Operating Systems

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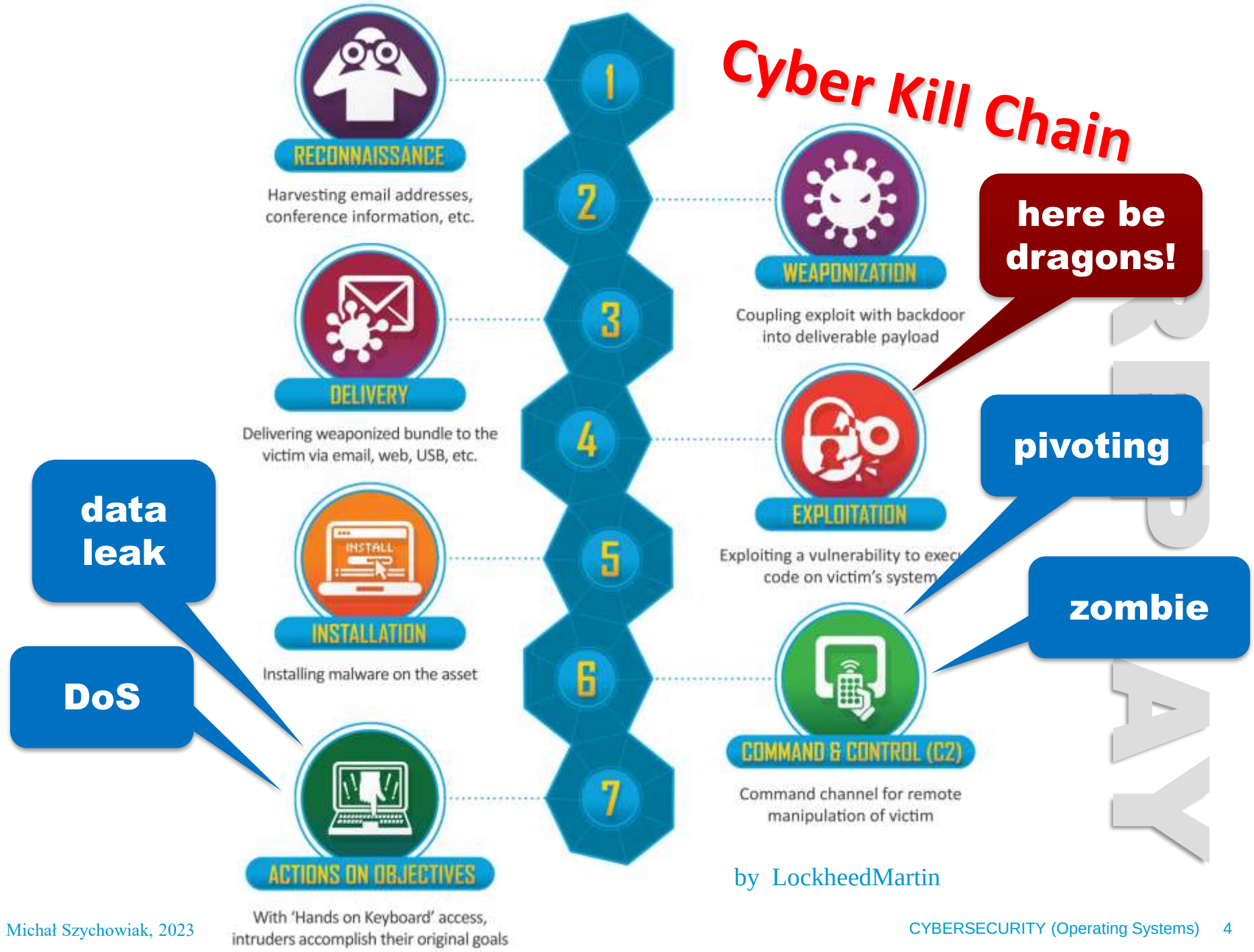
https://www.cs.put.poznan.pl/mszychowiak/en

3 Tiers Architecture

Agenda

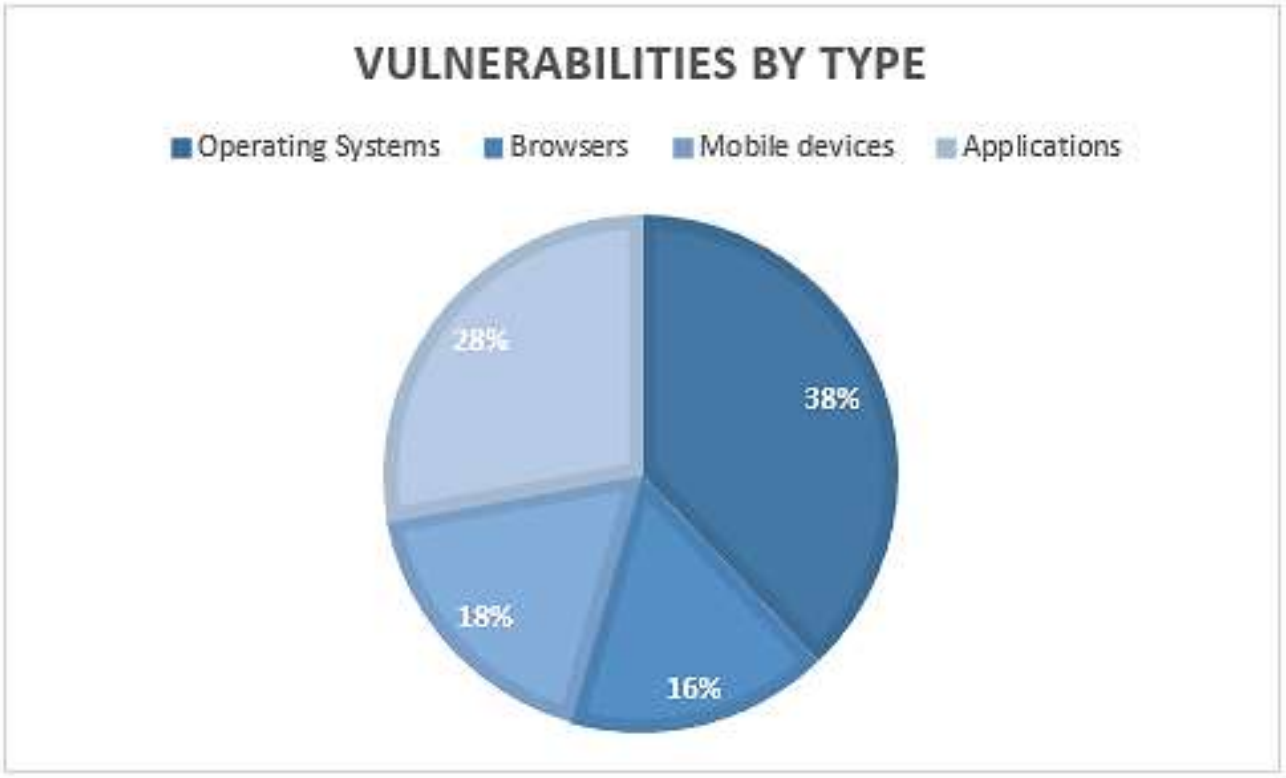
1. **OS Vulnerabilities**
2. **Defense**
    1. Authentication
    2. Authorization & Access Control
3. **Malware infections**
4. **Covered channels**


Cyber Kill Chain
1
RECONNAISSANCE
Harvesting email addresses, conference information, etc.
2
WEAPONIZATION
Coupling exploit with backdoor into deliverable payload
3
DELIVERY
Delivering weaponized bundle to the victim via email, web, USB, etc.
4
EXPLOITATION
Exploiting a vulnerability to exec code on victim's system
5
INSTALL
INSTALLATION
Installing malware on the asset
6
COMMAND & CONTROL (C2)
Command channel for remote manipulation of victim
7
ACTIONS ON OBJECTIVES
With 'Hands on Keyboard' access, intruders accomplish their original goals
here be dragons!
pivoting
zombie
data leak
DoS
by LockheedMartin

Vulnerabilities

Common Vulnerabilities and Exposures (CVE) database

https://cve.mitre.org





solaris

ReactOS


TinyOS




Mac OS

RIOT


iOS

KaiOS



QUBES OS
A REASONABLY SECURE OPERATING SYSTEM

MeeGo


VxWorks

FreeBSD

BlackBerry

MikroTik
RouterOS

CISCO
IOS

TIZEN

OpenWrt
Wireless Freedom

QNX

bada

Firefox OS

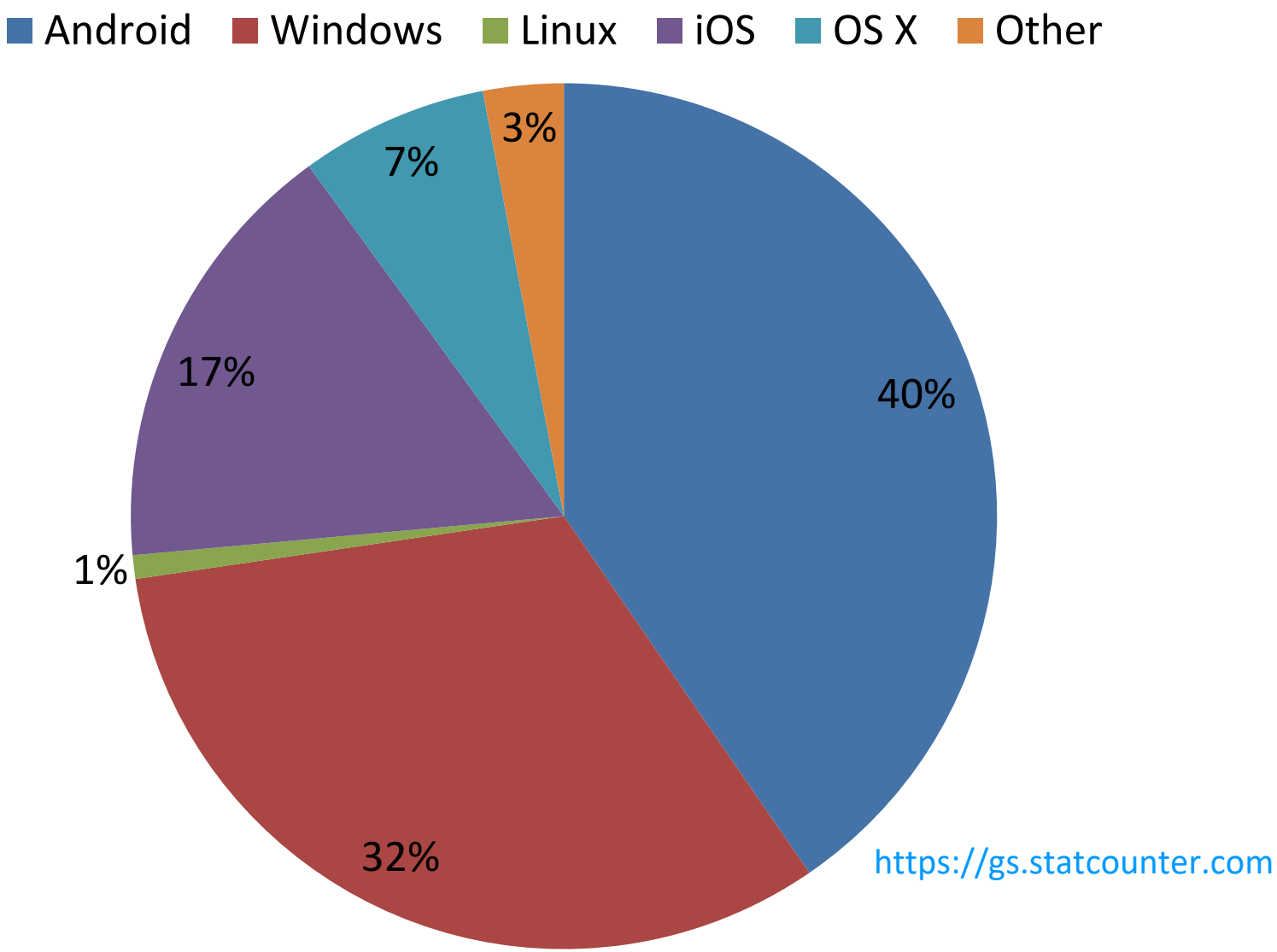

Cisco IOS
Cisco NX-OS
Cisco IOS-XR

ROS

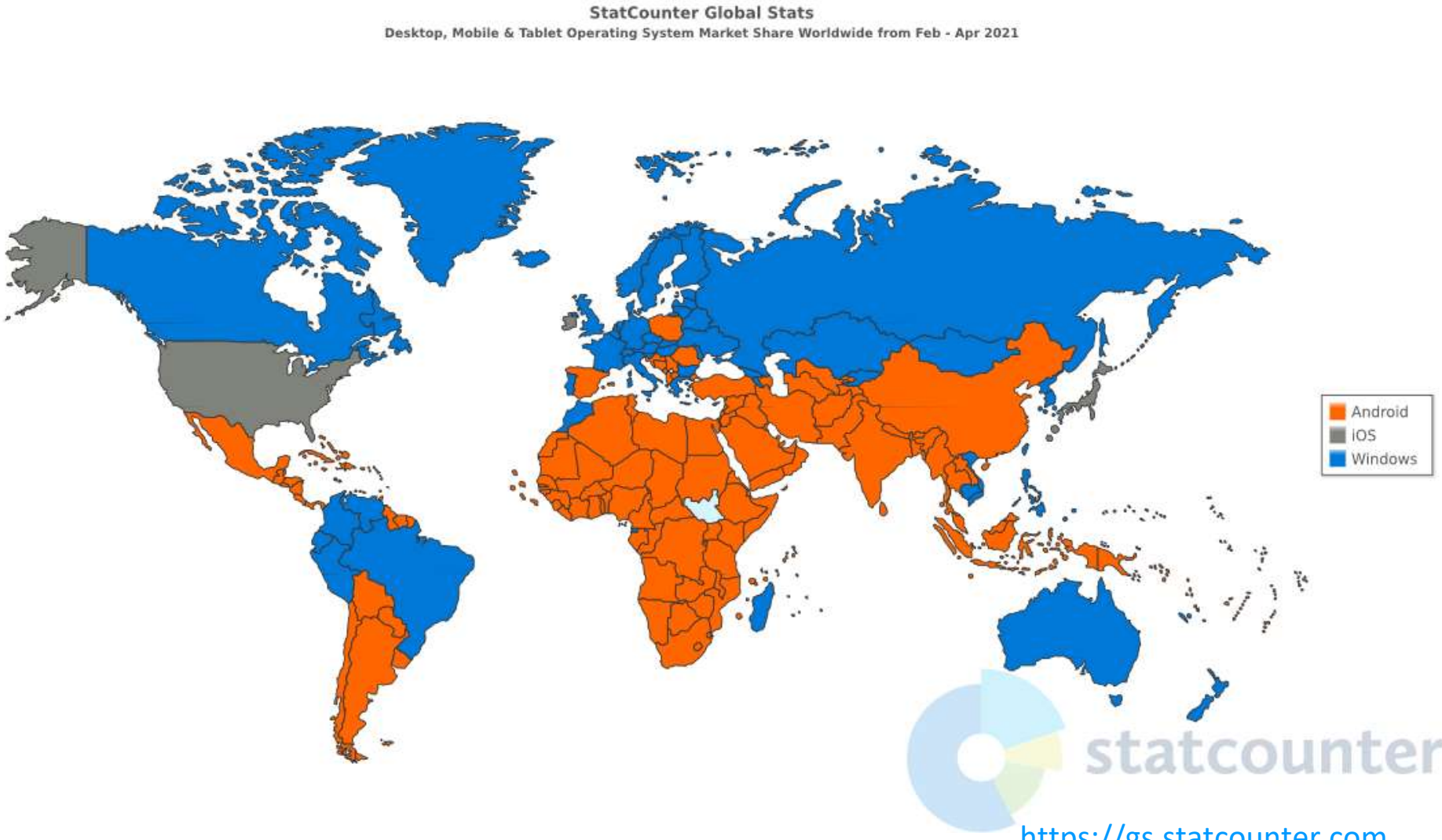
Open Source Robotics Foundation


NUCLEUS

OS Market Share



https://gs.statcounter.com


StatCounter Global Stats
Desktop, Mobile & Tablet Operating System Market Share Worldwide from Feb - Apr 2021
Android
iOS
Windows
statcounter
https://gs.statcounter.com

OS fingerprinting

Remote fingerprinting

- Active
  - initiating interactions with OS components (services)
- Passive
  - eavesdropping existing interactions

OS fingerprinting

Remote fingerprinting

- Banners

```
GET / HTTP/1.1
Host: www.example.com
User-Agent: Mozilla/5.0 (Windows NT 10; x64) Firefox/85.0
Accept: text/html,application/xhtml+xml,application/xml
Accept-Language: pl,en-US,en
Accept-Encoding: gzip, deflate
Connection: keep-alive
...
```

OS fingerprinting

Remote fingerprinting

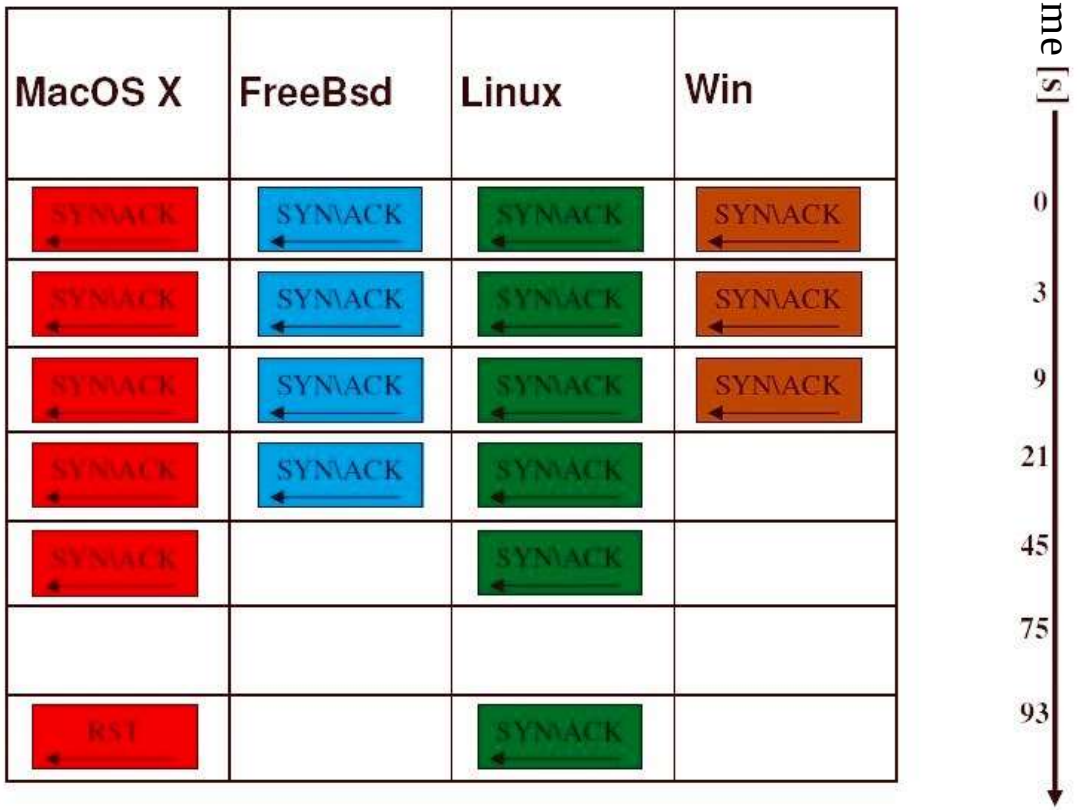
- OS differentiating features

Test type	Usable Protocol	Test precision
Directory Separator	HTTP	Windows vs. Unix
New line characters	HTTP	Windows vs. Unix
Special/reserved filenames	HTTP	Windows vs. Unix
Root directory	FTP	Windows, Unix, Symbian, OS/2
Special characters (EOF,EOL	-	-
Filesystem limitations	HTTP, FTP	Correlates FS-type to OS
Filesystem illegal characters	HTTP, FTP	Correlates FS-type to OS
Case sensitivity	HTTP, FTP	Windows vs. Unix
Special filenames handling	HTTP, FTP	Windows vs. Unix
Special files in directory	HTTP, FTP	Windows types, MacOS, Unix

OS fingerprinting

Remote fingerprinting

- RTO (Retransmission Time-Out)



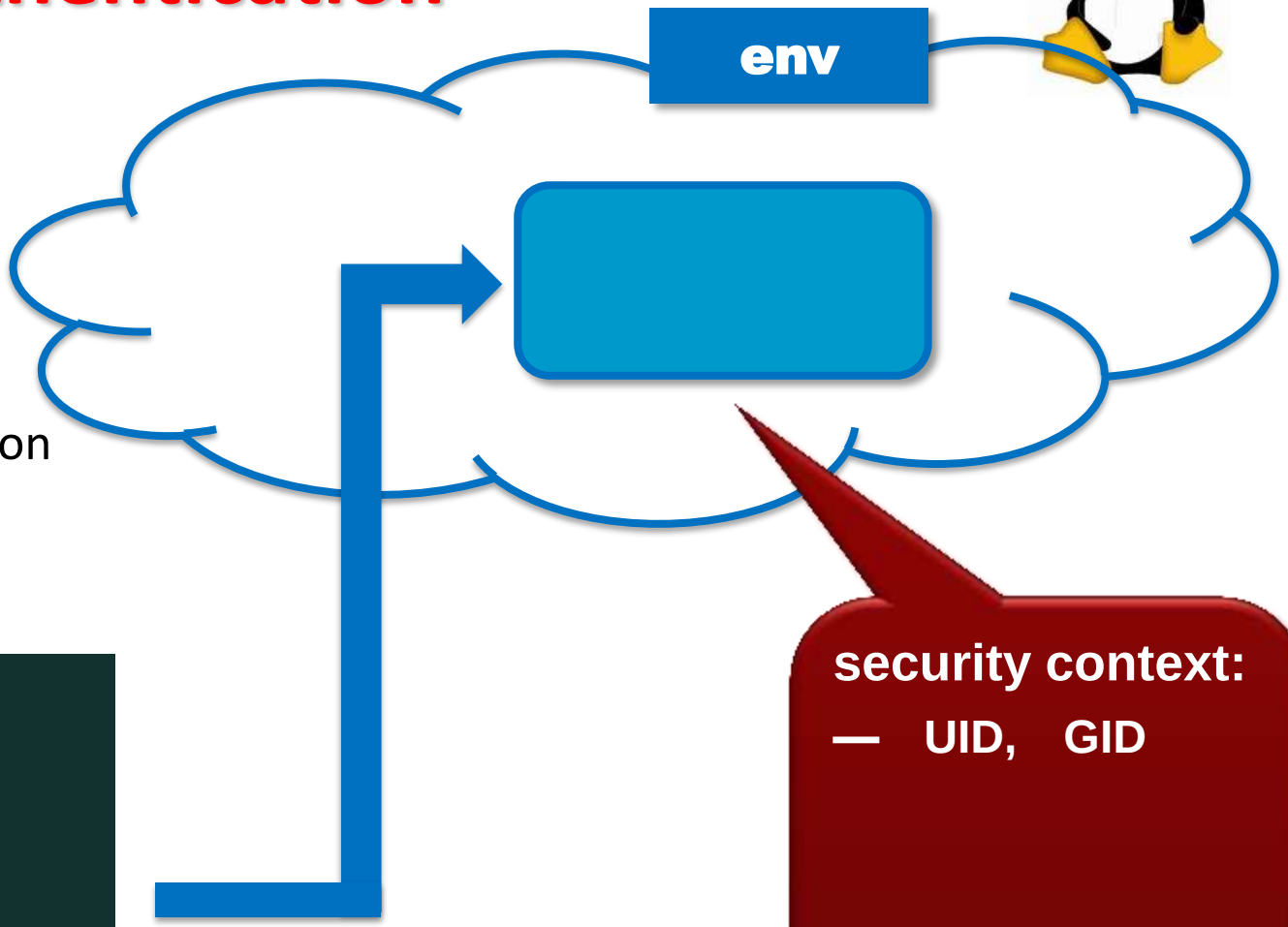
AUTHENTICATION

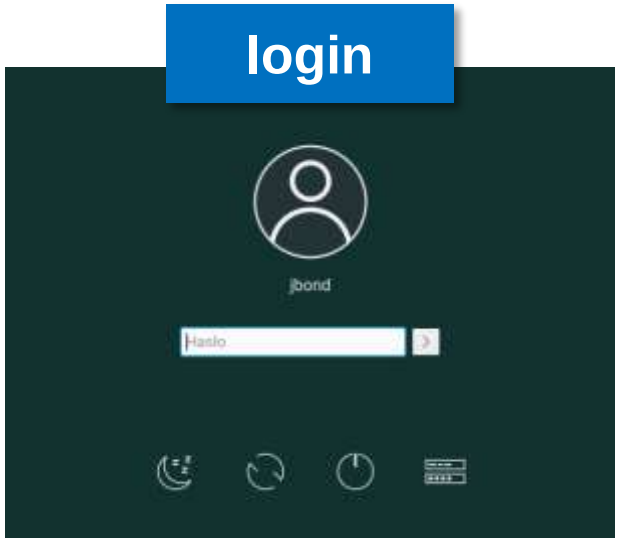
Authentication

Unix

IEEE 1003.1 (POSIX)

Single Unix Specification



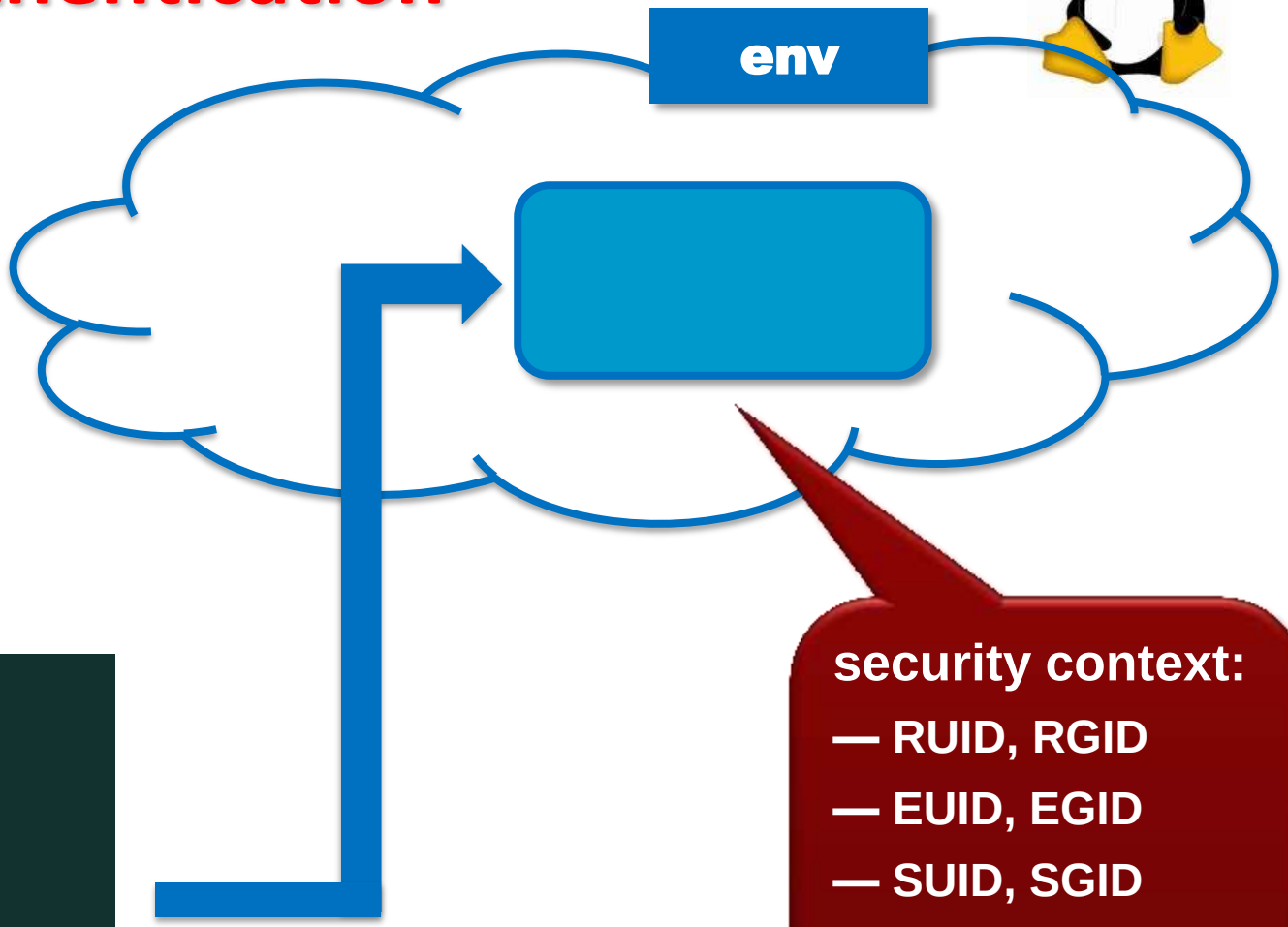


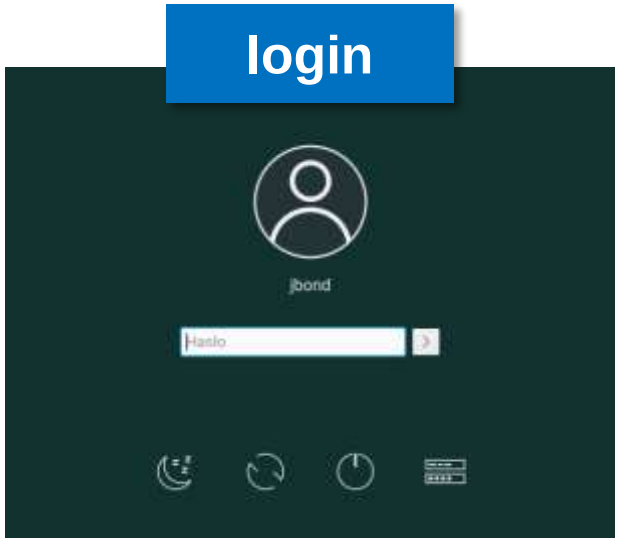
security context:

— **UID, GID**

Authentication

Unix





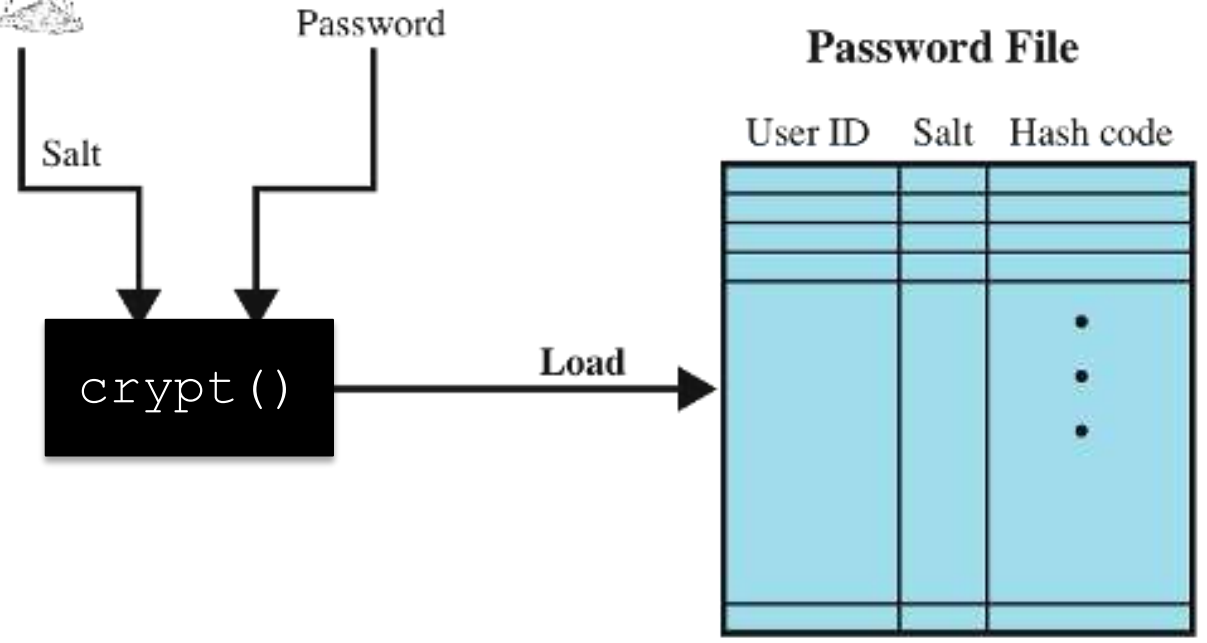
security context:

- **RUID, RGID**
- **EUID, EGID**
- **SUID, SGID**
- **FSUID, FSGID**
- **. . .**

Authentication

Unix

- `/etc/passwd`
- `crypt()`



William Stallings, "Operating Systems"

Authentication

Unix

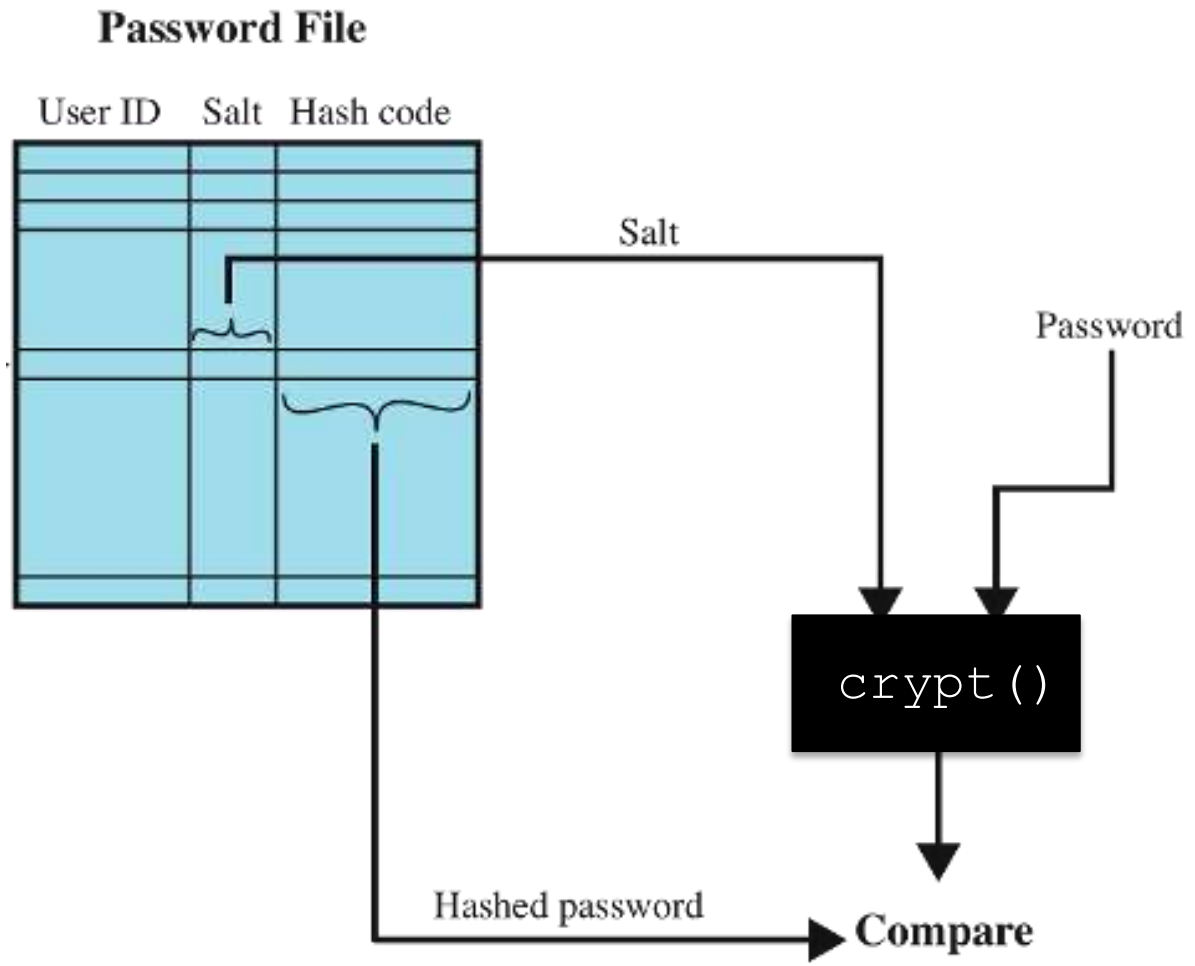
- /etc/passwd
- crypt()

```
wnj:ZDjXDBwXle2gc:8:2:Bill Joy,457E,7780:/a/guest/wnj:/bin/csh
dmr:AiInt5qKdjmHs:9:2:Dennis Ritchie:/a/guest/dmr:
ken:sq5UDrPlKj1nA:10:2:& Thompson:/a/guest/ken:
mike:KnKNwMkyCt8ZI:11:2:mike karels:/a/guest/mike:/bin/csh
carl:S2KiTfS3pH3kg:12:2:& Smith,508-21E,6258:/a/guest/carl:/bin/csh
joshua::999:2:&:/usr/games:/usr/games/wargames
```

Authentication

Unix

- `/etc/passwd`
- `crypt()`



William Stallings, "Operating Systems"

Authentication

Unix

- `/etc/passwd` → `/etc/shadow` → NIS, NetInfo, LDAP
- `crypt()` → SHA-2, `bcrypt()`, `scrypt()`, …

Authentication

Unix

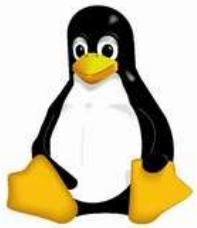
- `/etc/passwd` → `/etc/shadow` → NIS, NetInfo, LDAP
- `crypt()` → SHA-2, `bcrypt()`, `scrypt()`, …

Hash stretching:

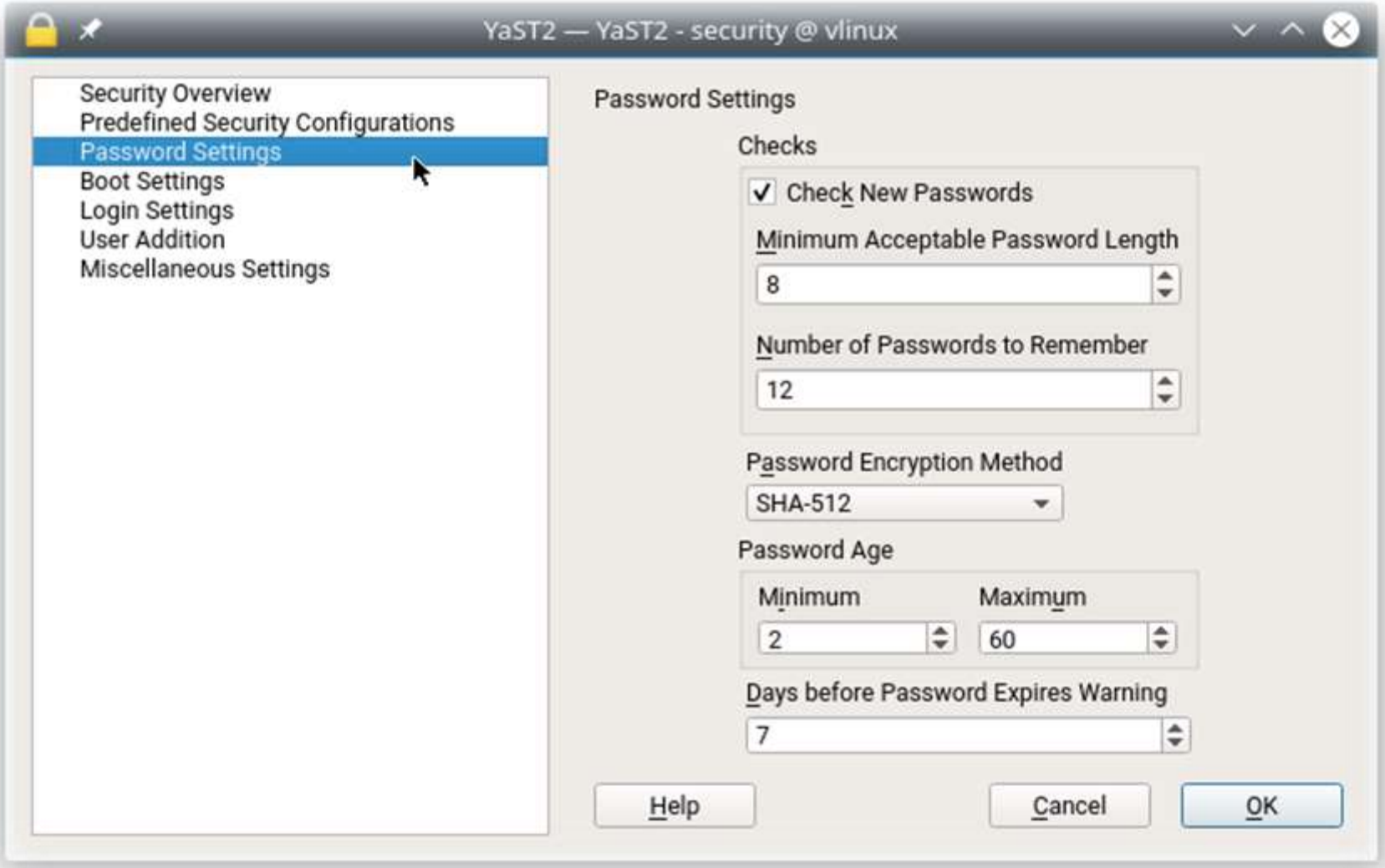
`/etc/security/crypt.conf`

```
CRYPT=SHA512
SHA512_CRYPT_FILES=500000
```

Authentication

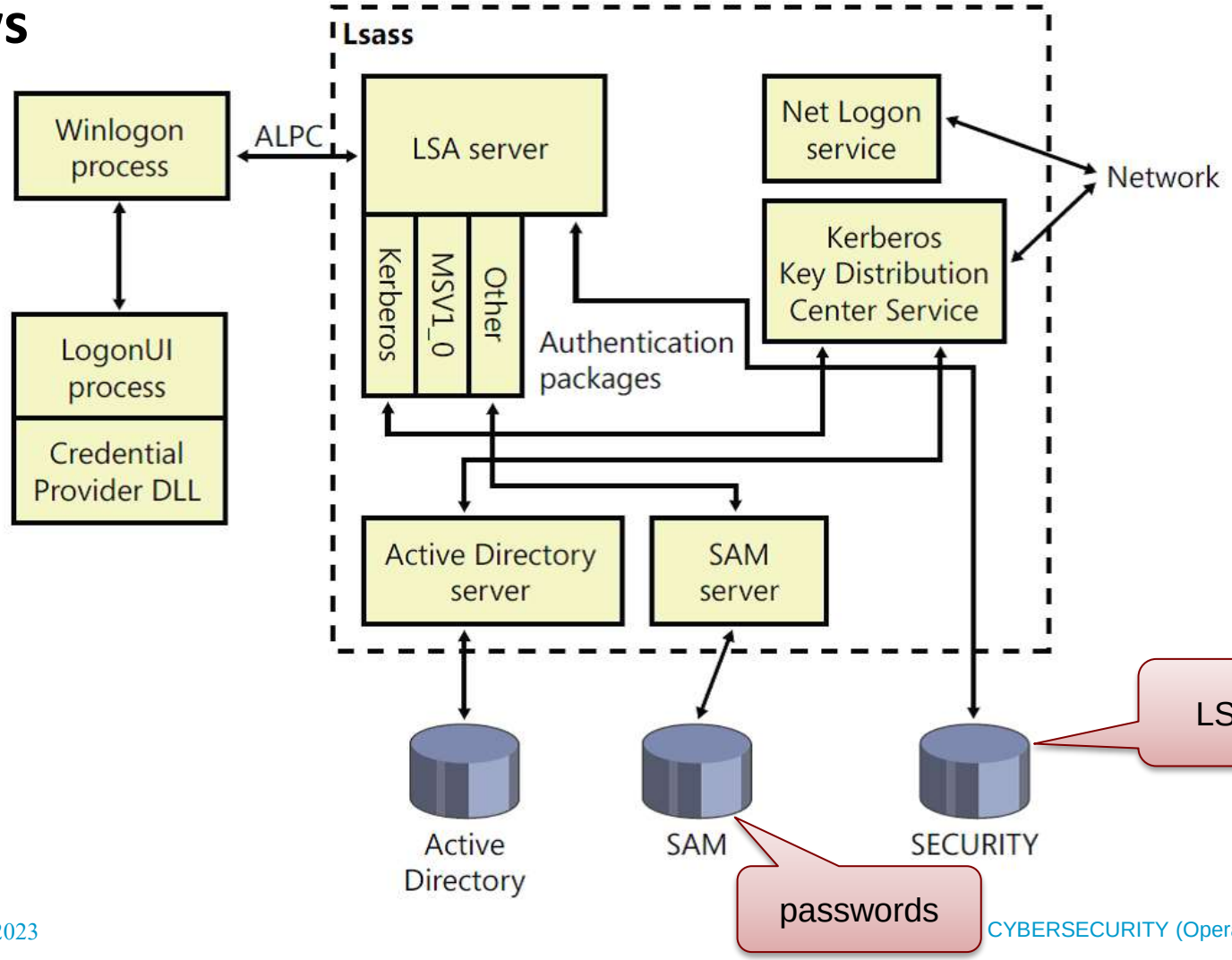


Unix



Authentication

Windows



Mark Russinovich, "Windows Internals"

Authentication

Windows

- SAM (Security Accounts Manager)
  NTFS: %SYSTEMROOT%\SYSTEM32\CONFIG\SAM ⇒ HKLM\SAM
- NTLM hash (variant of MD4) 128b
- storage encrypted with RC4 → AES-128 SysKey
- Win7: Password-Based Key Derivation Function (PBKCS) + SHA-256
- Win10: Windows Hello (biometrics) + Credentials Guard (→VBS)
- Active Directory: Kerberos

HOMEWORK

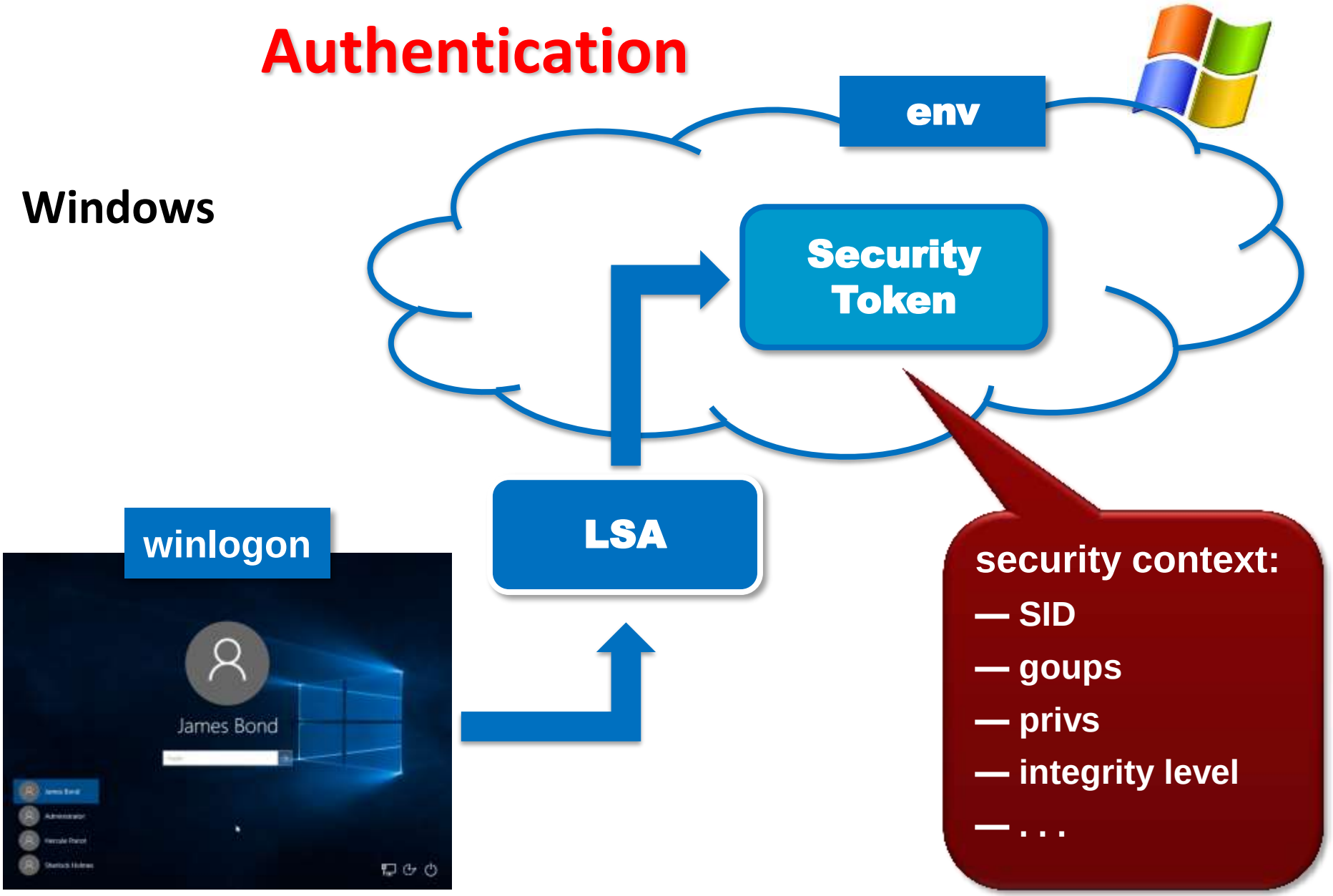
=

Half Of My Energy Wasted On Random Knowledge

→ **Pass the Hash (PtH) attack**

Authentication

Windows



Authentication

env

```
PS C:\Users\Administrator> $token = Get-NtToken -User JamesBond
PS C:\Users\Administrator> Show-NtToken $token
PS C:\Users\Administrator>
```

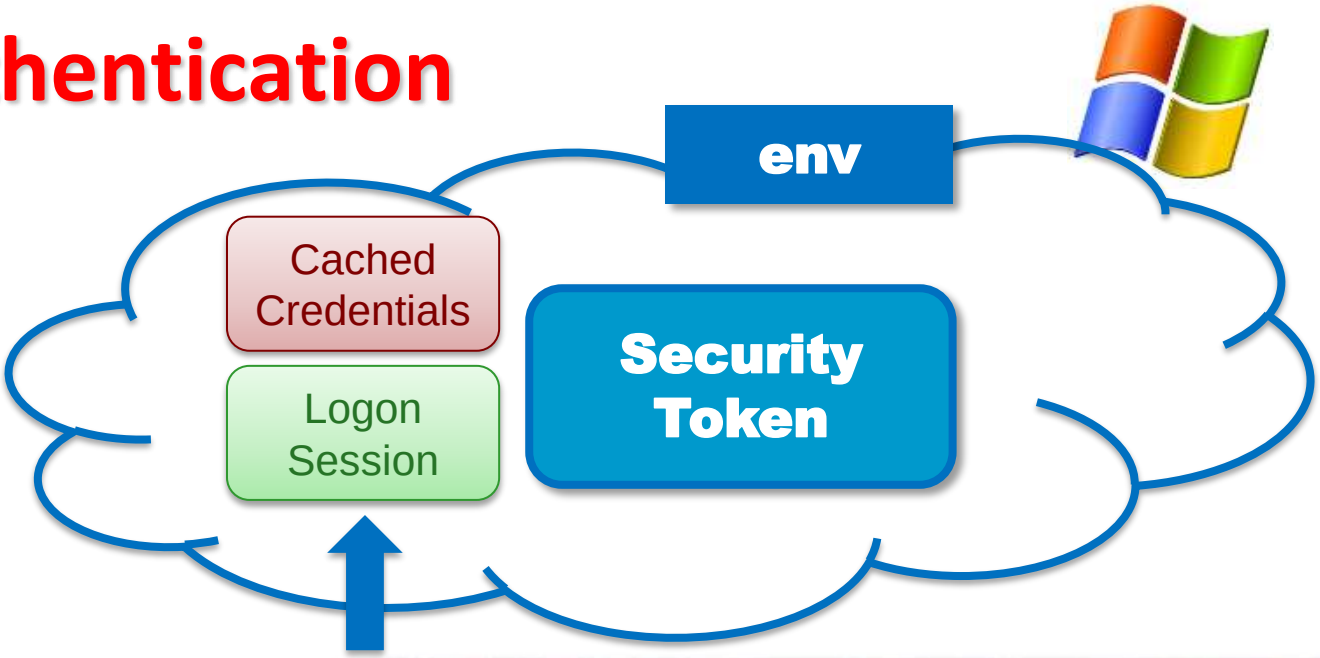
User VIRT-WIN\JamesBond - TokenId 00000000-00204933

Main Details | Groups | Privileges | Default Dacl | Misc | Operations | Security

Name	Flags
SeBackupPrivilege	Disabled
SeChangeNotifyPrivilege	Default Enabled
SeCreateGlobalPrivilege	Default Enabled
SeCreatePageFilePrivilege	Default Enabled
SeCreateSymbolicLinkPrivilege	Default Enabled
SeDebugPrivilege	Disabled
SeDelegateSessionUserImpersonatePrivilege	Disabled
SeImpersonatePrivilege	Disabled
SeIncreaseBasePriorityPrivilege	Default Enabled
SeIncreaseQuotaPrivilege	Default Enabled
SeIncreaseWorkingSetPrivilege	Default Enabled
SeLoadDriverPrivilege	Disabled
SeManageVolumePrivilege	Default Enabled
SeProfileSingleProcessPrivilege	Default Enabled
SeRemoteShutdownPrivilege	Default Enabled
SeRestorePrivilege	Disabled
SeSecurityPrivilege	Default Enabled
SeShutdownPrivilege	Default Enabled
SeSystemEnvironmentPrivilege	Default Enabled
SeSystemProfilePrivilege	Default Enabled
SeSystemTimePrivilege	Default Enabled
SeTakeOwnershipPrivilege	Disabled
SeTimeZonePrivilege	Default Enabled
SeUndockPrivilege	Default Enabled

Authentication

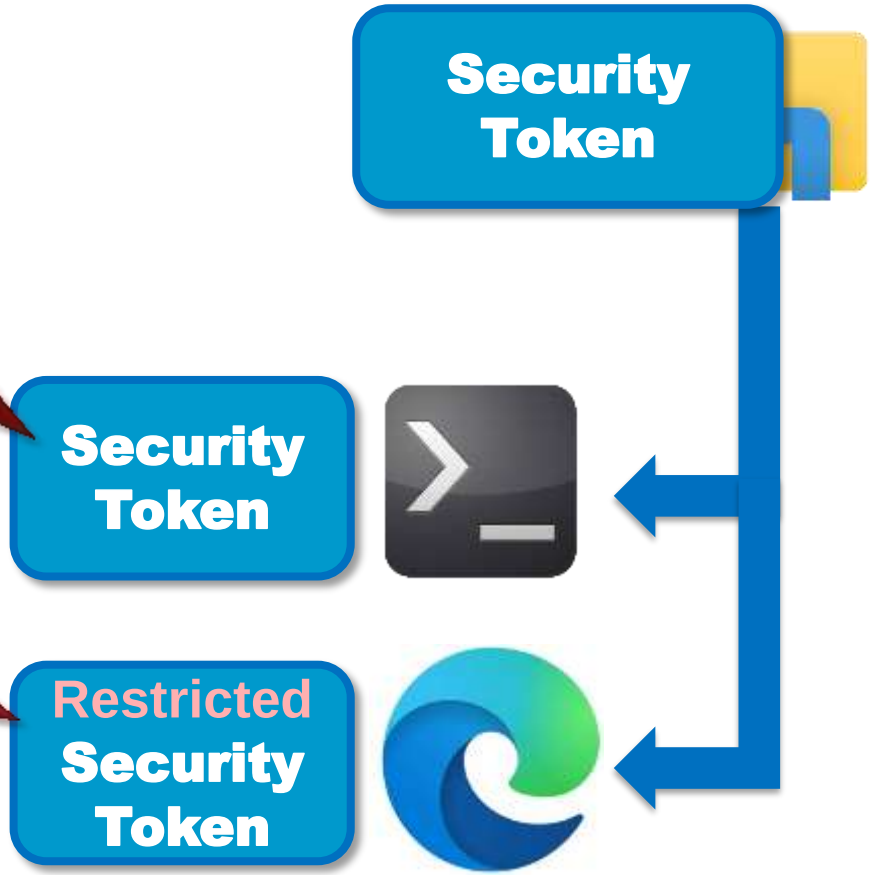
Windows



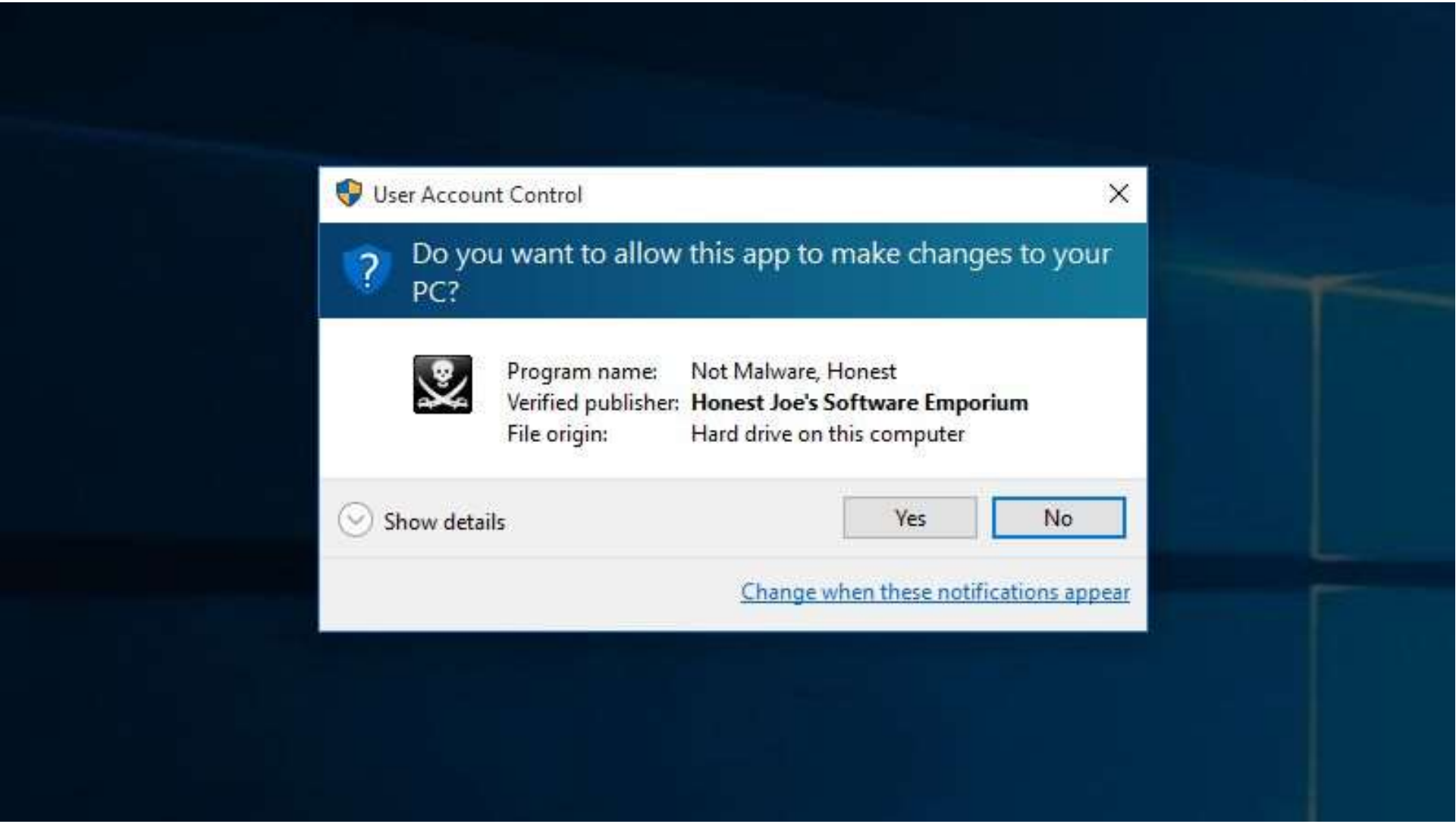
Authentication

security context:
— . . .
— privs:
1) …
2) …
3) …
4) …

security context:
— . . .
— privs:
2) …
4) …



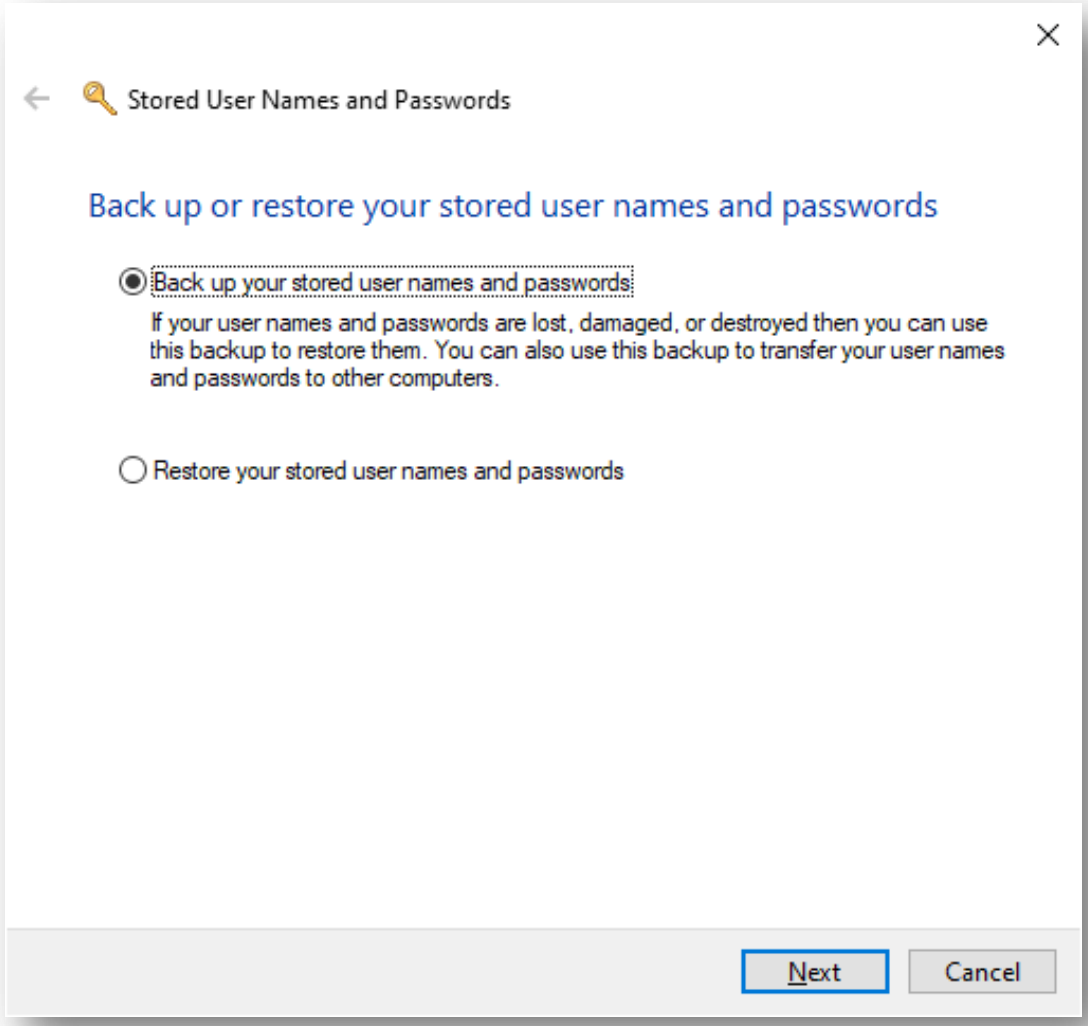
User Account Control (UAC)



Authentication

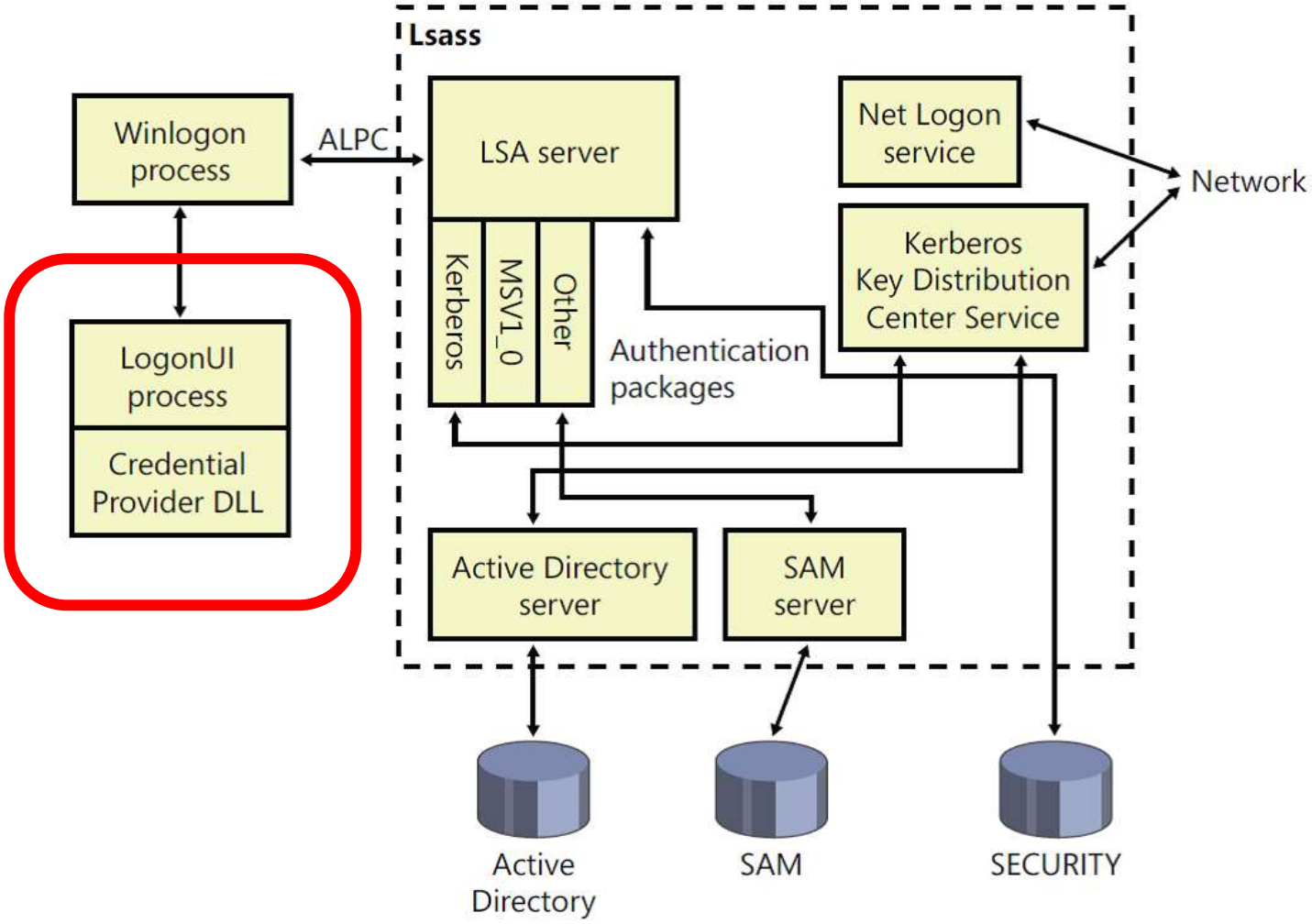
Windows

- credwiz.exe



Authentication

Windows

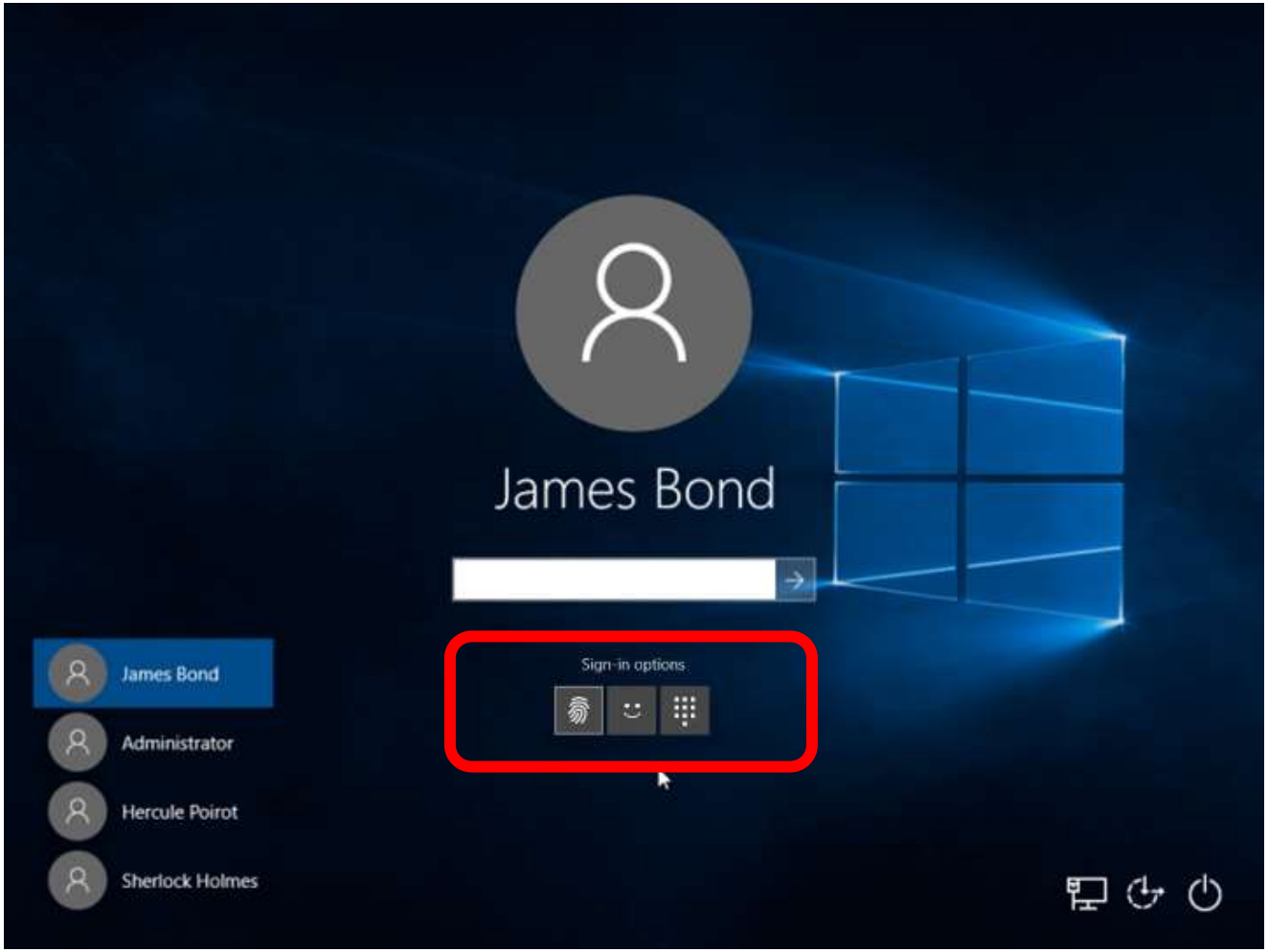


Mark Russinovich, "Windows Internals"

REPLAY

Authentication

Windows

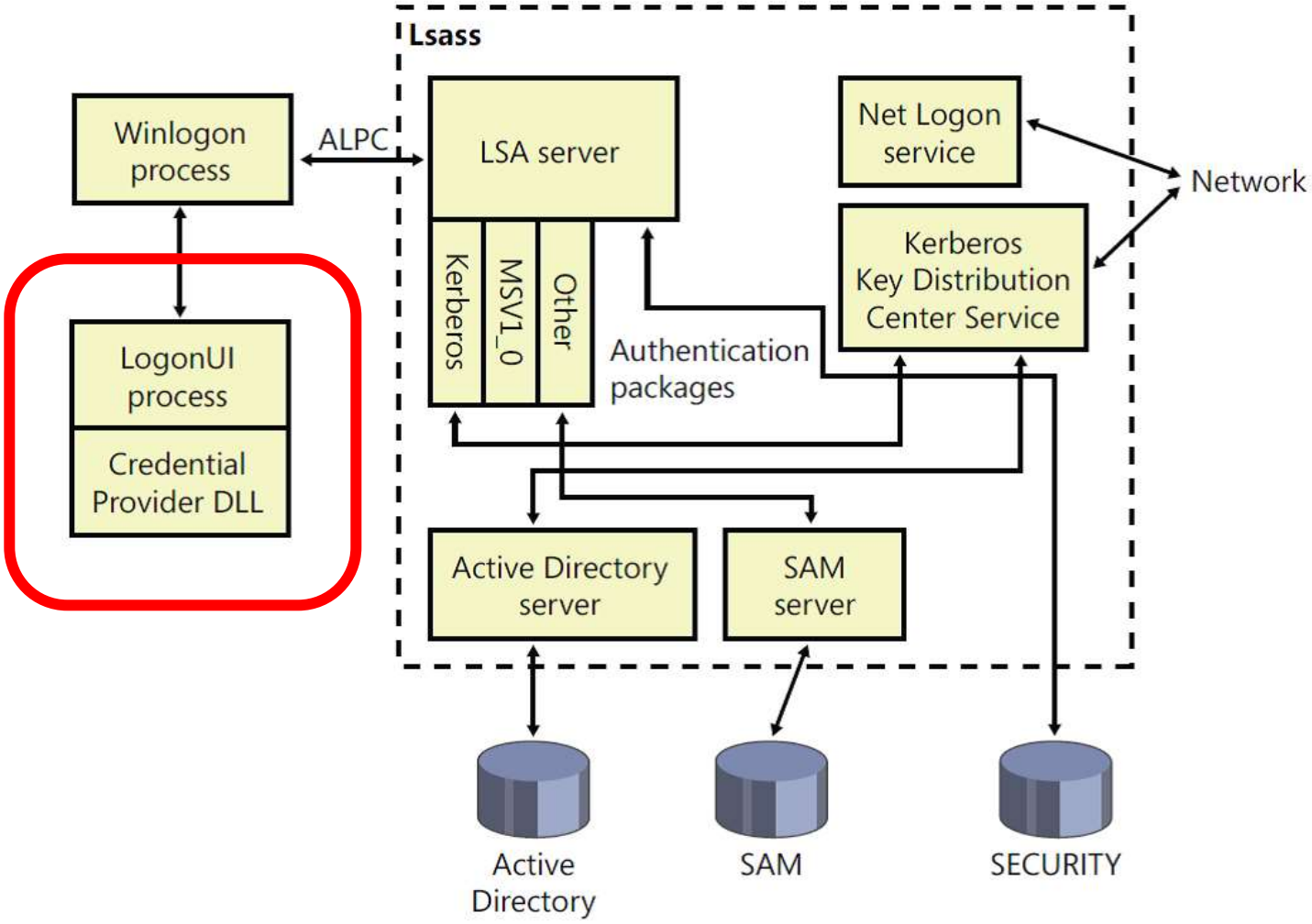


Authentication

One-Time Passwords

Authentication

Windows



Mark Russinovich, "Windows Internals"

REPLAY

Authentication

One-Time Passwords

Authentication

One-Time Passwords

Hardware:

Software:

S/Key

OPIE (One-time Passwords In Everything)

HOTP (HMAC OTP):

- open standard (RFC 4226)
- Time-based OTP (TOTP , RFC 6238)

. . .

Authentication

One-Time Passwords

S/Key (Lamport ’80)

- no crypto involved, only a hash function
- initial password: P
- hash list: P, $h(P)$, $h(h(P))$, ..., $h^{t-1}(P)$
- i-th password = $h^{t-i}(P)$, $1 \leqslant i \leqslant t$
- initial password reuse: $h^{t-i}(P|salt)$

Authentication

Two-Factor Authentication (2FA)

Multi-Factor Authentication (MFA)

Authentication

1. **Local passwords**
   - hashes
   - hash stretching and protection
   - password policy
2. **OTP, 2FA (MFA)**
3. **Security tokens (→ authorization)**
   - impersonation
   - Consent & Credentials (UAC)

AUTHORIZATION

&

ACCESS CONTROL

Authorization & Access Control

Unix — POSIX (*Portable Operating System Interface*)

POSIX 1003.1

- r w x
- u g o
- SUID, SGID, sticky

POSIX 1003.1e/1003.2c

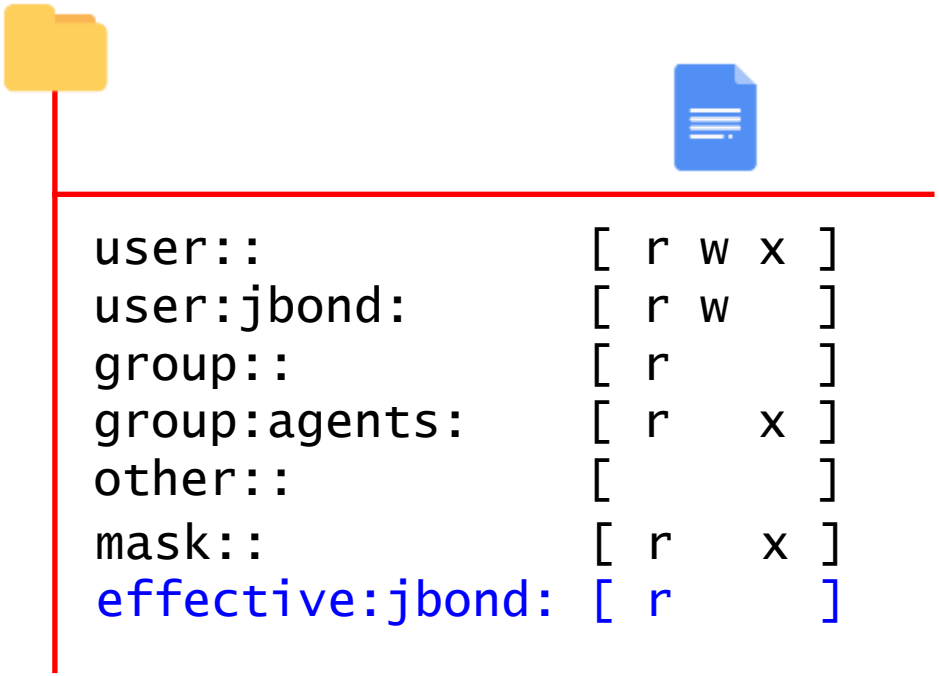
- ACL (also NFSv3, but not NFSv4!)
- CAP
- MAC: Trusted Solaris, Trusted IRIX, TrustedBSD, …
- LO MAC (Low Water-Mark MAC): Linux, FreeBSB

Authorization & Access Control

POSIX ACL

Access Control Entry

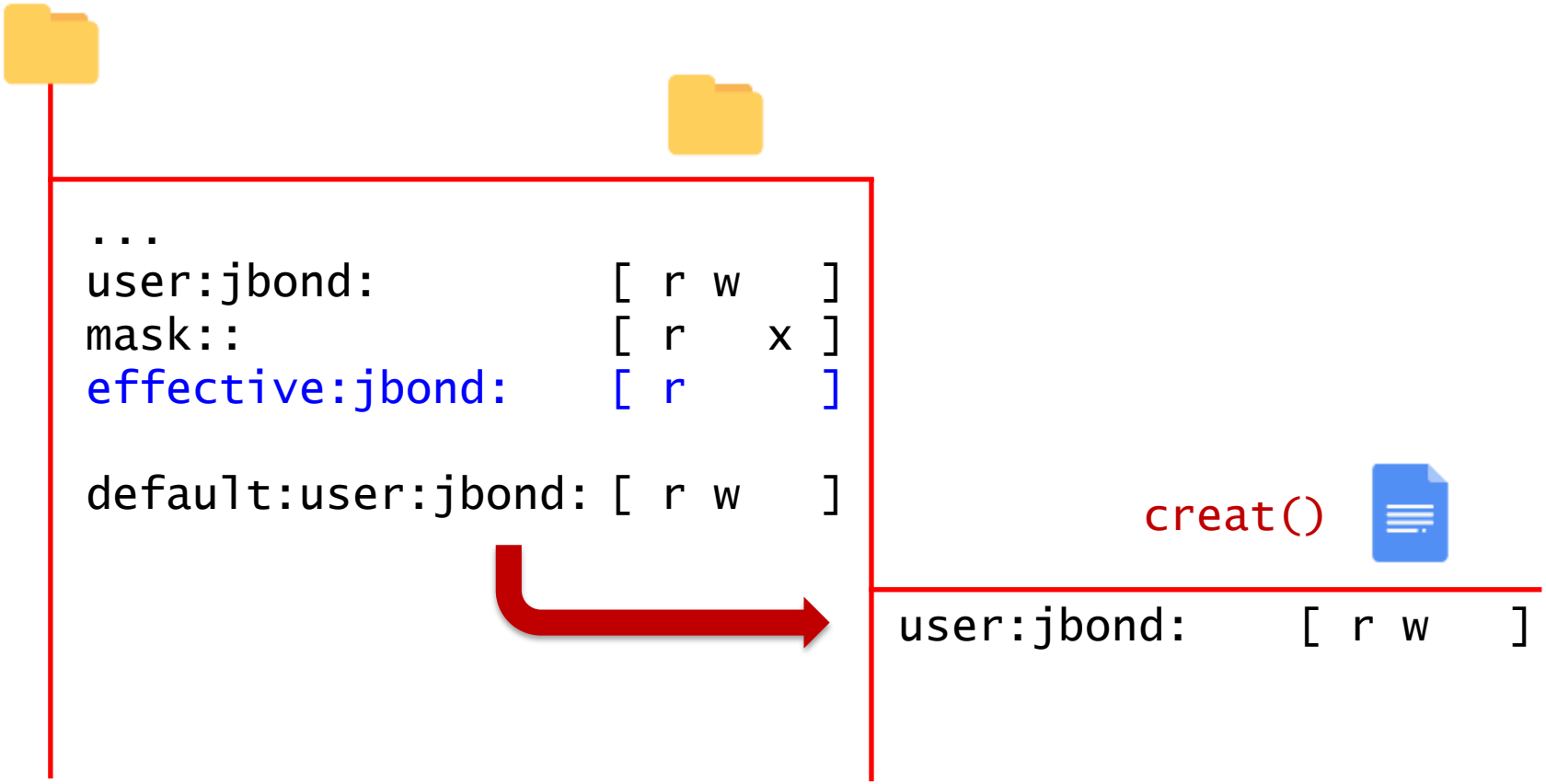
- base ACE = u g o
- extended ACE:



```
user::              [ r w x ]
user:jbond:         [ r w   ]
group::             [ r     ]
group:agents:       [ r   x ]
other::             [       ]
mask::              [ r   x ]
effective:jbond:    [ r     ]
```

Authorization & Access Control

POSIX ACL



Authorization & Access Control

POSIX ACL

```
$ setfacl -n -m user:jbond:rwx .
$ getfacl --omit-header .
  user::rwx
  user:jbond:rwx
  group::r-x
  group:agents:r-x
  mask::r-x
  other::---
  default:user::rwx
  default:group::r-x
  default:mask::r--
  default:other::---
```

Authorization & Access Control

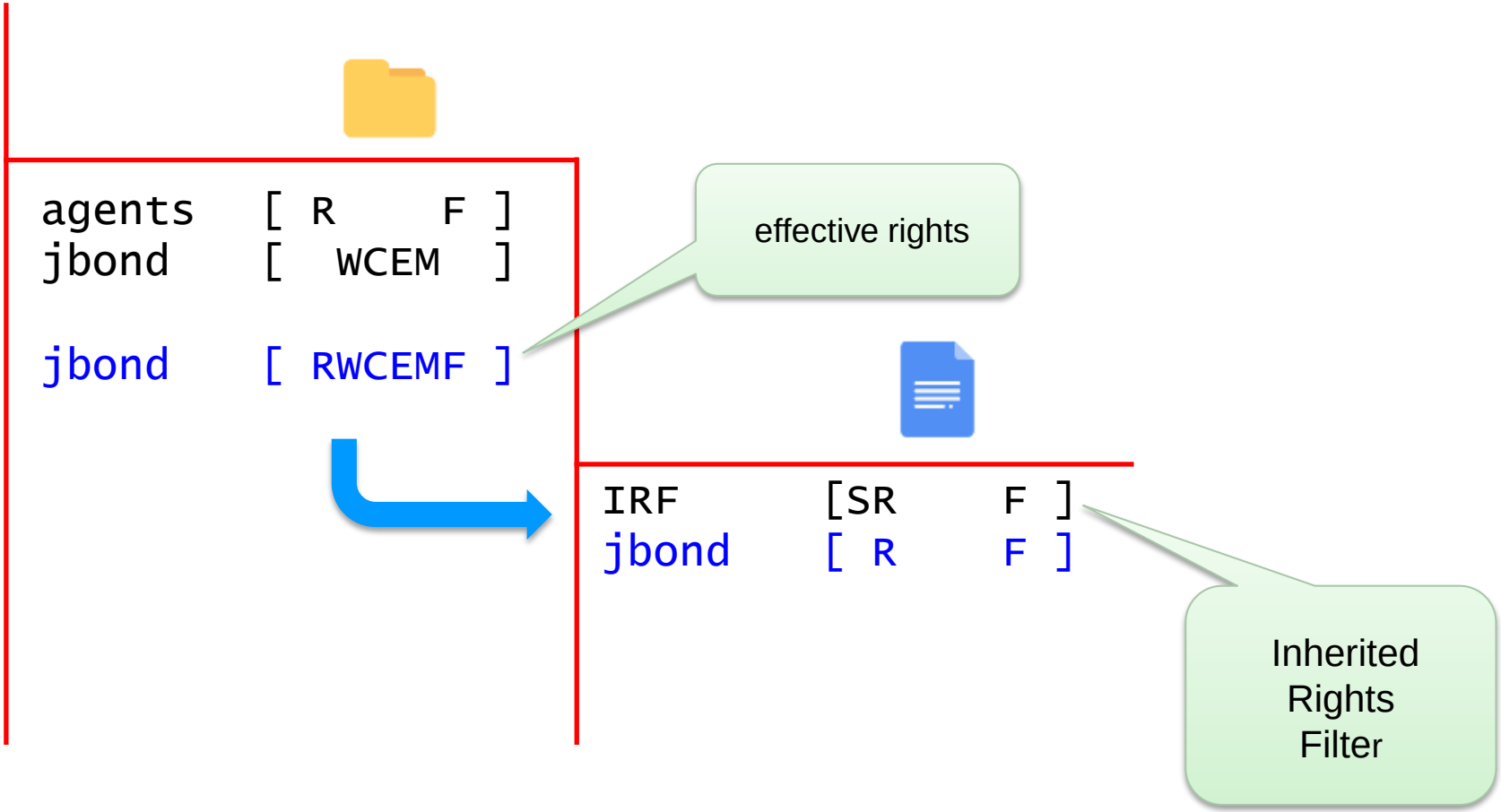
Trustees

- NetWare (Novell), Linux (http://trustees.sourceforge.net/), RSBAC

R (Read)
W (Write)
C (Create)
E (Erase)
M (Modify)
F (File scan)
A (Access control)
S (Supervisory)

Authorization & Access Control

Trustees



Authorization & Access Control

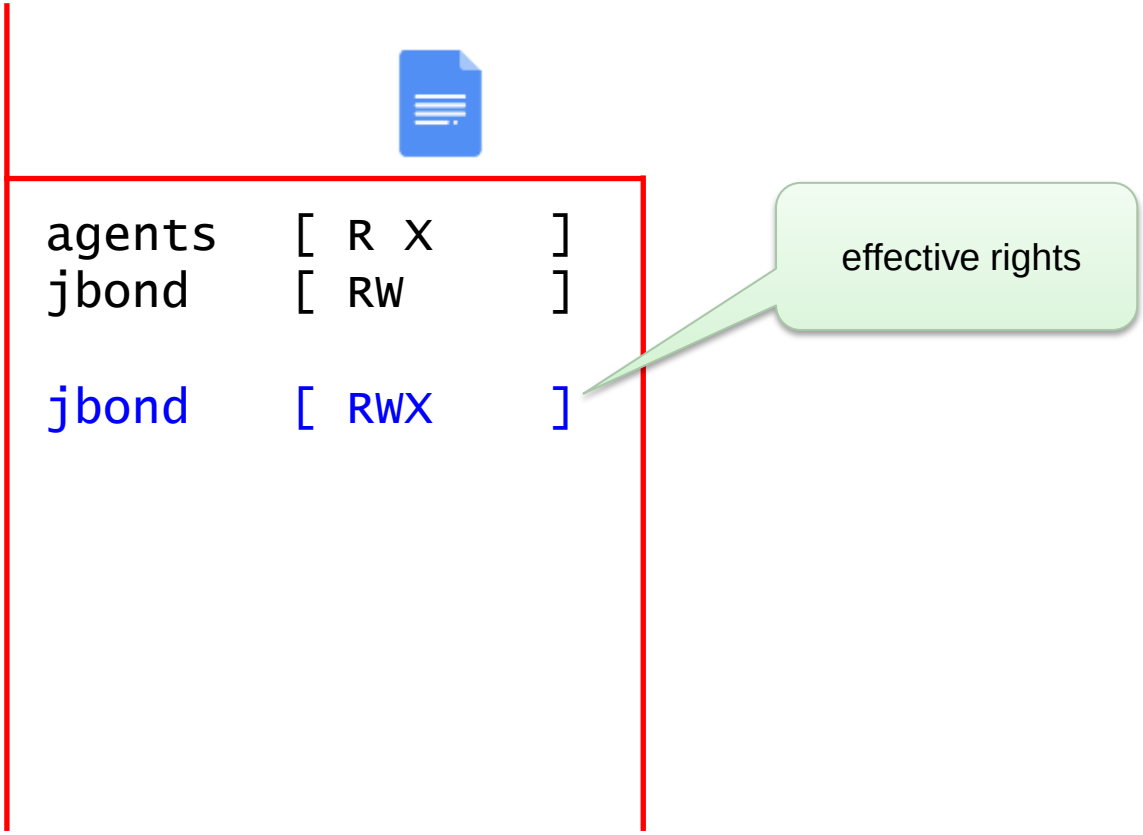
Windows

- ACL in NTFS (called DACL)
- SMB/CIFS (Common Internet File System) support
- distinct GRANT and DENY assignments
- dynamic groups (such as All Authenticated Users)
- multiple attributes: append
  delete
  change permissions
  take ownership
  . . .

similar to `chattr` *, richACL, and NTFSv4 for Unix*

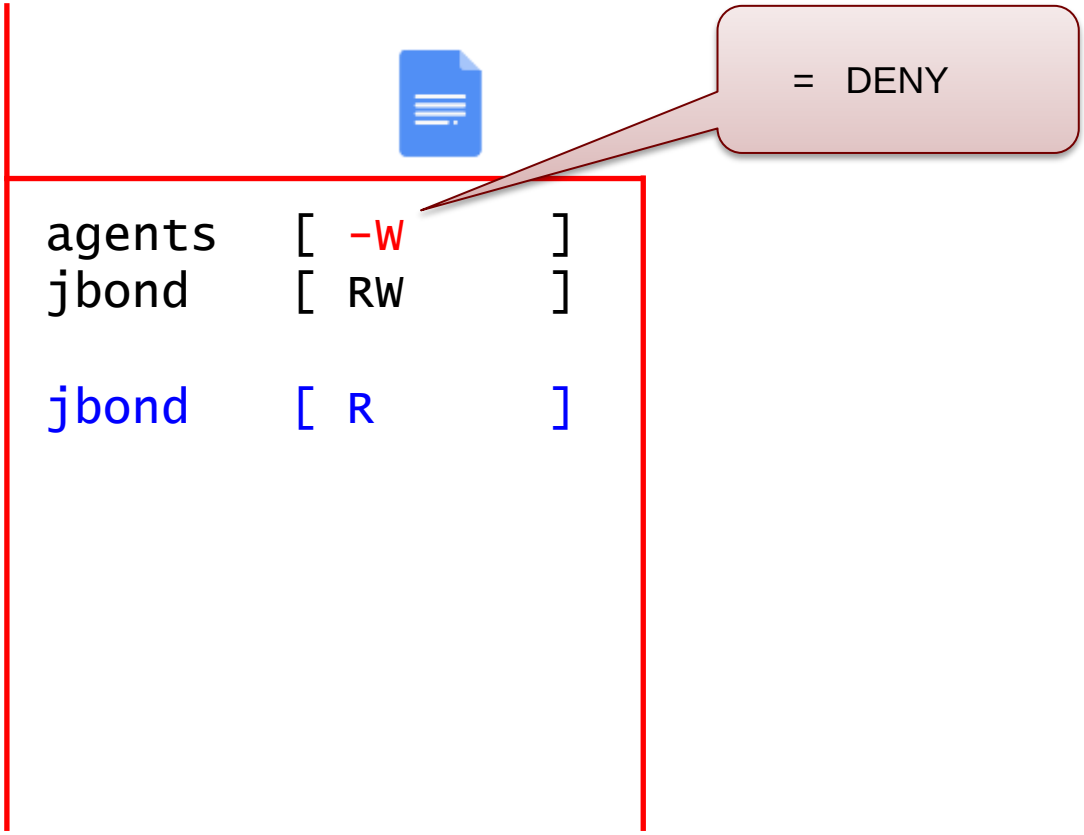
Authorization & Access Control

Windows DACL



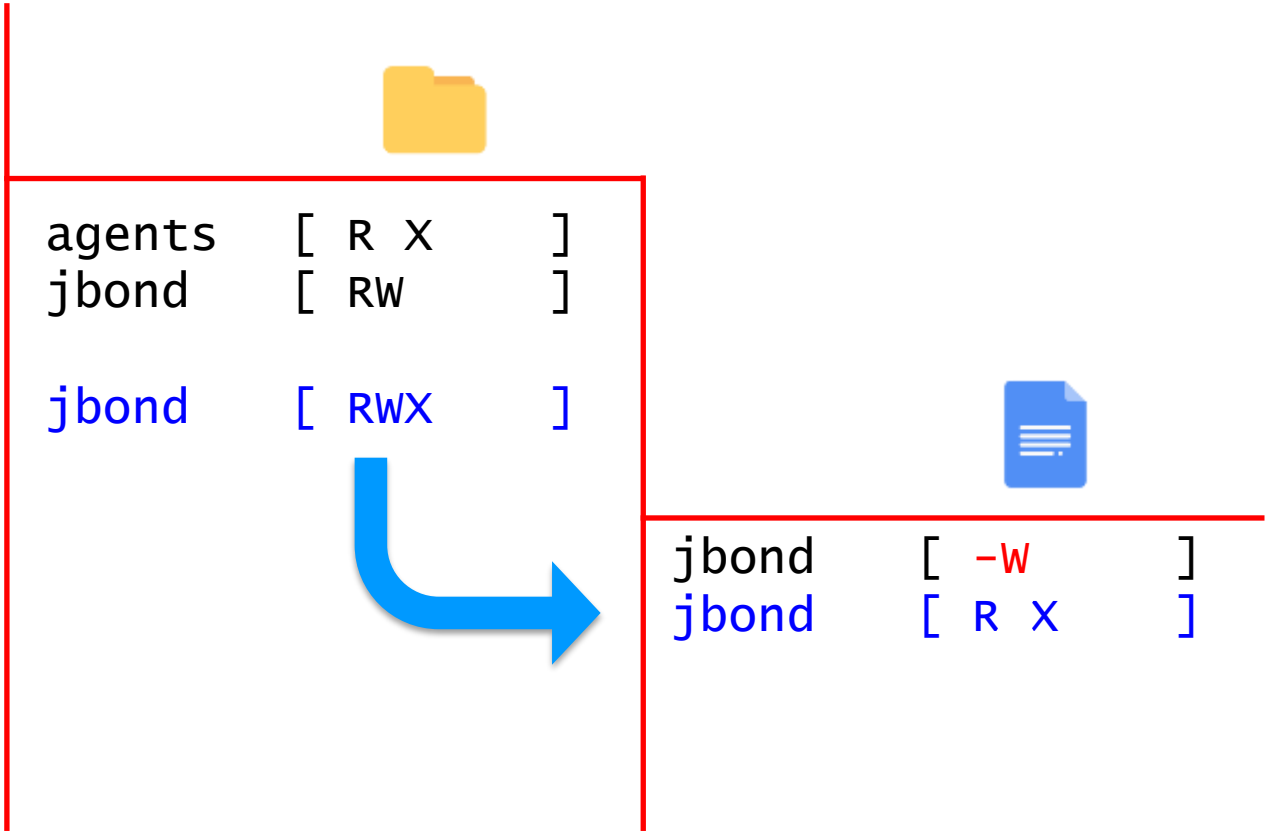
Authorization & Access Control

Windows DACL



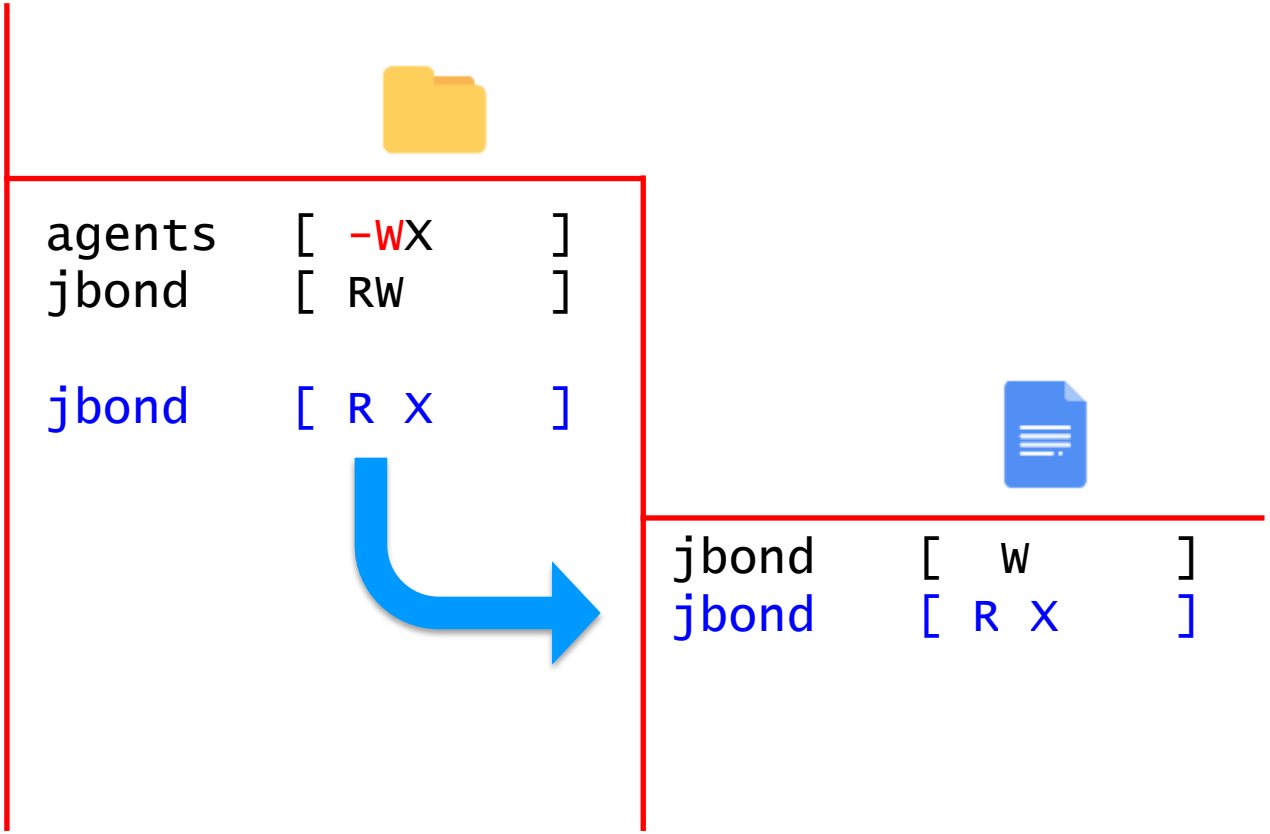
Authorization & Access Control

Windows DACL



Authorization & Access Control

Windows DACL



Mandatory Integrity Control (MIC)

Windows Integrity Levels

0 = untrusted: SID S-1-16-0x0000

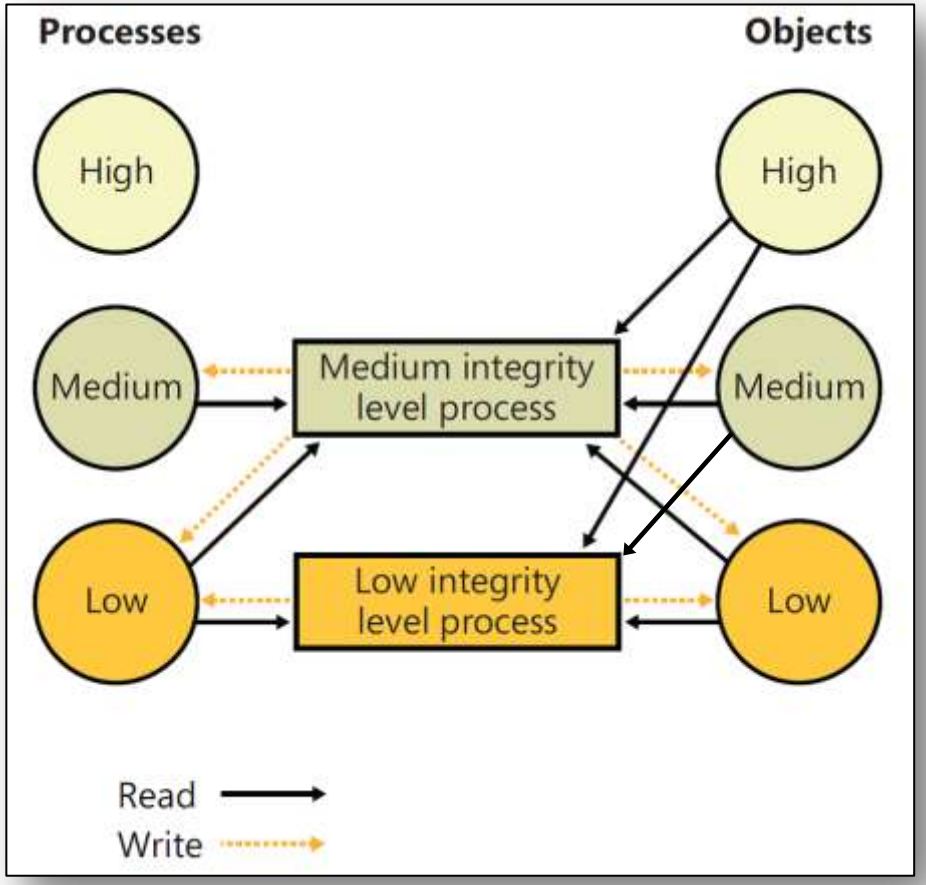
1 = low: SID S-1-16-0x1000

2= medium: SID S-1-16-0x2000

3 = high: SID S-1-16-0x3000

4 = system: SID S-1-16-0x4000

5 = protected: SID S-1-16-0x5000



Authorization & Access Control

Android

```
shell@android:/ $ ps
USER     PID   PPID VSIZE RSS     PC NAME
root     1     0     640   496   S /init
root     46    1     4660 1200   S /system/bin/vold
root     48    1     9772 1268   S /system/bin/netd
system   371   52 307064 46084 S system_server
shell    410   52 233948 17132 S adbd
...
radio    520   52 259604 25716 S com.android.phone
u0_a7    524   52 255172 45060 S com.android.systemui
u0_a8    534   52 248952 56996 S com.android.launcher
u0_a16   789   52 244992 20612 S com.android.calendar
u0_a59   819   52 246240 20104 S com.bar.foo
...
```

Authorization & Access Control

Android

```
shell@android:/ $ ls -ld /data/data/com.bar.foo

drwxr-x--x u0_a59 u0_a59 2018-02-27 14:01 com.bar.foo
```

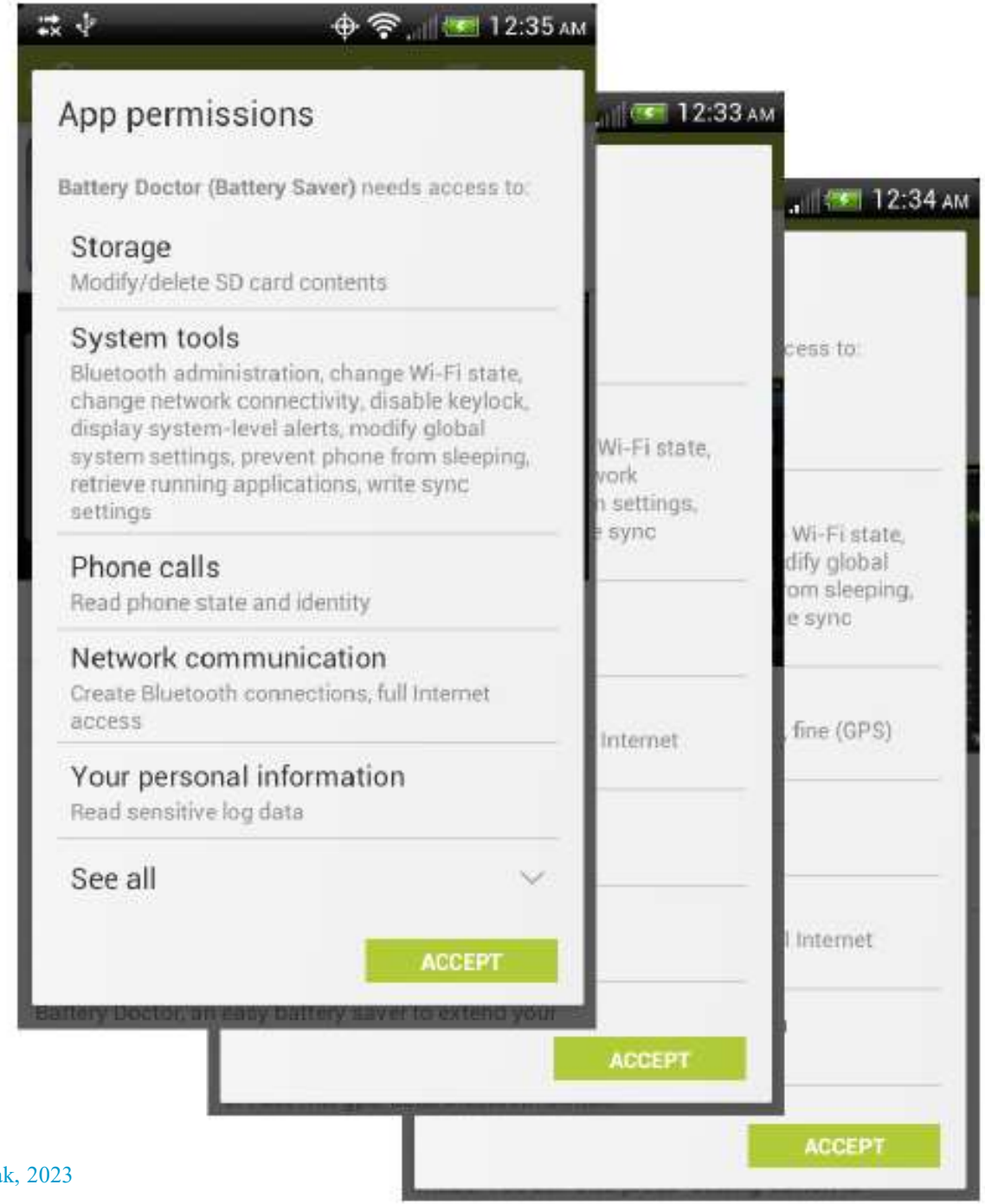
Authorization & Access Control

Android

- `system` user

```
shell@android:/ $ id system
 uid=1000(system) gid=1000(system)
 groups=1003(graphics),1004(input),1007(log),1009(mount),
 1011(adb),1015(sdcard_rw),1028(sdcard_r),3001(net_bt_admin),
 3002(net_bt),3003(inet),3006(net_bw_stats)
```

```
private static final void enforceSystemOrRoot(String message) {
    final int uid = Binder.getCallingUid();
    if (uid != Process.SYSTEM_UID && uid != 0) {
        throw new SecurityException(message);
    }
}
```


12:35 AM
App permissions
Battery Doctor (Battery Saver) needs access to:
Storage
Modify/delete SD card contents
System tools
Bluetooth administration, change Wi-Fi state, change network connectivity, disable keylock, display system-level alerts, modify global system settings, prevent phone from sleeping, retrieve running applications, write sync settings
Phone calls
Read phone state and identity
Network communication
Create Bluetooth connections, full Internet access
Your personal information
Read sensitive log data
See all
ACCEPT
12:33 AM
ACCEPT
12:34 AM
ACCEPT

Android permissions

AndroidManifest.xml

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="com.aditya.something"
    android:versionCode="1"
    android:versionName="1.0" >
    <uses-permission android:name="android.permission.ACCESS_WIFI_STATE" />
    <uses-sdk
        android:minSdkVersion="8"
        android:targetSdkVersion="17" />
...
```

declarative security

http://developer.android.com/guide/topics/manifest/manifest-element.html

Android permissions

/system/etc/permissions/platform.xml

```
<permissions>
   <permission name="android.permission.INTERNET" >
       <group gid="inet" />
   </permission>
   <permission name="android.permission.BLUETOOTH" >
       <group gid="net_bt" />
   </permission>
   <permission name="android.permission.CAMERA" >
       <group gid="camera" />
   </permission>
. . .
```

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.bar.foo"
  <permission-group
      android:name="com.bar.foo.permission-group.TEST_GROUP"                ①
      android:label="@string/foo_permission_group_label"
      android:description="@string/foo_permission_group_desc“  />
  <permission
      android:name="com.bar.foo.permission.PERMISSION1"                     ②
      android:label="@string/permission1_label"
      android:description="@string/permission1_desc"
      android:permissionGroup="com.bar.foo.permission-group.TEST_GROUP"
      android:protectionLevel="signature" />
  <permission-tree
      android:name="com.bar.foo.permission"                                 ③
      android:label="@string/foo_permission_tree_label" />
. . .
```

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.bar.foo"
```

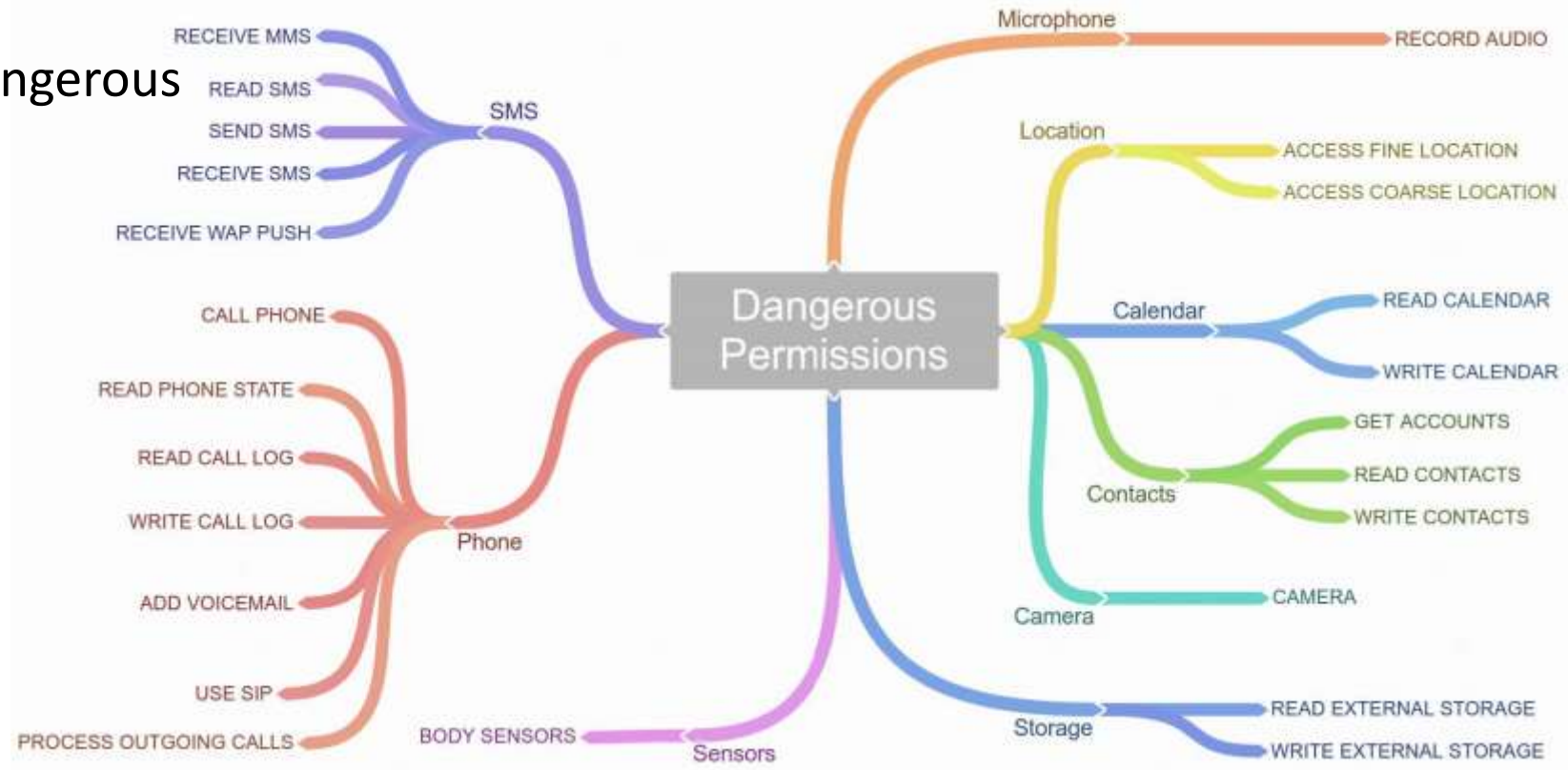
```
PackageManager pm = getPackageManager();
PermissionInfo permission = new PermissionInfo();                    ①
permission.name = "com.bar.foo.permission.PERMISSION2";
permission.labelRes = R.string.permission2_label;
permission.protectionLevel = PermissionInfo.PROTECTION_SIGNATURE;
boolean added = pm.addPermission(permission);                        ②
Log.d(TAG, "permission added: " + added);
```

```
      android:description="@string/permission1_desc"
      android:permissionGroup="com.bar.foo.permission-group.TEST_GROUP"
      android:protectionLevel="signature" />
  <permission-tree
      android:name="com.bar.foo.permission"                          ③
      android:label="@string/foo_permission_tree_label" />
. . .
```

Android permissions

Permission Protection Levels:

- normal
- dangerous



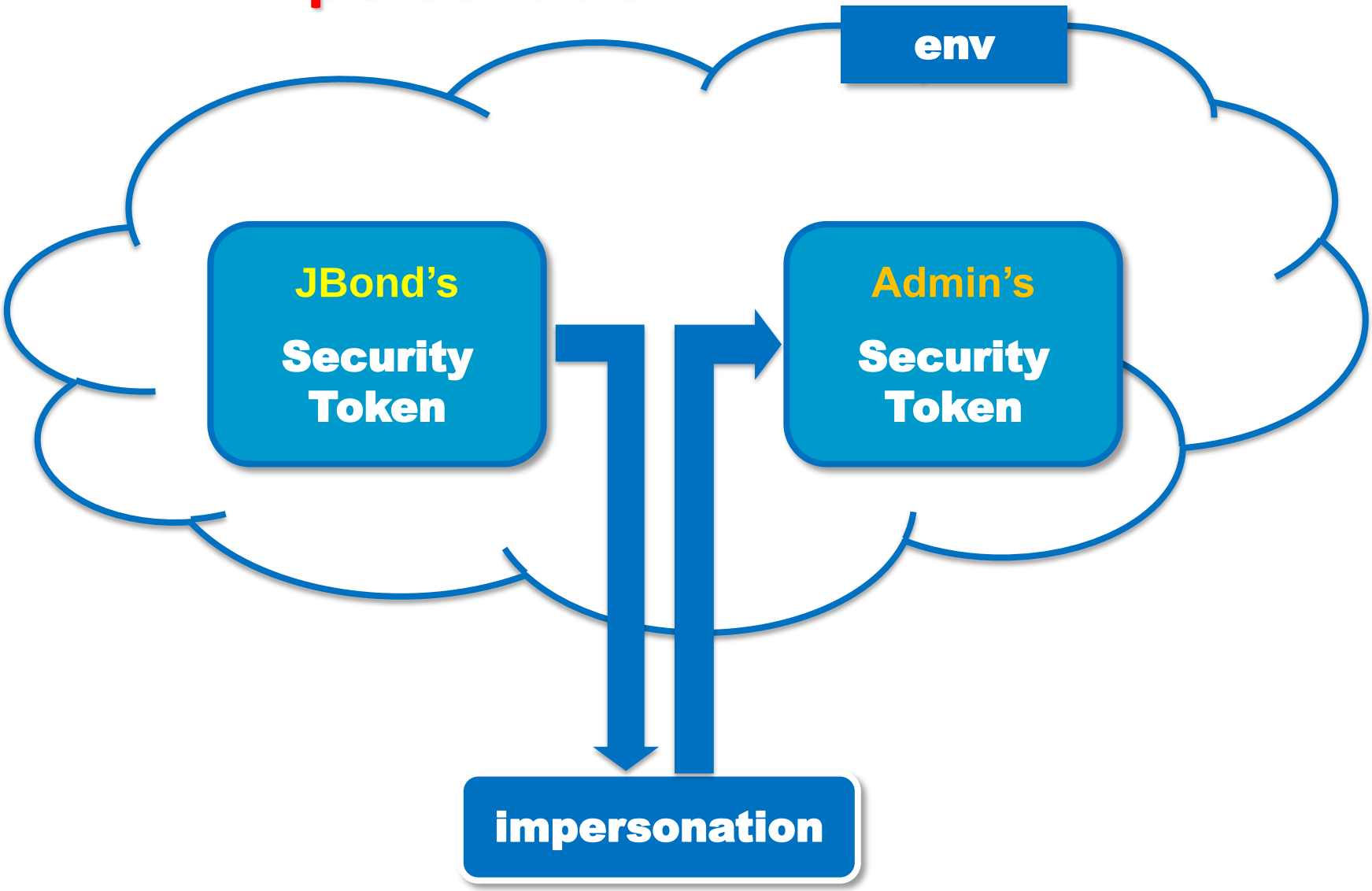
Android permissions

Permission Protection Levels:

- normal
- dangerous (e.g. READ_SMS, CAMERA)
- signature (only applications that are signed with the same key)
- system (only system image applications or `/system`)
- signatureOrSystem (`/system/priv-app/`)
- development (only privileged context ADB)
- *applications that do not have any intention of sharing data or functionality with applications from other developers should always define permissions with the* signature *protection level*

Impersonation

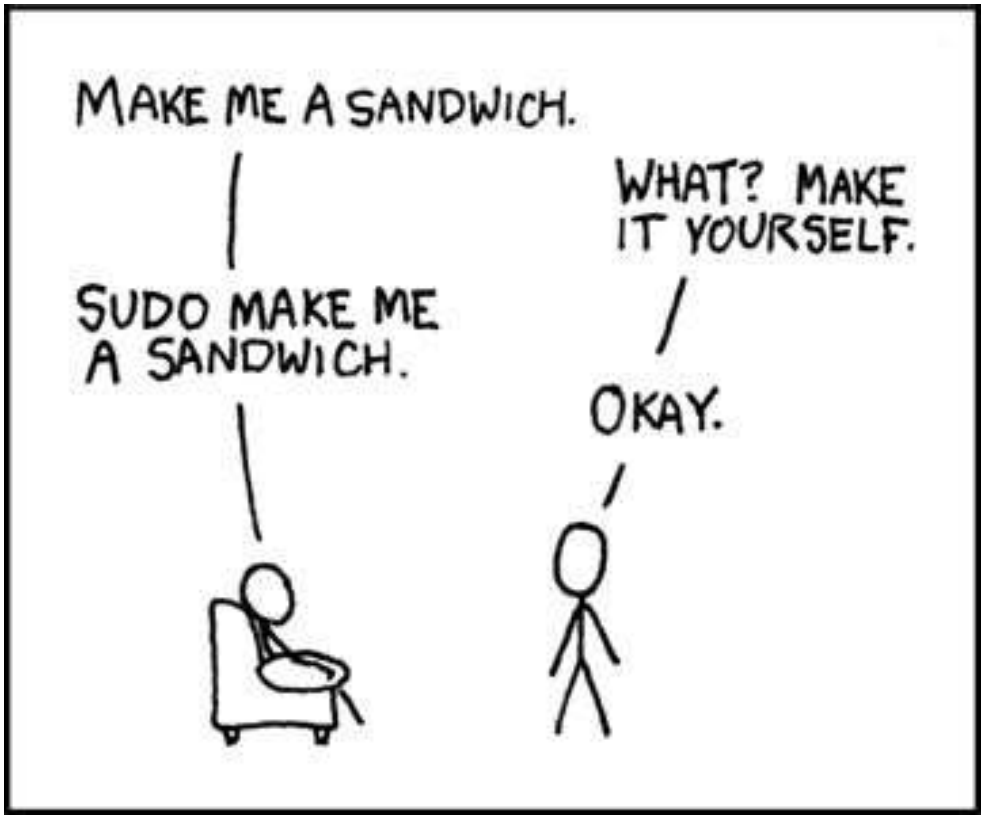
Impersonation



Impersonation

Unix: su
sudo
SUID/SGID

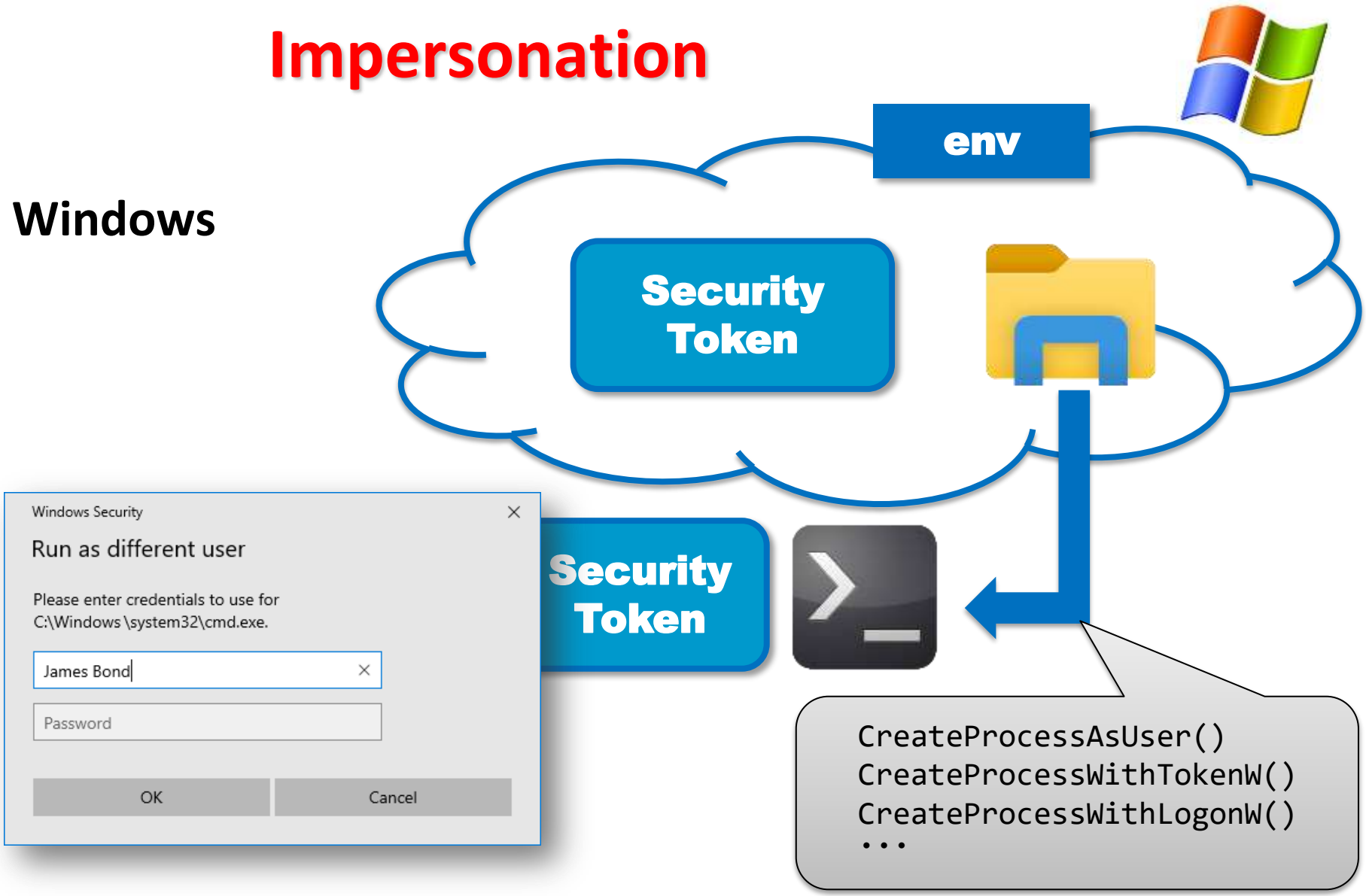
Windows: runas



(*Randall Munroe*) https://xkcd.com

Impersonation

Windows



Impersonation

Android

- `root/system` users do not have a password (no `/etc/passwd`)
- by default no `su` or `sudo`
- `/system` partition is mounted as `nosuid`
- Android 4.3 has removed all SUID/SGID system programs and added support for → POSIX capabilities instead

Privilege separation

Unix

env

Security context

EUID = root

EUID = nobody

Security context

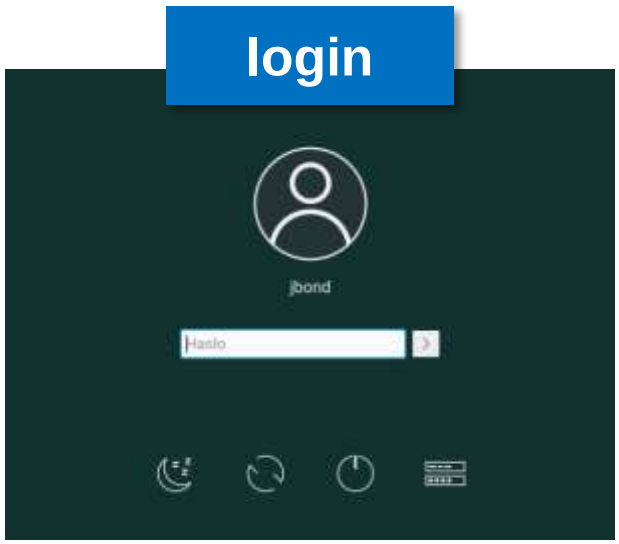
EUID = nobody

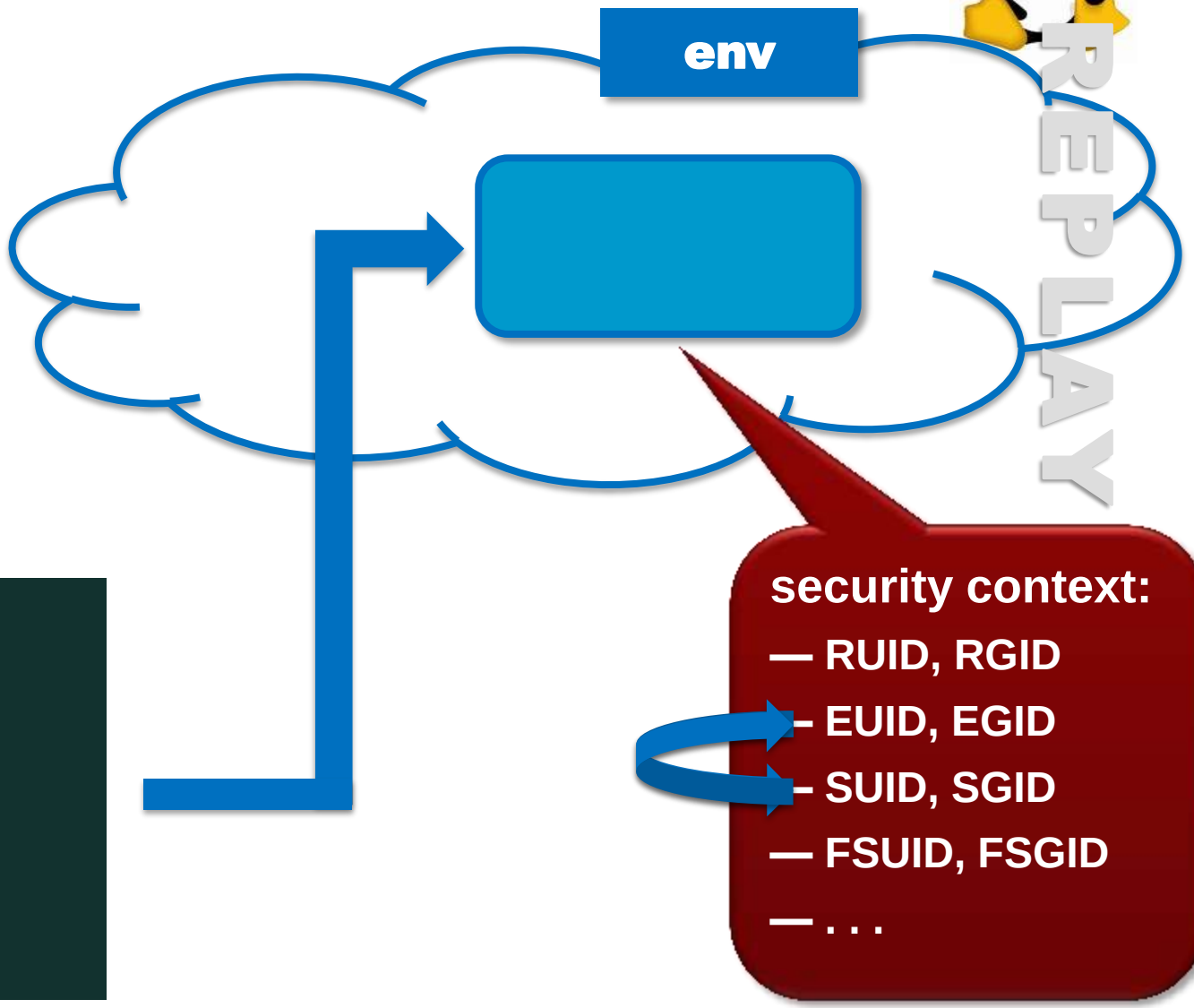
Security context

seteuid()

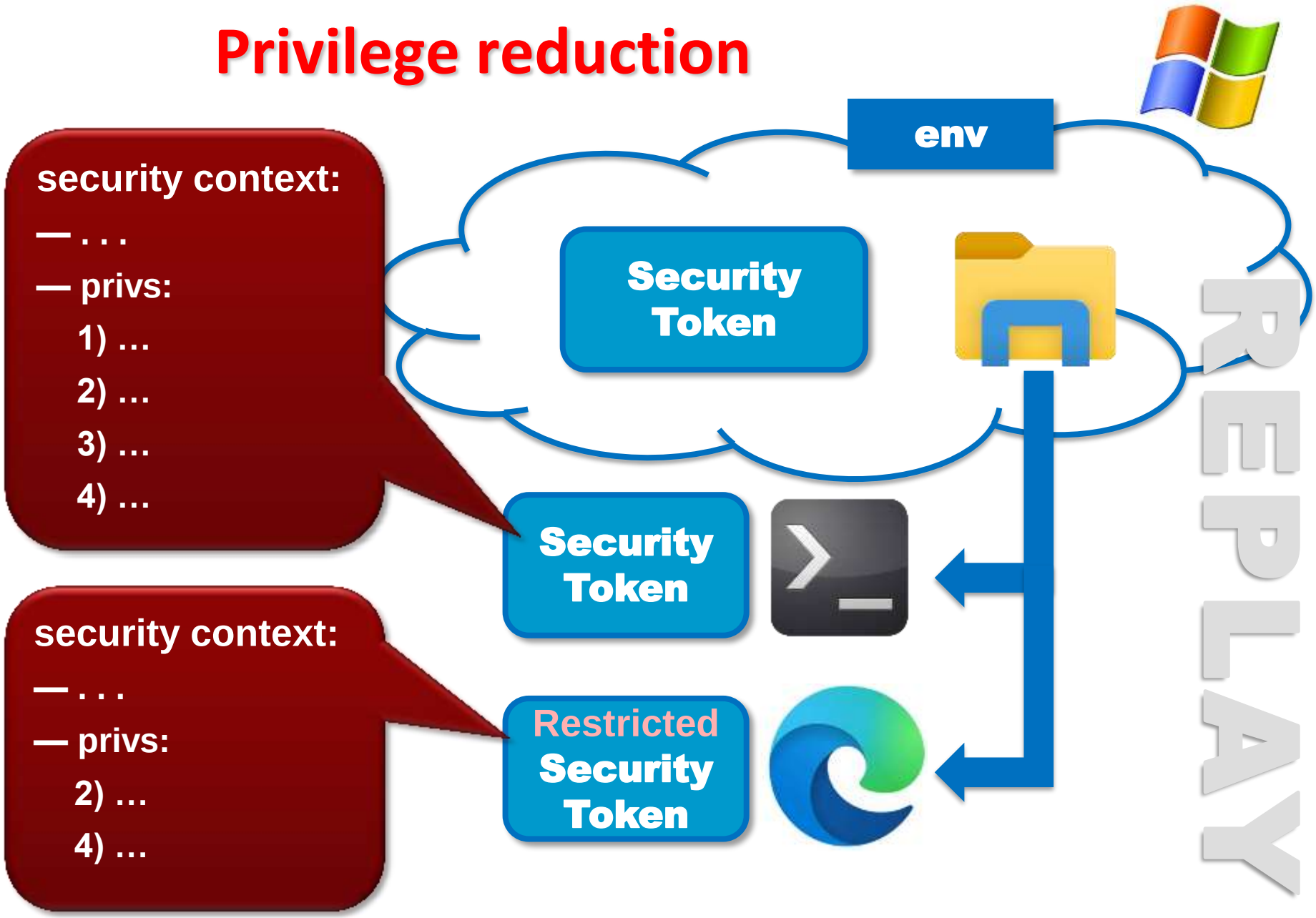
Privilege separation

Unix

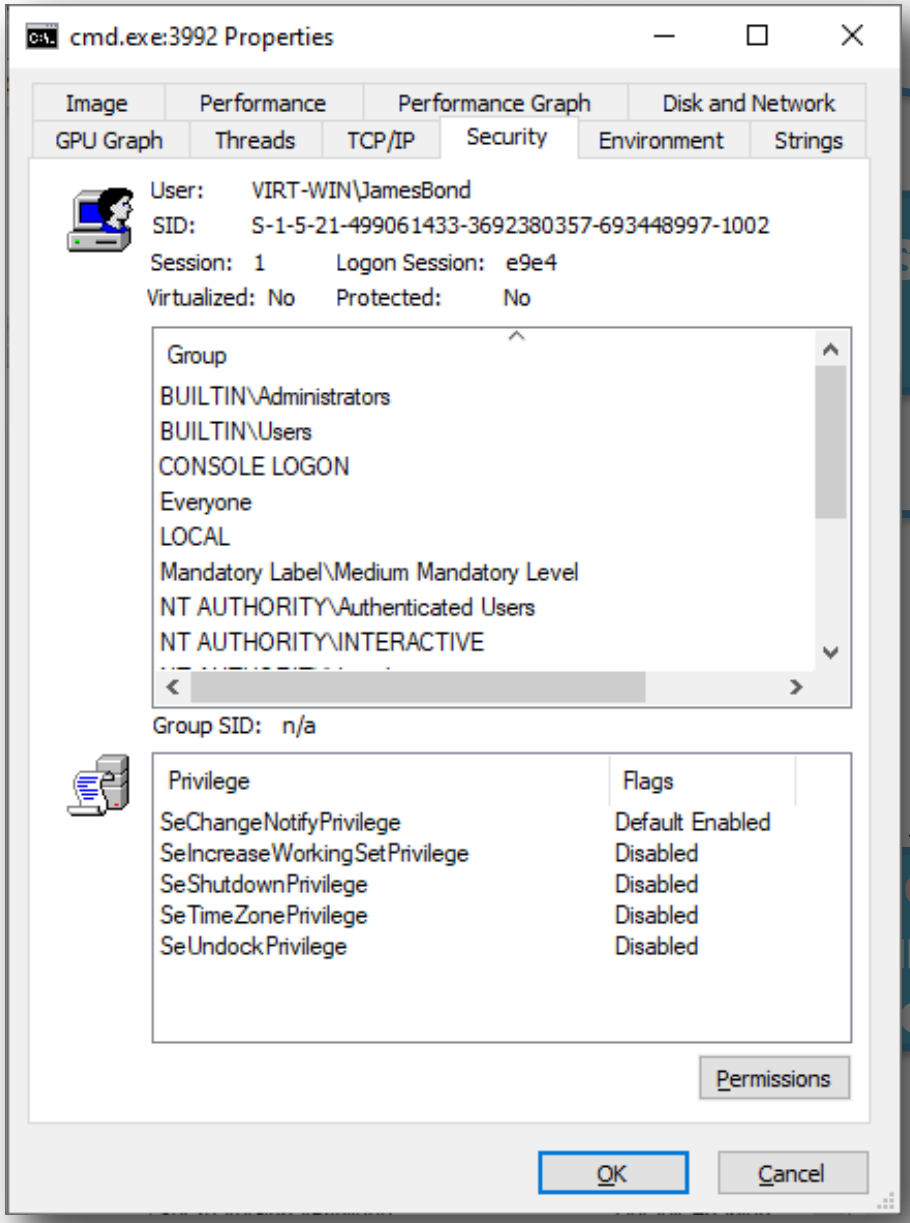


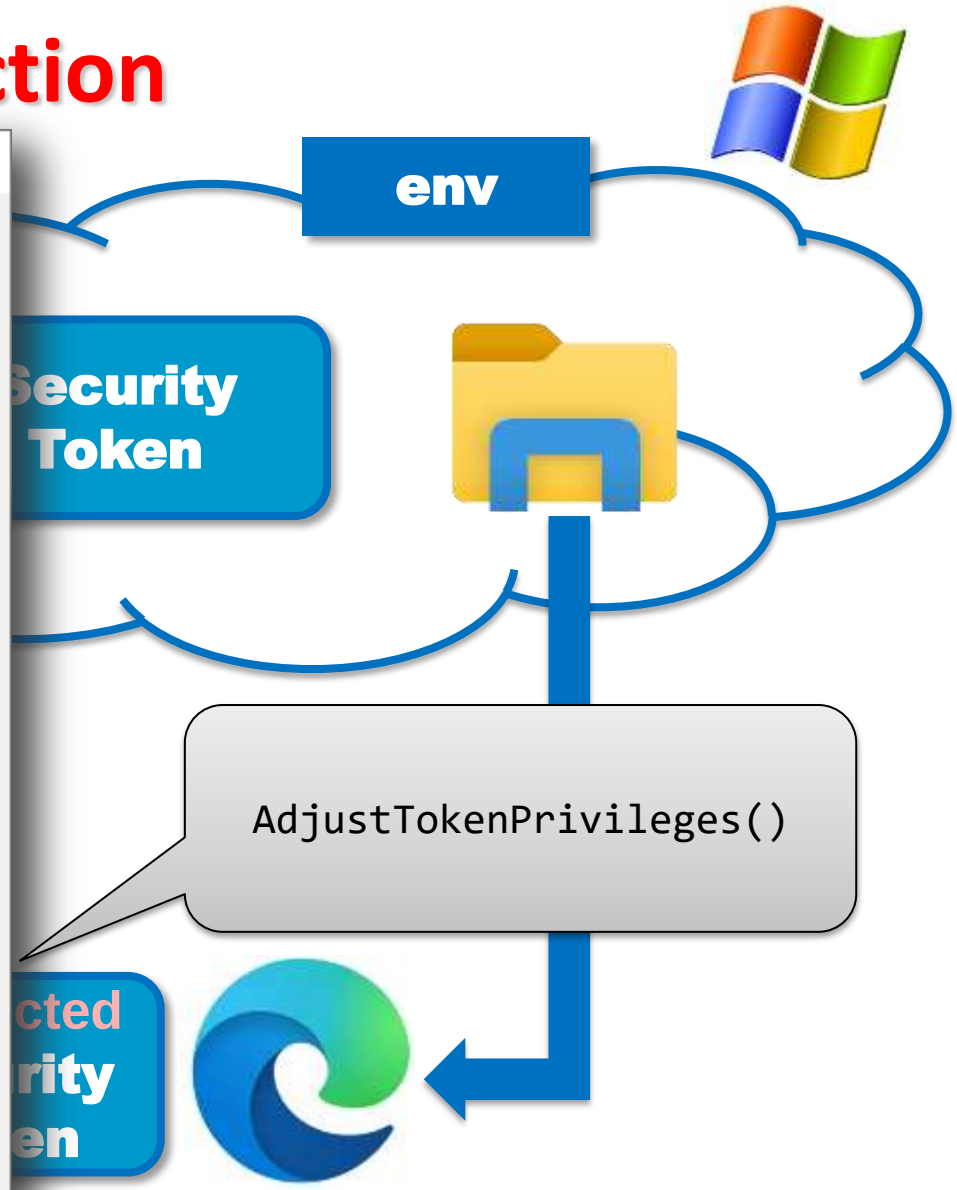


Privilege reduction



Privilege reduction





Privilege reduction

POSIX capabilities (CAP)

- CAP_NET_ADMIN
- CAP_NET_RAW
- CAP_KILL
- CAP_DAC_OVERRIDE
- CAP_FOWNER
- CAP_SETUID
- CAP_MKNOD
- CAP_SYS_TIME
- CAP_SYS_NICE
- CAP_MAC_ADMIN
- . . .

Privilege reduction

POSIX capabilities (CAP)

- CAP_NET_ADMIN
- CAP_NET_RAW
- CAP_KILL
- CAP_DAC_
- CAP_FOW
- CAP_SETU
- CAP_MKN
- CAP_SYS_T
- CAP_SYS_
- CAP_MAC_ADMIN
- ...

```
$ ps -fC sshd
root   2238   1  00:00:00  /usr/sbin/sshd -D

$ getpcaps 2238
Capabilities for `2238': = cap_chown,
cap_fowner, cap_fsetid, cap_kill, cap_setgid,
cap_setuid, cap_setpcap, cap_net_bind_service,
cap_net_broadcast, cap_net_admin, cap_net_raw,
...
```

Privilege reduction

POSIX capabilities (CAP)

CAP for programs

```
$ setcap  cap_net_raw+ep  /usr/bin/ping
$ getcap  /usr/bin/ping
  /usr/bin/ping = cap_net_raw+ep
```

CAP for users

/etc/security/capability.conf

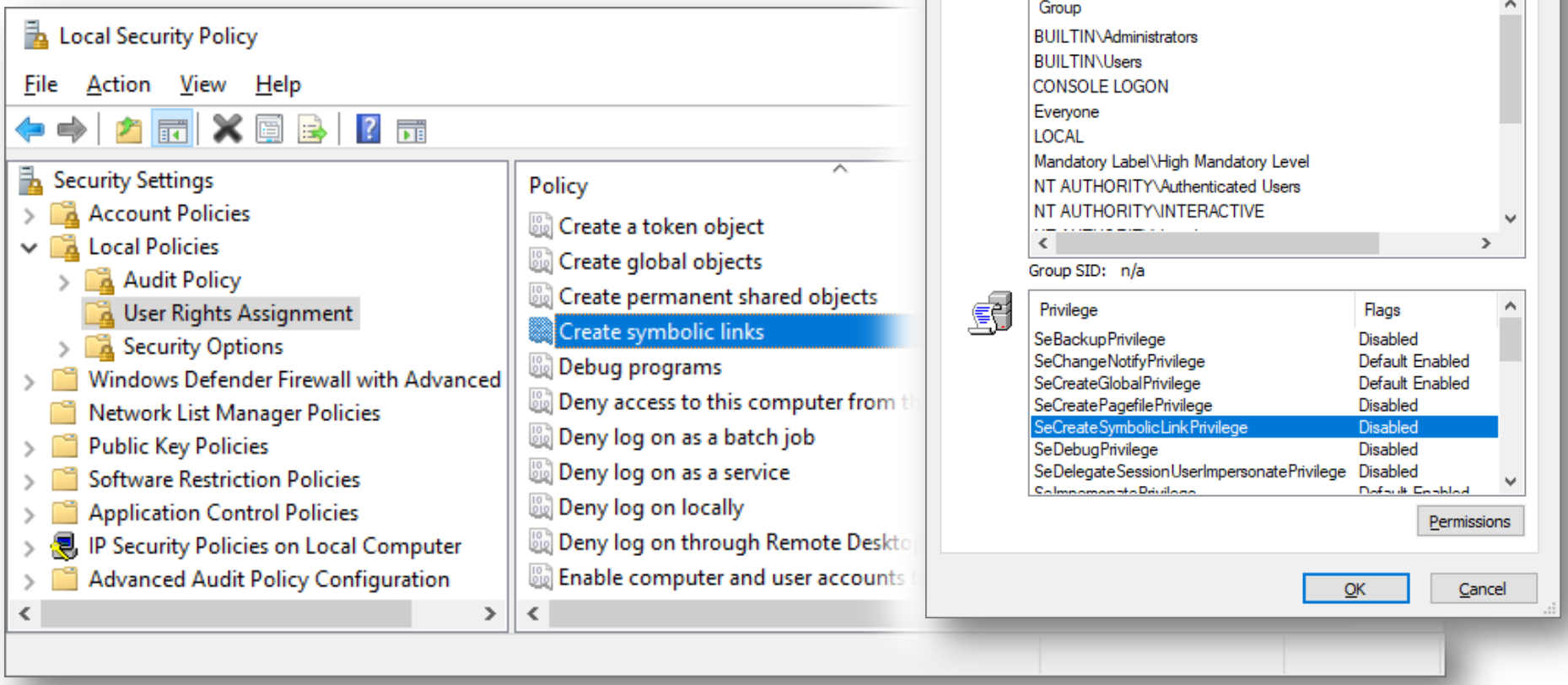
```
cap_net_raw      jbond
cap_sys_ptrace   jdeveloper
```

+ PAM module: pam_cap

Privilege reduction

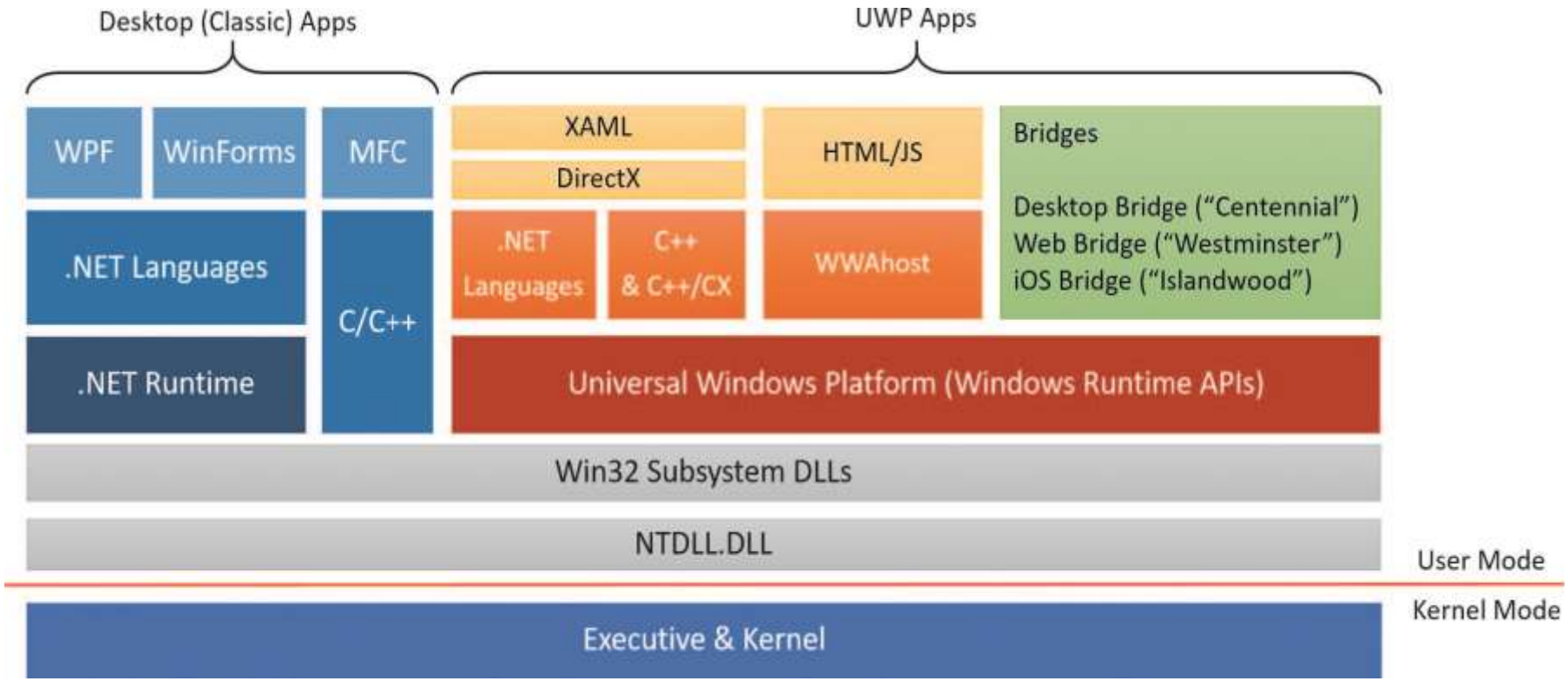
Windows privileges ≈ CAP

- e.g. SeCreateSymbolicLinkPrivilege



Privilege reduction

Universal Windows Platform capabilities ≈ Android permissions



Privilege reduction

Universal Windows Platform capabilities ≈ Android permissions

Win8MetroTest - Microsoft Visual Studio

FILE EDIT VIEW PROJECT BUILD DEBUG TEAM SQL TOOLS TEST ARCHITECTURE ANALYZE WINDOW HELP

Local Machine | Debug | Any CPU

Toolbox

Package.appxmanifest

The properties of the deployment package for your app are contained in the app manifest file. You can use the Manifest Designer to set or modify one or more of the properties.

Application UI | Capabilities | Declarations | Packaging

Use this page to specify system features or devices that your app can use.

Capabilities:

- [ ] Documents Library
- [ ] Enterprise Authentication
- [x] Internet (Client)
- [x] Internet (Client & Server)
- [ ] Location
- [ ] Microphone
- [ ] Music Library
- [ ] Pictures Library
- [x] Private Networks (Client & Server)
- [ ] Proximity
- [ ] Removable Storage
- [ ] Shared User Certificates
- [ ] Videos Library
- [ ] Webcam

Description:

Provides inbound and outbound access to Intranet networks that have an authenticated domain controller, or that the user has designated as either home or work networks. Inbound access to critical ports is always blocked.

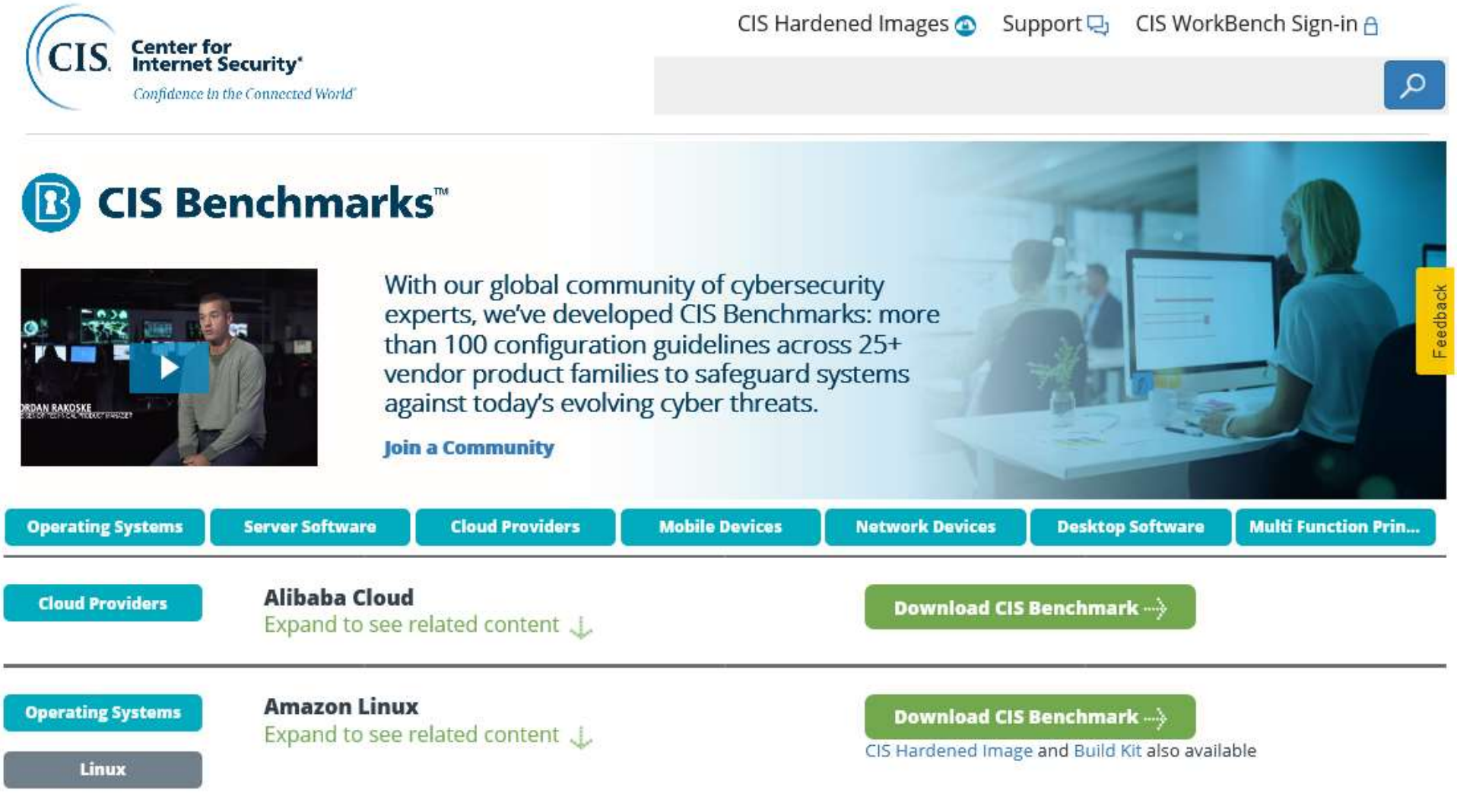
More information

Authorization & Access Control

1. **DAC ACL examples:**
   - POSIX ACL
   - Windows DACL
2. **Impersonation (→ authentication)**
3. **Privilege separation**
   = change of security context through forking a child process
4. **Privilege reduction**
   - POSIX CAP
   - Windows Restricted Token

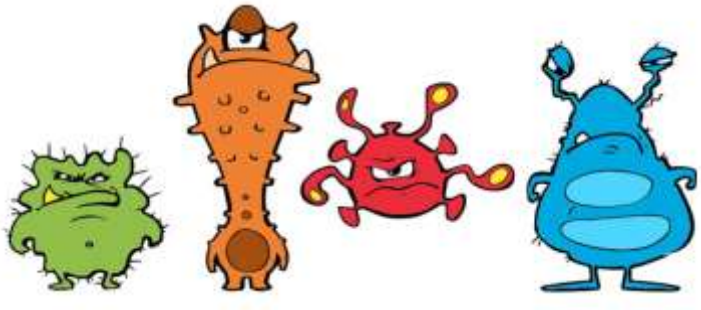
Guidelines & Recommendations

https://www.cisecurity.org/cis-benchmarks/



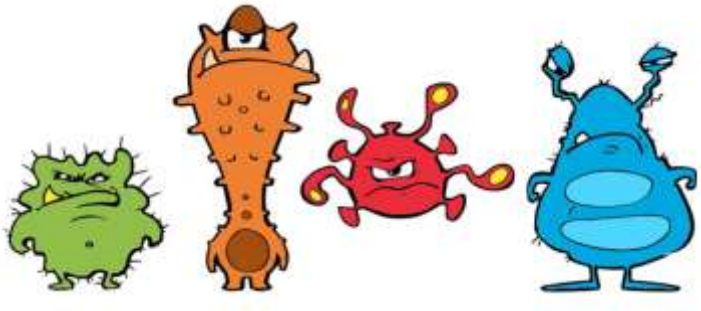
MALWARE

Malware



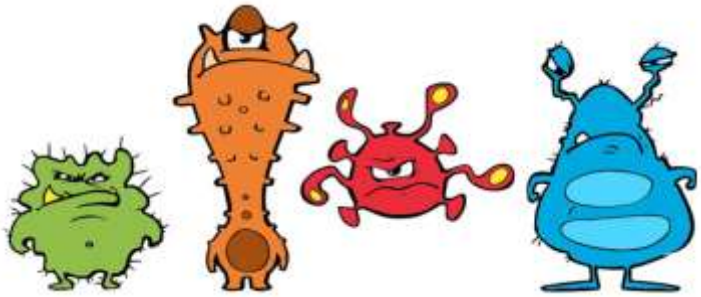
- viruses
- network worms
  - Internet Worm (© Robert Morris junior, 1988)
- Trojan horses

Malware



- viruses
- network worms
  - Internet Worm (© Robert Morris junior, 1988)
- Trojan horses
- rootkits
  - kernel rootkits
  - BIOS/UEFI rootkits (ACPI = Advanced Configuration & Power Interface)
  - VM rootkits (e.g. Blue Pill)
  - hypervisor rootkits

Malware



There's a new virus on the loose that's worse than anything we've seen before! It gets in through the power line. It works by changing the serial port pinouts, and by reversing the direction one's disks spin.

Don't use the powerline. Don't use batteries either, since there are rumours that this virus has invaded most major battery plants, and is infecting the positive poles of the batteries. (You might try hooking up just the negative pole.) Don't use Internet. Don't read messages. No, not even this one!

HOAX

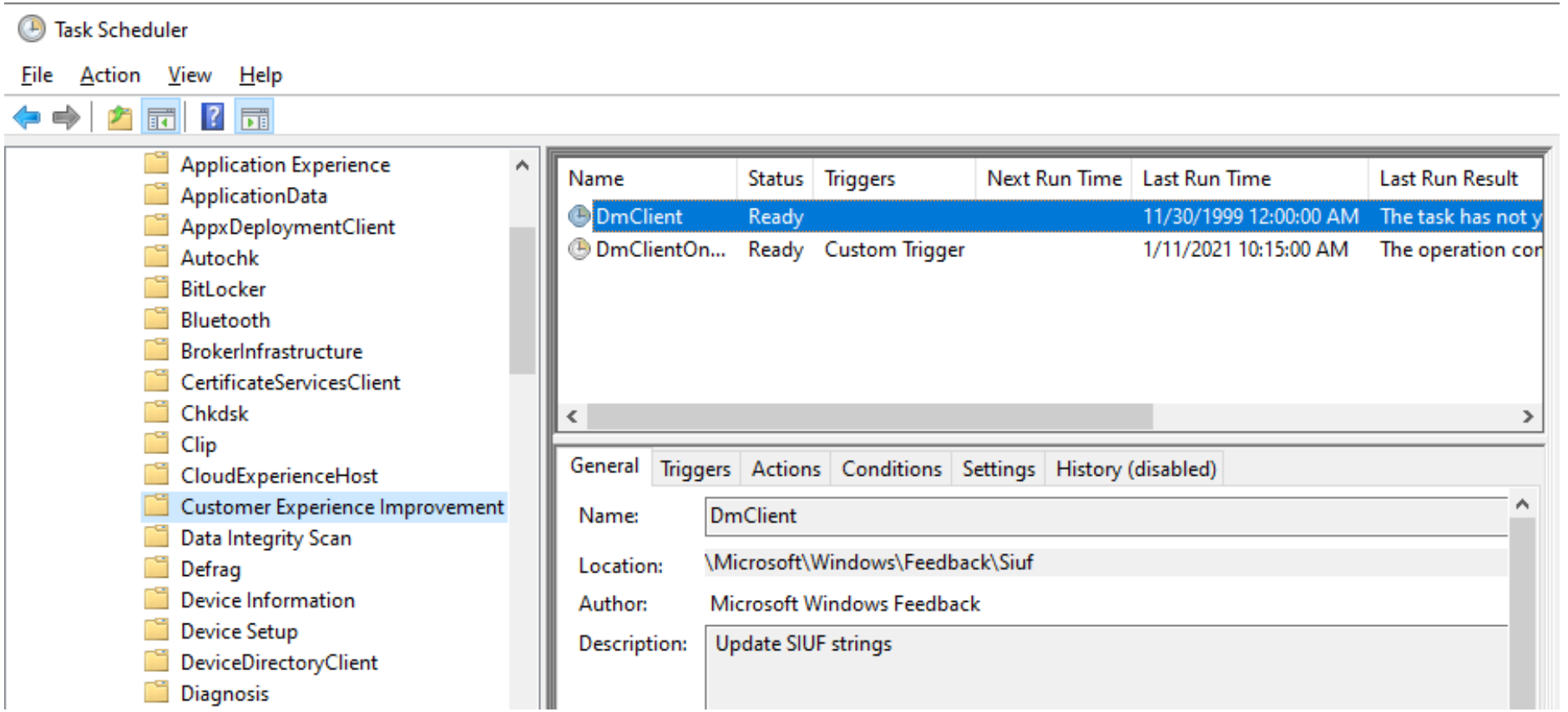
https://www.hoax-slayer.net

Malware

Ransomware

Malware?

Greyware (spyware, trackware)



Malware

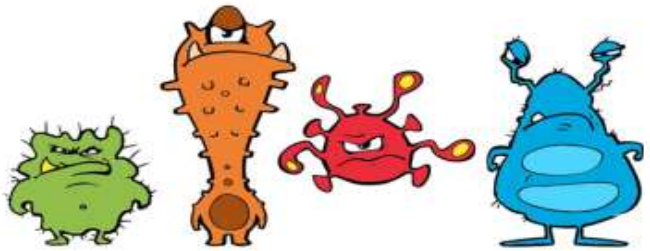
The best antivirus software for Android

July 2017

Name	Protection	Usability
AhnLab V3 Mobile Security 3.1	●●●●●●	●●●●●●
Antiy AVL 2.5	●●●●●●	●●●●●●
Avast Mobile Security 6.1	●●●●●●	●●●●●●
Bitdefender Mobile Security 3.2	●●●●●●	●●●●●●
G Data Internet Security 26.0	●●●●●●	●●●●●●
Ikarus mobile.security 1.7	●●●●●●	●●●●●●
Kaspersky Lab Internet Security 11.13	●●●●●●	●●●●●●
McAfee Mobile Security 4.9	●●●●●●	●●●●●●
PSafe DFNDR 4.0	●●●●●●	●●●●●●
Sophos Mobile Security 7.0	●●●●●●	●●●●●●

https://www.av-test.org

Malware



black hat USA 2017

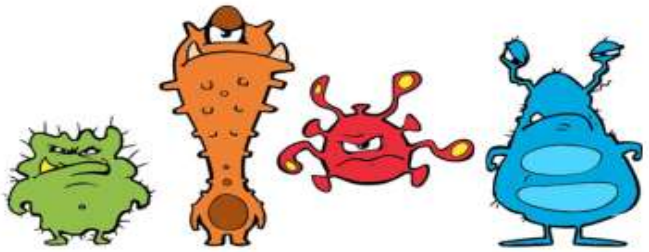
JULY 22-27, 2017
MANDALAY BAY / LAS VEGAS

AVPASS: Automatically Bypassing Android Malware Detection System

Jinho Jung, Chanil Jeon, Max Wolotsky, Insu Yun, and Taesoo Kim
Georgia Institute of Technology, July 27, 2017

#BHUSA / @BLACKHATEVENTS

Malware



black hat USA 2017

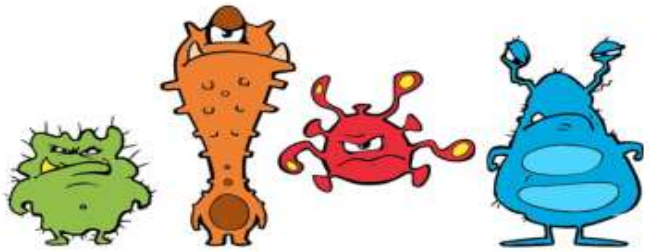
Evaluation: Bypassing AVs

- General bypass ability

Category	Avg. Detections	Detection Ratio
Average Detections	38 / 58	65%

** Experiment in **July / 2017**, Test with 2,000 malware*

Malware



black hat USA 2017

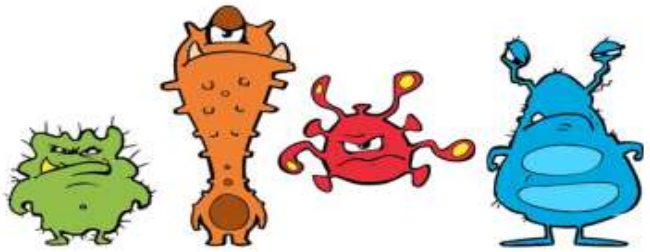
Evaluation: Bypassing AVs

- General bypass ability

Category	Avg. Detections	Detection Ratio
Average Detections	38 / 58	65%
After AVPASS	3.42 / 58	5.8%

** Experiment in **July / 2017**, Test with 2,000 malware*

Malware



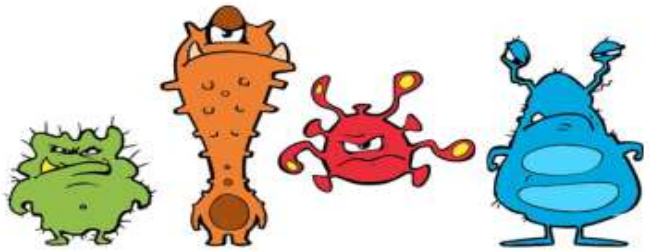
EPP = End-Point Protection = Antivirus

EDR = Endpoint Detection and Response

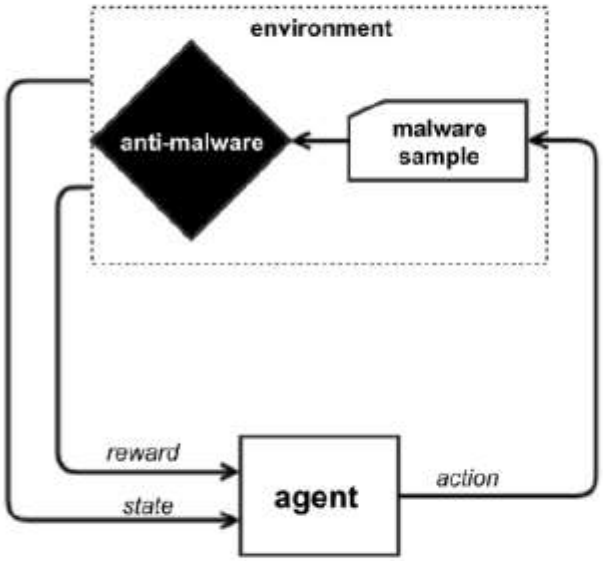
XDR = Extended Detection and Response

MDR = Managed Detection and Response

Malware



Bot vs. Bot: Evading Machine Learning Malware Detection.
Hyrum Anderson. Blackhat USA 2017.



- **Environment**
  - A malware sample (*Windows PE*)
  - Buffet of malware mutations
    - *preserve format & functionality*
  - Reward from static malware classifier
- **Agent**
  - Input: **environment state** (*malware bytes*)
  - Output: **action** (*stochastic*)
  - Feedback: **reward** (*AV reports benign*)

Functionality-preserving mutations:

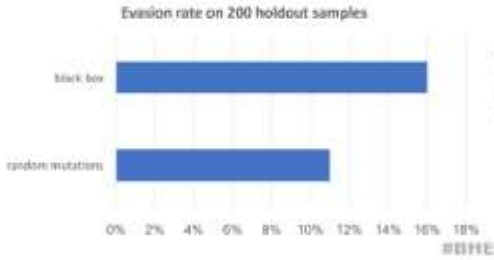
- **Create**
  - New Entry Point (w/ trampoline)
  - New Sections
- **Add**
  - Random Imports
  - Random bytes to PE overlay
  - Bytes to end of section
- **Modify**
  - Random sections to common name
  - (break) signature
  - Debug info
  - UPX pack / unpack
  - Header checksum
  - Signature

Features

- Static Windows PE file features compressed to 2350 dimensions
  - General file information (size)
  - Header info
  - Section characteristics
  - Imported/exported functions
  - Strings
  - File byte and entropy histograms
- Feed a neural network to choose the best action for the given "state"

Evasion Results

- Agent training: 15 hours for 100K trials (~10K games x 10 turns ea.)
- Using malware samples from VirusShare



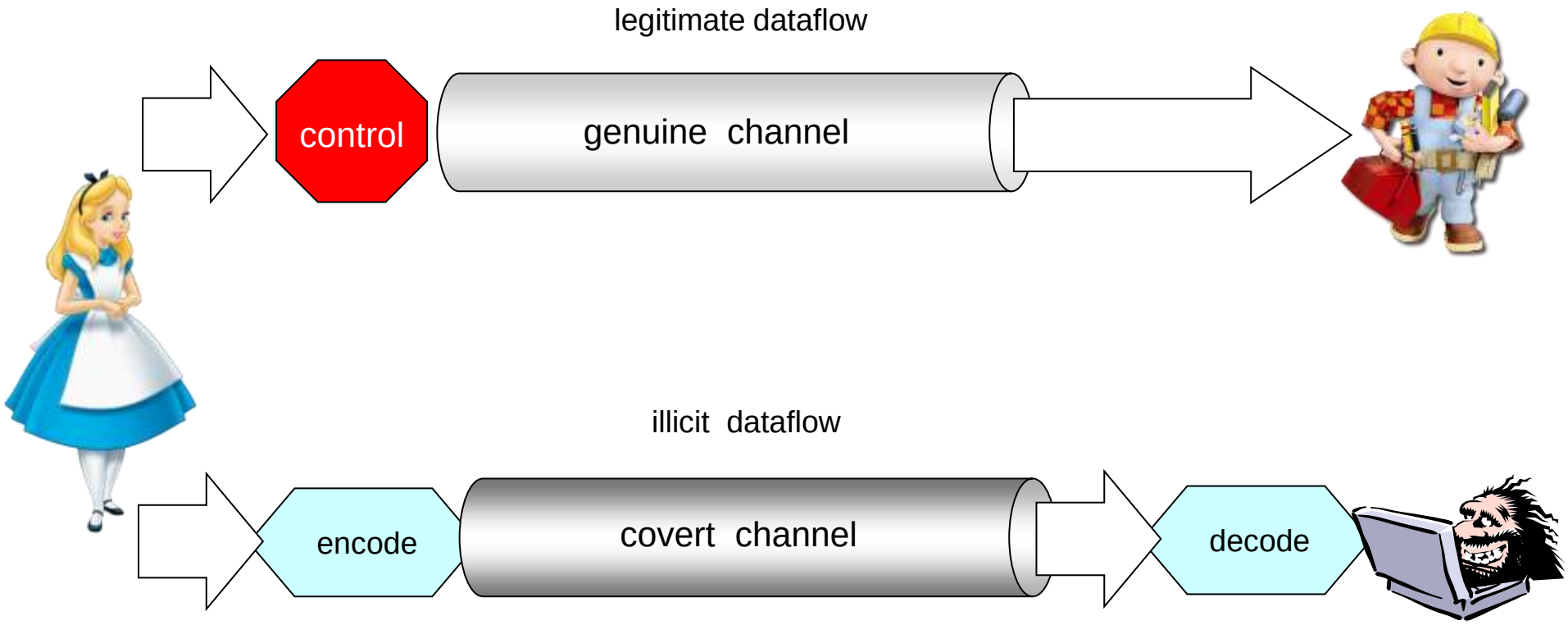
Cross-evasion: detection rate on VirusTotal (average)

- from 35/62 (original)
- to 25/62 (evade)


“And now for something completely different.”
Monty Python

COVERT CHANNELS

Covert Channels



Covert Channels

Sample covered channels:

- timing-based
- print spooler
- filesystem
- DNS
- IP TTL / Hop Limit

Sample defense:

- communication noise (for the timing-based channels):
  1 MB · 1b / 10s = 2 ½ year


"That's all Folks!"