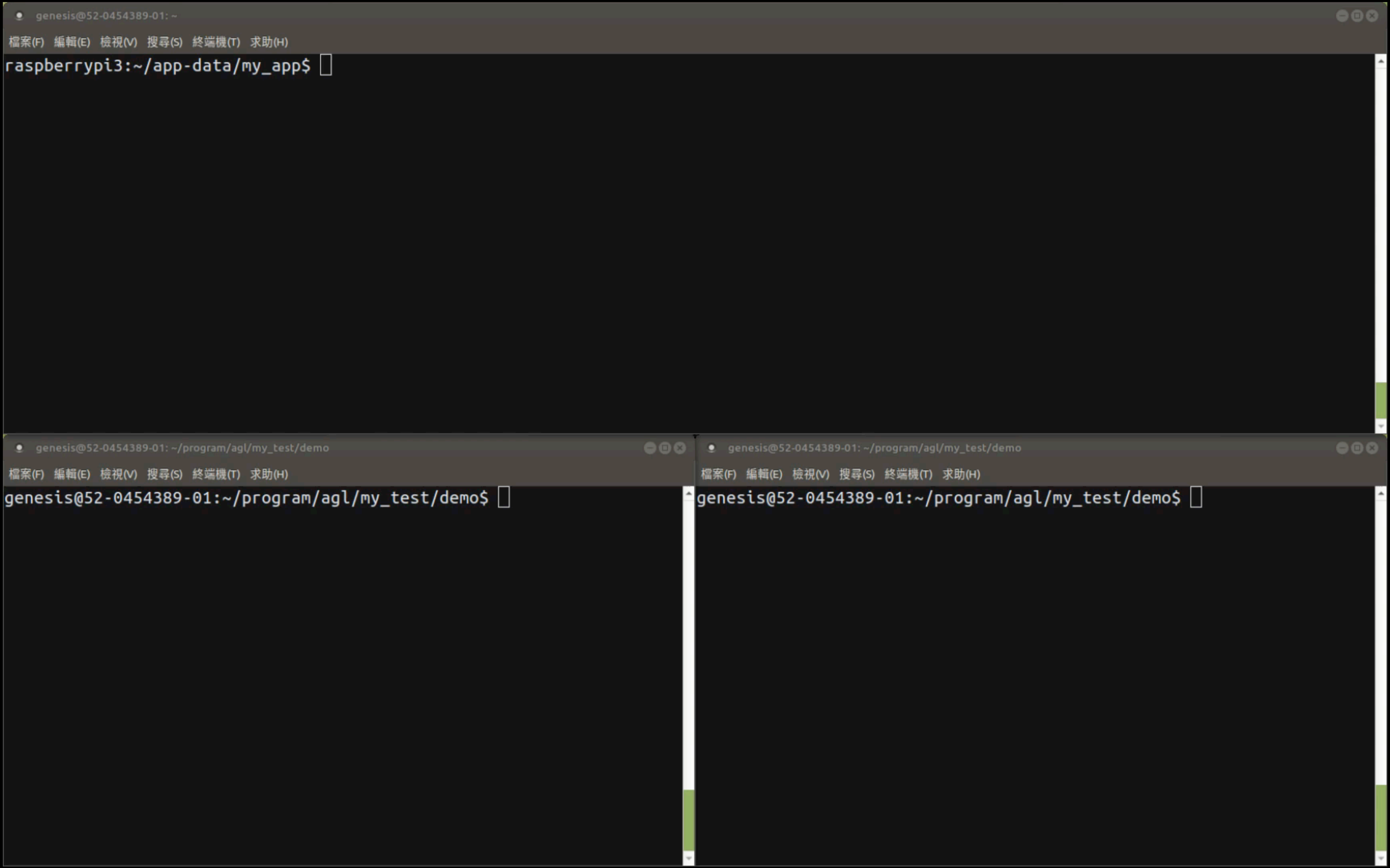


```
raspberrypi3:~/app-data$ ls -ld my_app/
drwxr-xr-x+ 2 agl-driver agl-driver 4096 Jun 18 06:50 my_app/
```



```
raspberrypi3:~/app-data$ getfacl my_app/
# file: my_app/
# owner: agl-driver
# group: agl-driver
user::rwx
group::r-x
other::r-x
default:user::rw-
default:group::rw-
default:other::rw-
```

- Change permission ?
  - Let app not allow to run relative command
  - Mark chmod, setfacl a new label
    - e.g. System::Privileged


genesis@52-0454389-01: ~
檔案(F) 編輯(E) 檢視(V) 搜尋(S) 終端機(T) 求助(H)

```
raspberrypi3:~/app-data/my_app$ 
```

genesis@52-0454389-01: ~/program/agl/my_test/demo
檔案(F) 編輯(E) 檢視(V) 搜尋(S) 終端機(T) 求助(H)

```
genesis@52-0454389-01:~/program/agl/my_test/demo$ 
```

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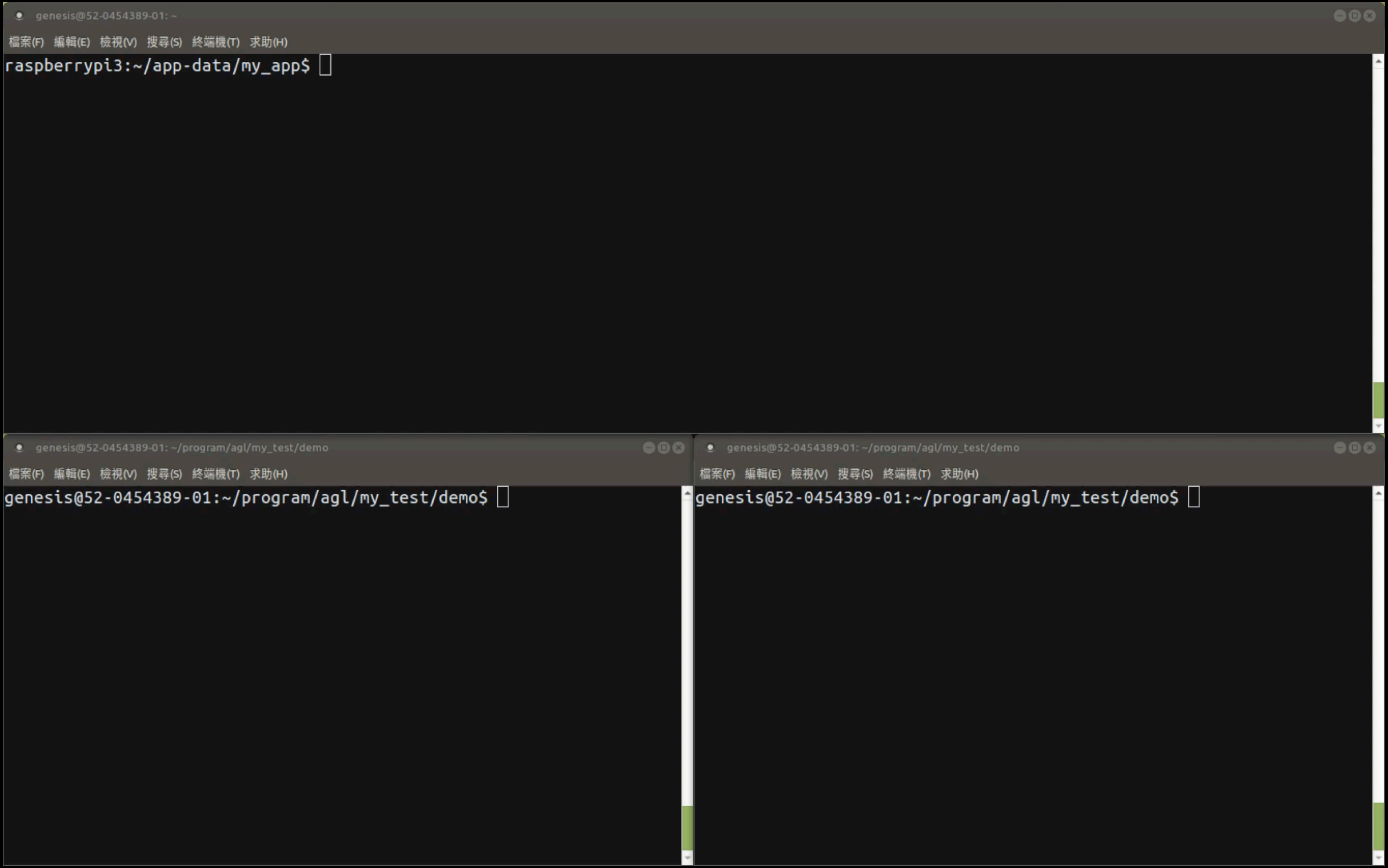
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```
genesis@52-0454389-01:~/program/agl/my_test/demo$
```

- 4 features:
  - Block binary execute ✓
  - **Block library load**
  - Block interpreter script
  - Block kernel module load

BLOCK LIBRARY LOAD

- Use SMACK64MMAP extended attributes
  - Cannot inherit label
- Use ACL to set default permission without read permission
  - False negative

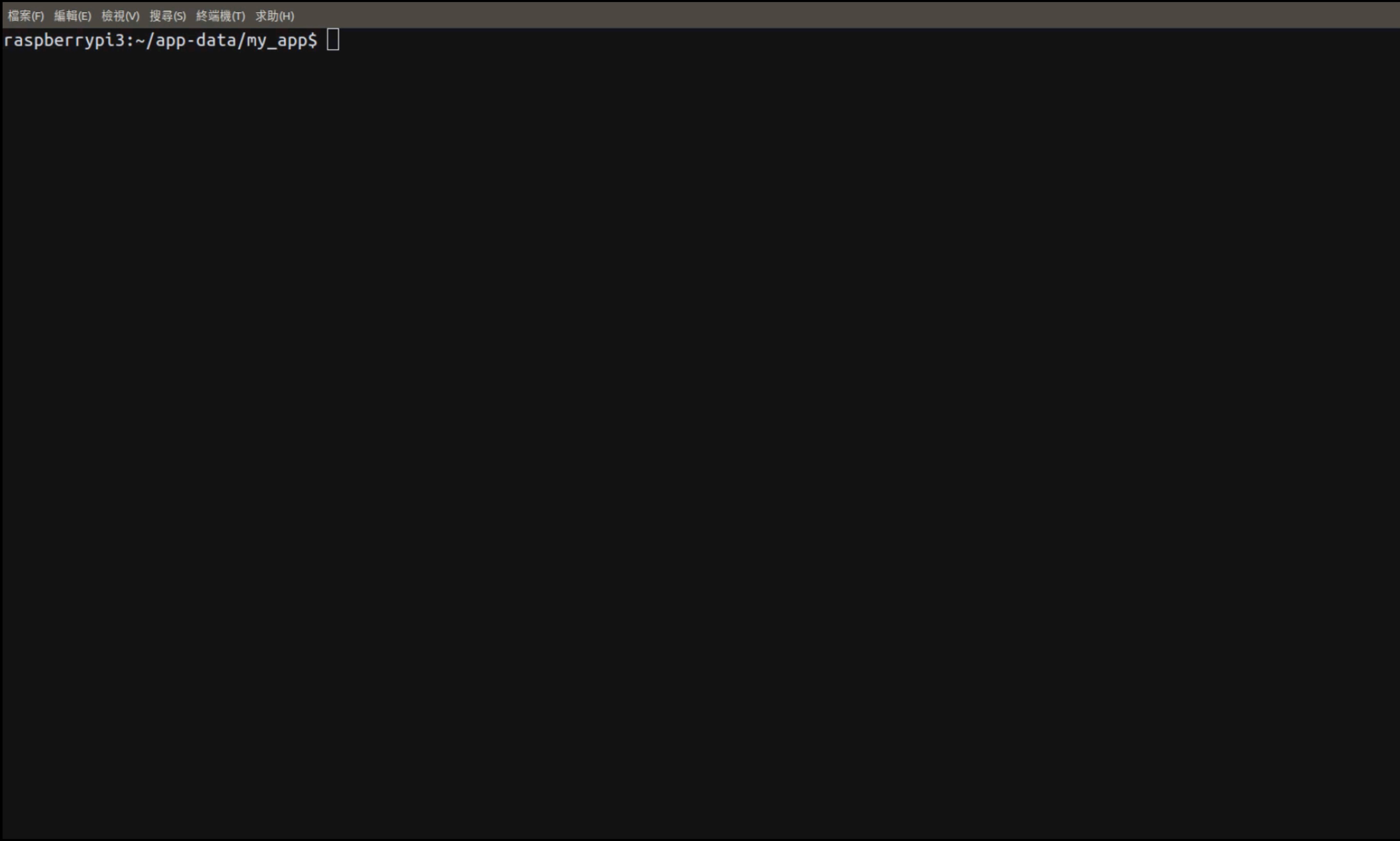
- 4 features:
  - Block binary execute ✓
  - Block library load ✗
  - **Block interpreter script**
  - Block kernel module load

BLOCK INTERPRETER SCRIPTS

- Take python for example
- Set unique label for python and .py, .pyc file
  - e.g. System::Python
- Only allow python to read script with same label

BLOCK INTERPRETER SCRIPTS

- Cases could not be blocked
  - cat test.py | python
  - python -c "print 'hello'"



```
raspberrypi3:~/app-data/my_app$ 
```

- 4 features:
  - Block binary execute ✓
  - Block library load ✗
  - Block interpreter script ✓
  - **Block kernel module load**

BLOCK LOAD KERNEL MODULE

- Currently cannot handle
- Load kernel module need root privilege
- SMACK will ignore rule when in root privilege
- We assume not using root permission

CONCLUSION

- Application whitelist prototype on AGL
- 4 features:
  - Block binary execute ✓
  - Block library load ✗
  - Block interpreter script ✓
  - Block kernel module load ✗

Q&A