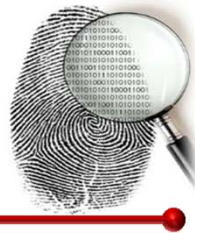

Forenzika log datoteka
Kristian Skračić
Petar Djerasimović
Predrag Pale

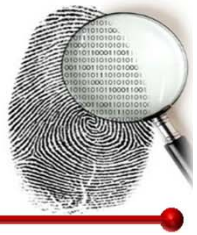
Zašto forenzika log datoteka?



- **problemi** u sustavu
- obično postaju **očiti**
- tek **nakon** događaja koji ih je uzrokovao
  - ponekad **puno kasnije**:
    - dani, tjedni, mjeseci
- Čak i ako pratimo događaje dok se događaju
  - moguće je da ćemo trebati znati kada se sličan događaj desio u **prošlosti**
- stoga, imamo potrebu **istraživati prošle** događaje
- Srećom **postoji način** da se to postigne
- postoje **zapisi događaja (eng. event logs)** na sustavu
  - stvara ih operacijski sustav, servisi i aplikacije
  - često
  - arhiviraju se mjesečno, godišnje


Linux logovi

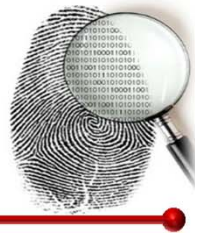
Linux logovi



- Obično **pohranjeni** u tekstualnom (ASCII) obliku
- **Jedan redak** predstavlja **jedan događaj**
- Ponekad je problematično naći **u kojem se logu nalaze** informacije koje su nam potrebne

- No, sama analiza je jednostavna
  - jer se najčešće radi o čitljivom/tekstualnom formatu
- Nažalost – ovo svojstvo koriste i zlonamjernici
  - za pronalaženje vlastitih tragova
  - i njihovo brisanje

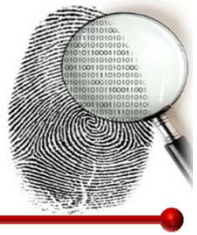
User activity logs



- Prijave i odjave korisnika
  - /var/run/utmp
    - Sadrži informacije samo za aktivne prijave
  - /var/log/wtmp
    - Za dulje čuvanje informacija o prijavama

- /var/log/lastlog
  - binarni log
  - Sadrži informacije o zadnjoj prijavi svih korisnika
    - » Vrijeme prijave,
    - » remote host

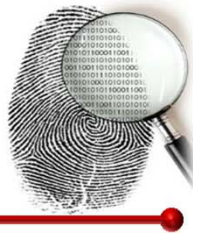
/var/log/wtmp



`user:~$ last -f wtmp.1`

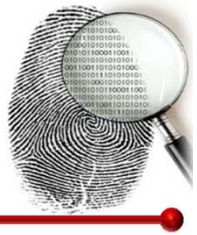
Korisnik		dolazi s računala							
its	pts/0	dhcp-154.zesoi.f	Thu	Dec	31	17:45	-	18:22	(00:37)
ppale	pts/1	dhcp-93.zesoi.fe	Sat	Dec	26	11:30	-	18:37	(07:06)
ppale	pts/1	dhcp-93.zesoi.fe	Sat	Dec	26	11:26	-	11:30	(00:04)
ppale	pts/1	dhcp-93.zesoi.fe	Sat	Dec	26	11:19	-	11:26	(00:06)
its	pts/0	dhcp-154.zesoi.f	Sat	Dec	26	11:00	-	09:48	(1+22:48)
its	pts/0	dhcp-154.zesoi.f	Fri	Dec	25	22:13	-	22:48	(00:35)
its	pts/0	dhcp-154.zesoi.f	Wed	Dec	23	10:18	-	10:38	(00:20)
reboot	system boot	3.16.0-4-amd64	Wed	Dec	23	10:18	-	23:49	(21+13:30)
its	pts/0	dhcp-154.zesoi.f	Wed	Dec	23	10:16	-	10:18	(00:01)
its	pts/0	dhcp-154.zesoi.f	Fri	Dec	11	09:14	-	09:38	(00:24)
reboot	system boot	3.16.0-4-amd64	Fri	Dec	11	09:13	-	10:18	(12+01:04)
its	pts/0	dhcp-154.zesoi.f	Fri	Dec	11	09:12	-	09:13	(00:00)
its	pts/0	dhcp-154.zesoi.f	Thu	Dec	10	15:52	-	16:33	(00:41)
reboot	system boot	3.16.0-4-amd64	Fri	Dec	4	15:40	-	09:13	(6+17:33)
its	pts/0	dhcp-154.zesoi.f	Fri	Dec	4	15:10	-	15:12	(00:01)

/var/log/lastlog



```
ppale@maja:/var/log$ lastlog

Username         Port     From             Latest
root             tty1                      Fri Jul 31 07:09:26 +0200 2015
mail                                       **Never logged in**
news                                       **Never logged in**
postfix                                    **Never logged in**
postgrey                                   **Never logged in**
amavis                                     **Never logged in**
ppale            pts/0    dhcp-73.zesoi.fe Wed Jan 13 23:47:48 +0100 2016
its              pts/0    dhcp-154.zesoi.f Wed Jan 13 11:09:51 +0100 2016
proftpd                                    **Never logged in**
ftp                                        **Never logged in**
nagios                                     **Never logged in**
nastava                                    **Never logged in**
messagebus                                 **Never logged in**
dovecot                                    **Never logged in**
jpetrovic        pts/0    2001:b68:16:70:1 Thu Nov 19 13:06:57 +0100 2015
clamav                                     **Never logged in**
vkezdorf         pts/0    dhcp-94.zesoi.fe Fri Jul 12 09:07:50 +0200 2013
debian-spamd                               **Never logged in**
ntp                                        **Never logged in**
```

Syslog

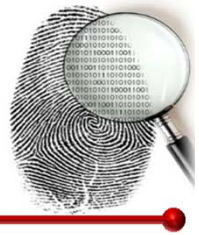


- Većina Linux logova pohranjeni su u
  - /var/log
    - bilo u vršnom direktoriju
      bilo u poddirektorijima
  - Syslog koristi client/server model
    - što omogućuje pohranu logova
      na udaljenom računalu

/var/log/**messages**
/var/log/**auth.log**
/var/log/**sulog**
/var/log/**httpd/***
/var/log/samba/**smbd.log**
/var/log/audit/**audit.log**
/var/log/**maillog**
/var/log/**cron**
/var/log/**xferlog**

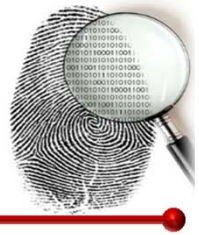
- Syslog koristi
  - „*facility/priority*” sustav klasifikacije praćenih događaja
    - “facility” = tko (koji program) je prijavio događaj
    - “priority” = koliko je važan taj događaj

Syslog facility



Auth	Authentication activity
Authpriv	Authentication and PAM messages
Cron	Cron/At/Task Scheduler messages
Daemon	Daemons/service messages
Kern	Kernel messages
Lpr	Printing services
Mail	Email (imap, pop, smtp) messages
News	Usenet News Server messages
Syslog	Messages from syslog
User	User program messages
Local	Locally defined

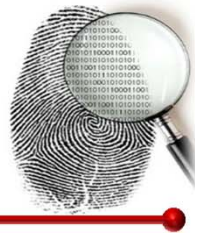
Syslog priority



Syslog ljestvica važnosti događaja

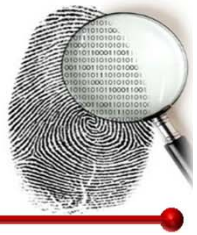
Emerg or Panic	System is unusable
Alert	Action must be taken immediately
Crit	Critical conditions
Err	Error conditions
Warning	Warning conditions
Notice	Normal but significant conditions
Info	Informational messages
Debug	Debugging level messages, very noisy
None	Used to override (*) wildcard
*	All levels except none

Syslog sadržaj



- **Vrijeme i datum** stvaranja poruke/događaja
- **Naziv računala** (host name)
  na kojemu se poruka/događaj dogodila
- Naziv **procesa** koji je napravio poruku/događaj
- **Tekst** poruke/događaja

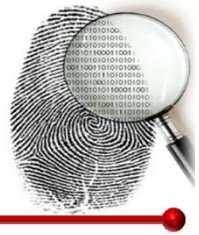
Syslog primjer



Time stamp Host Process Message

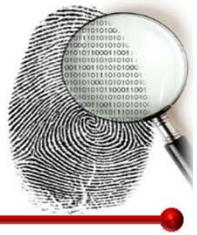
```
Mar 7 04:02:08 avas syslogd 1.4.1: restart.
Mar 7 04:02:16 avas clamd[11165]: /var/amavis/amavis-20040307T033734-
      10329/parts/part-00003: Worm.Mydoom.F FOUND
Mar 7 04:05:55 avas clamd[11240]: /var/amavis/amavis-20040307T035901-
      10615/parts/part-00002: Worm.SomeFool.Gen-1 FOUND
Mar 7 04:11:15 avas dccifd[11335]: write(MTA socket,4): Broken pipe
Mar 7 04:14:12 avas clamd[11346]: /var/amavis/amavis-20040307T033734-
      10329/parts/part-00002: Worm.SomeFool.Gen-2 FOUND
Mar 7 04:58:25 avas clamd[27173]: SelfCheck: Database status OK.
Mar 7 05:20:01 avas clamd[20434]: /var/amavis/amavis-20040307T051352-
      20223/parts/part-00003: Worm.Mydoom.F FOUND
Mar 7 05:59:01 avas clamd[27173]: SelfCheck: Database modification
      detected. Forcing reload.
Mar 7 05:59:01 avas clamd[27173]: Reading databases from
      /usr/local/share/clamav
Mar 7 05:59:02 avas clamd[27173]: Database correctly reloaded (20400
      viruses)
Mar 7 06:12:56 avas dccifd[21165]: write(MTA socket,4): Broken pipe
```

Useful log files



/var/log/**messages**	Catch-all, nonspecified logs
/var/log/**auth.log**	User authentication successes/failures
/var/log/**sulog**	“su” attempts/success
/var/log/**httpd/***	Apache Web Server
/var/log/samba/**smbd.log**	Samba (Windows File Sharing)
/var/log/audit/**audit.log**	Auditd/SELinux
/var/log/**maillog**	Mail servers (sendmail/postfix)
/var/log/**cron**	Anacron/cron
/var/log/**xferlog**	FTP servers

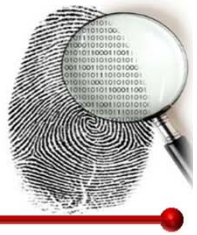
Syslog karakteristike



- Uniforman format čini ih jednostavnim za pretraživanje
- Većina Linux sustava koristi neki oblik „rotacije” logova
  - npr. svaki mjesec se svi postojeći logovi komprimiraju u Gzip arhivu, te se otvaraju novi za taj mjesec
  - serveri će vjerojatno puno češće napraviti rotaciju zbog veće količine logova

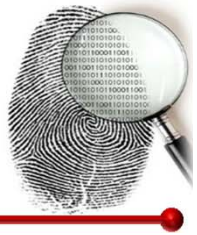

Drugi zanimljivi
artefakti na Linuxu

SSH



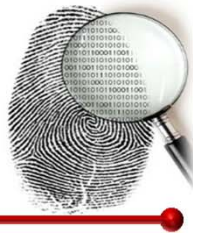
- Sve datoteke potrebne za korištenje SSH
  - se nalaze u korisničkom (home direktoriju)
- .ssh/known_hosts
  - kada se korisnik prijavi putem SSH, u ovu datoteku se pohranjuje
    - IP adresa računala udaljenog korisnika
    - Naziv računala (host name)
    - Javni ključ
  - Neke Linux distribucije
    - omogućuju hash-iranje ove datoteke

.ssh/known_hosts



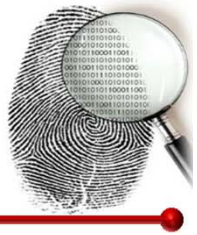
```
$ cat .ssh/known_hosts

192.168.0.106 ssh-
rsaAAAAB3NzaC1yc2EAAAADAQABAAABAQDRtd74Cp19PO44
zRDUdMk0EmkuD/d4WAefzPaf55L5Dh5C06Sq+xG543sw0i1LjMN7C
IJbz+AnSd967aX/BZZimUchHk8gm2BzoAEbp0EPIJ+G2vLOrc+faM
1NZhDDzGuoFV7tMnQQLOrqD9/4PfC1yLGVlIJ9obd+6BR78yeBRdq
HVjYsKUtJl46aKoVwV60dafV1EfbOjh1/ZKhhliKAaYlLhXALnp8/
l8EBj5CDqsTKCcGQbhkSPgYgxuDg8qD7ngLpB9oUvV9QSDZkmR0R937MY
i
IpUYPqdK5opLVnKn81B1r+TsTxiI7RJ7M53pOcvx8nNfjwAuNzWTLJz6z
r
```

.ssh/known_hosts – uz hashiranje




```
|1|rjAWXFqldZmjmgJnaw7HJ04KtAg=|qfrtMVerwngkTaW
C7mdEF3HNx/o=
ssh-
rsaAAAAB3NzaC1yc2EAAAADAQABAAABAQDRtd74Cp19PO44
zRDUdMk0EmkuD/d4WAefzPaf55L5Dh5C06Sq+xG543sw0i1
LjMN7CIJbz+AnSd967aX/BZZimUchHk8gm2BzoAEbp0EPIJ
+G2vLOrc+faM1NZhDDzGuoFV7tMnQQLOrqD9/4PfC1yLGVl
IJ9obd+6BR78yeBRdqHVjYsKUtJl46aKoVwV60dafV1EfbO
jh1/ZKhhliKAaYlLhXALnp8/l8EBj5CDqsTKCcGQbhkSPgY
gxuDg8qD7ngLpB9oUvV9QSDZkmR0R937MYiIpUYPqdK5opL
VnKn81B1r+TsTxiI7RJ7M53pOcvx8nNfjwAuNzWTLJz6zr
```

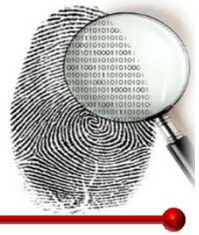
Logs of command line interface



- Bash je najčešće (default) korisničko sučelje (ljuska) za većinu Linux sustava
- ~/.bash_history
  - sadrži "povijest" Bash ljuske
    - tj, prethodno izdane naredbe
  - svaki korisnik ima vlastitu povijest
  - obično nemaju vremenske oznake ☹
    - već samo niz naredbi koje su zadane i izvršene

```
ls -al
rm comfor_automat
mkdir comfor_automat
ls -al
chmod -R g+w comfor_automat/
cd comfor_automat/
nano program
ls -al
chmod +x program
./program
nano program
./program
nano /etc/postfix/aliases
exit
l pr*
```

DNS



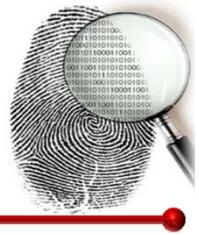
- Velik broj zlođudnih aplikacija
- često mijenja korisnikov DNS sustav
  - kako bi legitiman promet preusmjerila na vlastite poslužitelje
    - Man-in-the-middle ili
    - Phishing napad
  - /etc/resolv.conf
    - mnogi Linux sustavi ga koriste za konfiguraciju DNS-a
  - /etc/hosts
    - Služi za mapiranje IP adresa na DNS adrese

```
/etc > more resolv.conf
nameserver 161.53.64.4
nameserver 161.53.64.60
nameserver 161.53.64.61
```

```
maja:~$ more /etc/hosts
127.0.0.1        localhost
161.53.64.3      maja.zesoi.fer.hrmaja

# The following lines are desirable
#  for IPv6 capable hosts
::1     localhost ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
ff02::3 ip6-allhosts
```


Forenzika Windows
logova

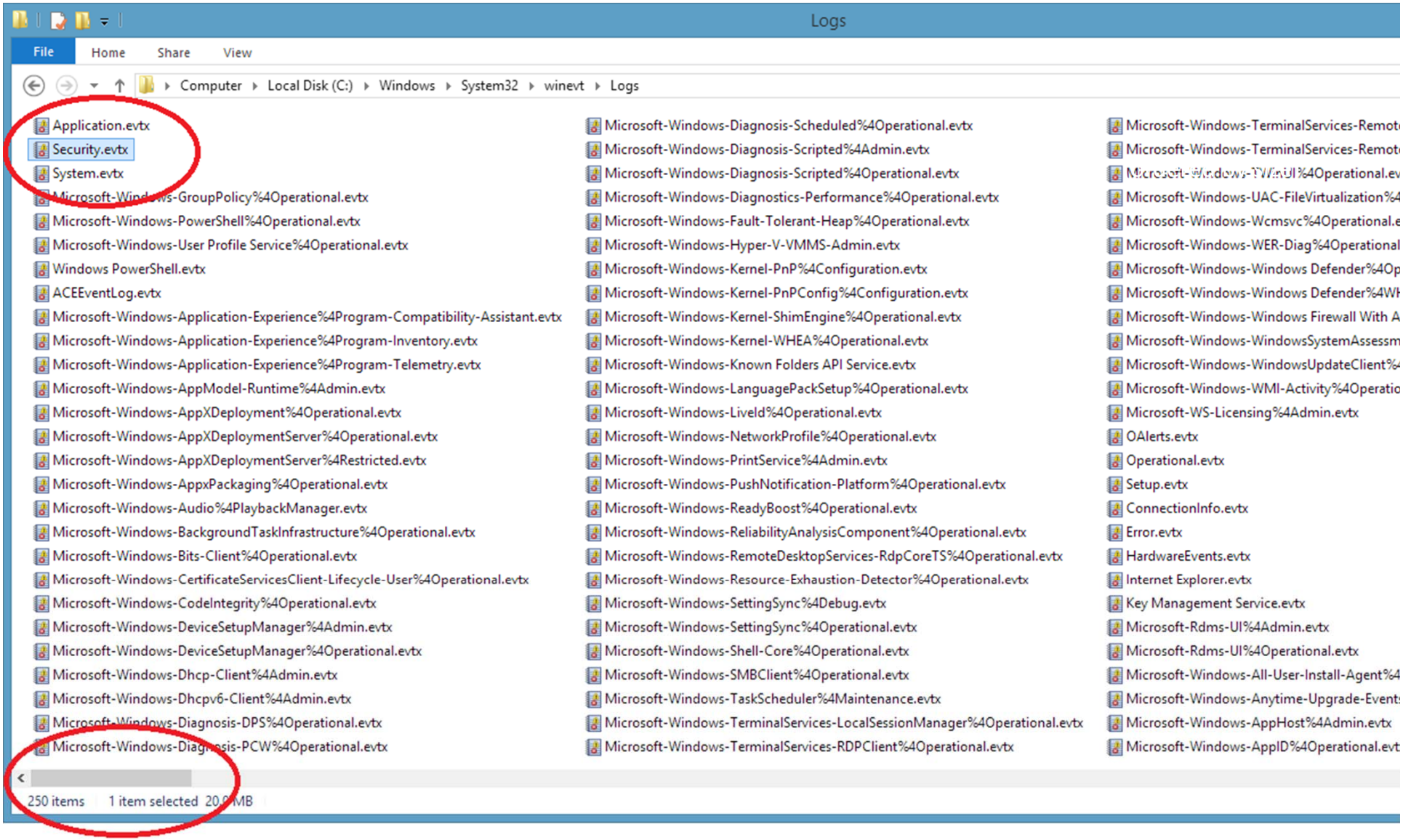
Uvod



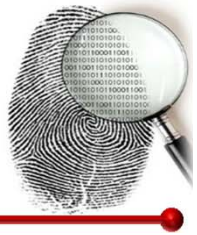
- Windows logovi (pre-Vista):
  - Windows 2000, XP, Server 2003
  - Binarne datoteke, ekstendija: .evt
  - Najvažniji logovi:
    - System
    - Security
    - Application
  - c:\windows\system32*.evt
- Windows logovi (Vista i novije):
  - Vista, 7, 8, 10
  - Binarne datoteke/XML format, .evtx
  - Najvažniji logovi:
    - System
    - Security
    - Application
    - Mnogo novih logova (specifičnih za određene aplikacije)
  - c:\windows\system32\winevt\Logs*.evtx

Predavanje će biti usmjereno na novi format logova

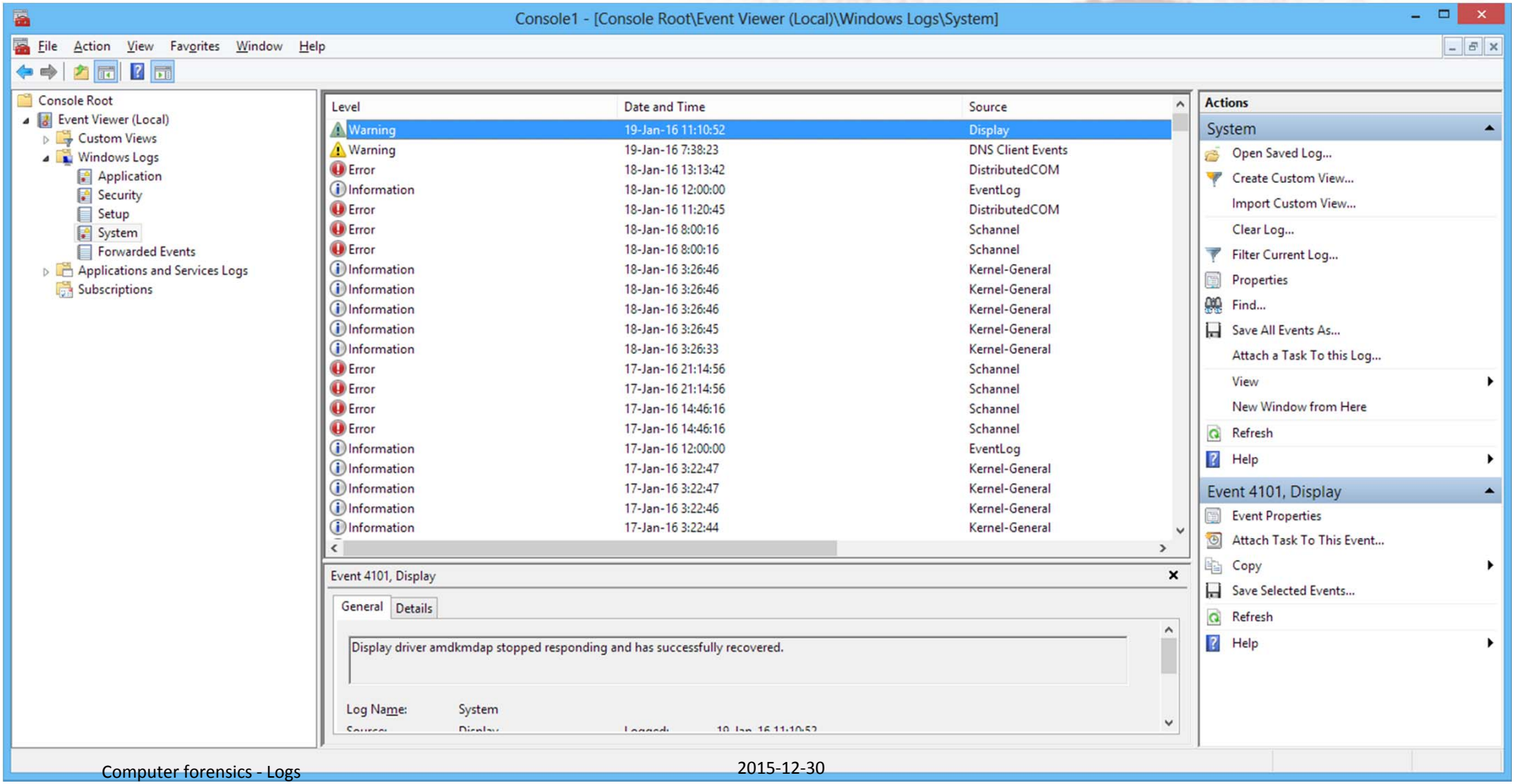
Koliko novih logova?



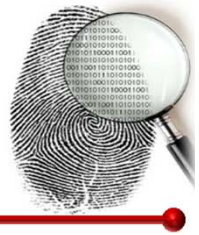
Poznatiji pregled logova



- Koristeći „*MMC console event viewer snap-in*”, slično Event Viewer alatu u prijašnjim inačicama

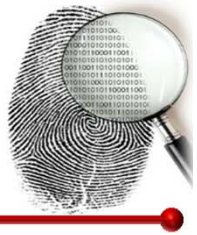


Format poruka

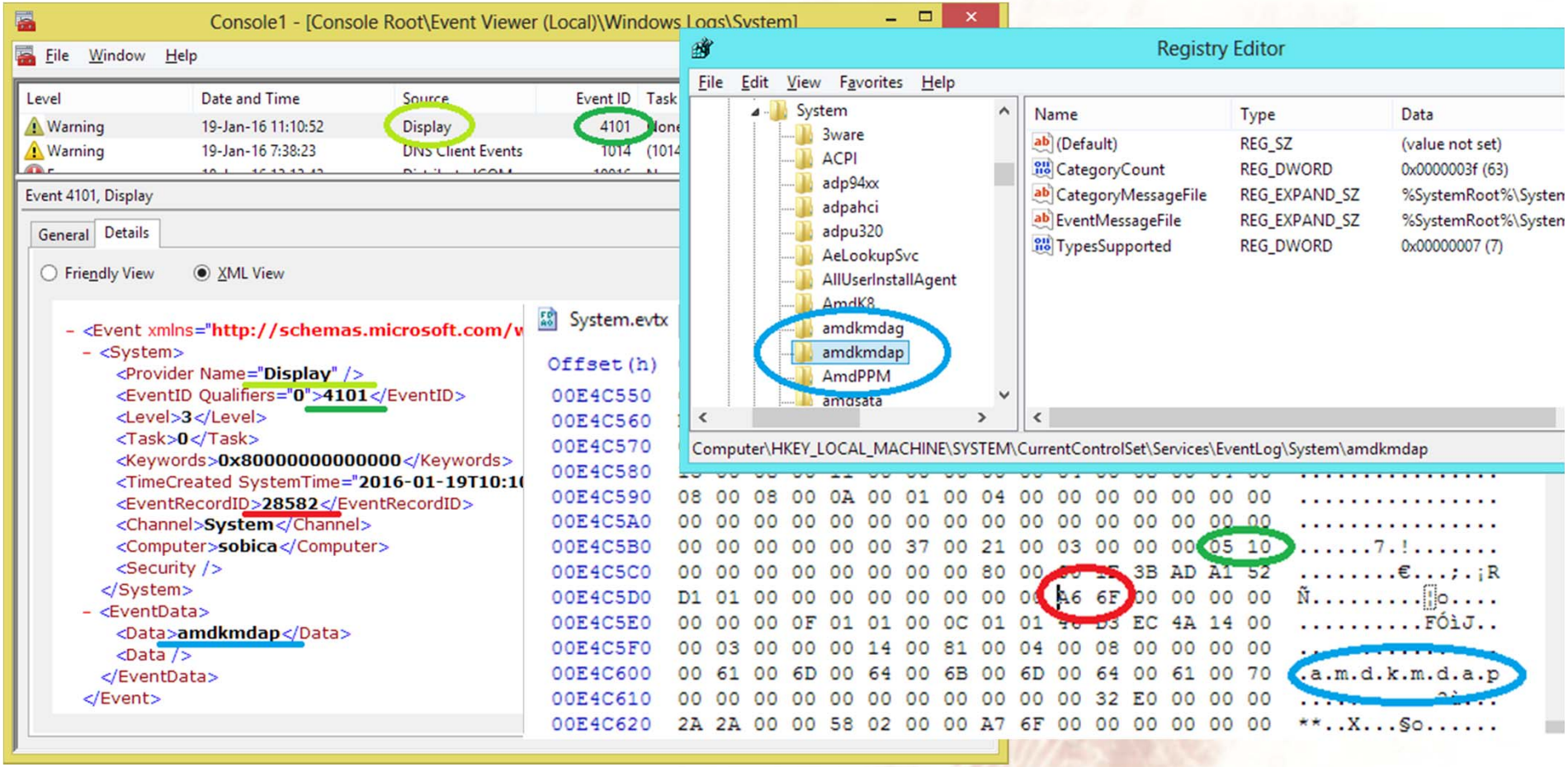


- Svaka poruka sastoji se od dva dijela:
  - Struktura poruke
    - Definirana u biblioteci koja sadrži zapis za sve poruke iste vrste
  - Podatci poruke
    - Pohranjeni u .evtx datotekama
- Struktura poruke se ponekad definira u zasebnoj datoteci
  - Koju dostavlja treća strana (npr. stvaratelj poruke nekog loga)
- Uobičajeno se prilikom instalacije aplikacije dodaju 3 nove datoteke koje sadrže poruke s metapodatcima koje se registriraju
  - i registarski ključ se stvara (CategoryMessageFile, EventMessageFile, ParameterMessageFile)
- Svi ključevi (za različite aplikacije koje proizvode poruke) su u
  - HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\EventLog*

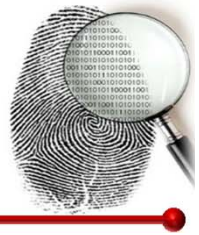
Primjer: display driver warning



($4101_{(10)}=1005_{(16)}$; $28582_{(10)}=6FA6_{(16)}$; entries are LE)

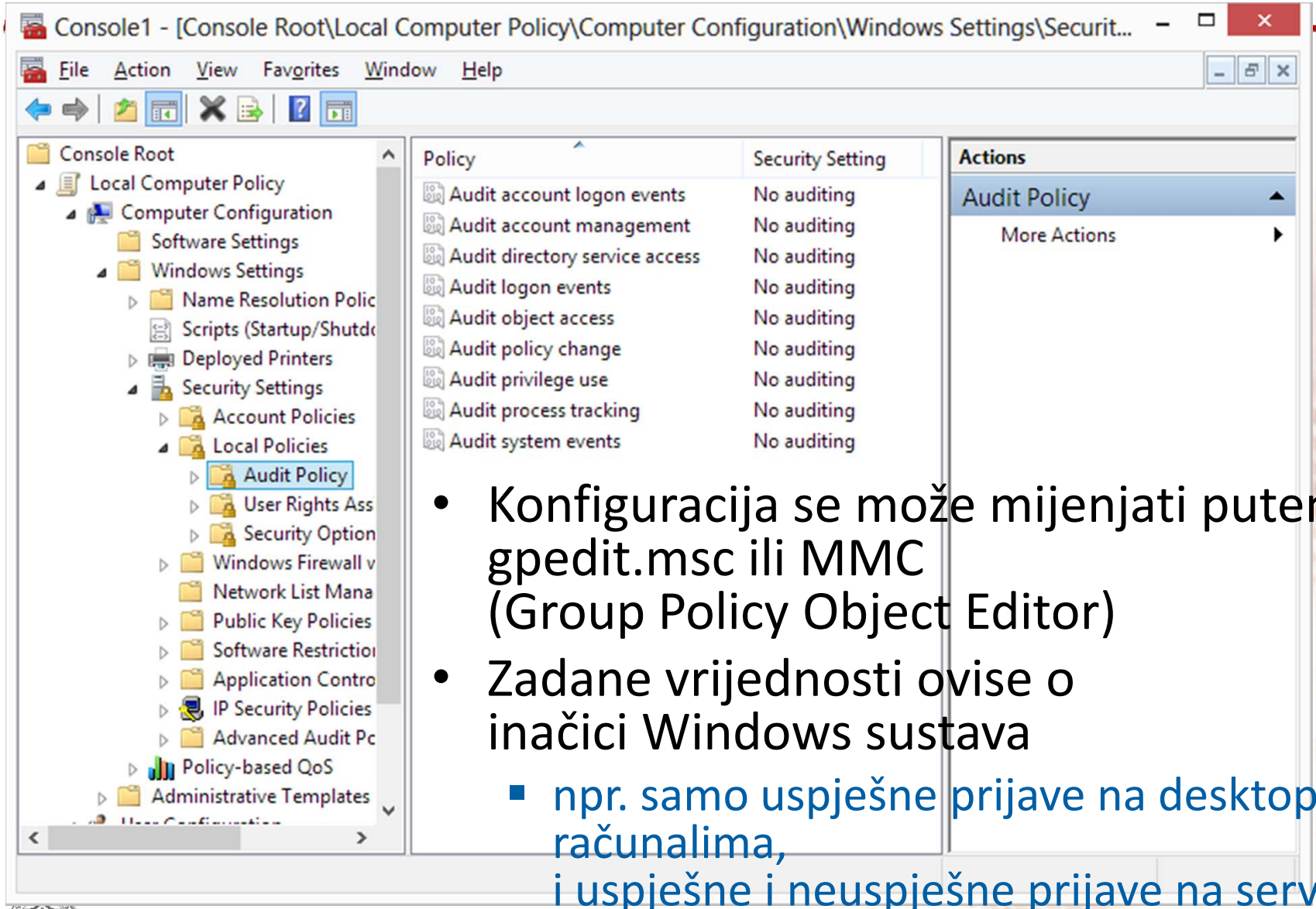


Događaji vezani uz sigurnost



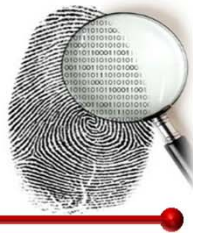
- Revizijski kodovi, mogu biti **uspješne** ili **neuspješne**
- Kratko objašnjenje dostupno u “properties”->”Explain” opciji u *Group Policy Editor* alatu
- Identifikatori (ID) ovise o inačici Windows sustava
- Alternativno, većina revizijskih kodova je dostupna na webu (https://support.microsoft.com/en-us/kb/977519)
- Alternativno, moguće je od Microsoft-a preuzeti
  - xls tablice i tekstualne datoteke s popisom događaja i kodova
- Događaji koji se bilježe ovise o konfiguraciji
  - Revizijska politika (eng. audit policy)
- Zanimljivi događaji su obično prijave i odjave korisnika, neuspješne prijave, eskalacija ovlasti na sustavu i slično

Konfiguracija sigurnosnih događaja



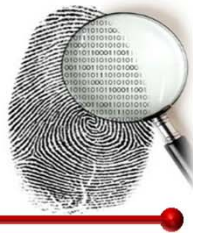
- Konfiguracija se može mijenjati putem alata gpedit.msc ili MMC (Group Policy Object Editor)
- Zadane vrijednosti ovise o inačici Windows sustava
  - npr. samo uspješne prijave na desktop računalima, i uspješne i neuspješne prijave na serverima

Sistemski događaji



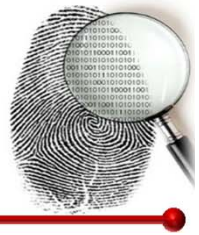
- Zapisi koje stvara:
  - Operacijski sustav, i njegovi servisi
- Najzanimljiviji događaji su
  - Pokretanje i zaustavljanje servisa
  - Pokretanje i zaustavljanje operacijskog sustava
  - Promijene sistemskog vremena
- Zaustavljanje računala se ponekad ne bilježi
  - Zbog neočekivanog zaustavljanja (npr. ispad sustava)
- Korisno za korelaciju s drugim tragovima
  - Promjene vremena su posebno značajne
- Razine:
  - error, warning, information

Aplikacijski događaji



- Također tri razine (Error, Warning, Information)
- MSDN smjernice
  - Error: nije moguće nastaviti s daljnjim radom aplikacije
    - Npr. Ispad zbog nedostatka memorije
  - Warning: ne-kritičan događaj koji bi u budućnosti mogao izazvati ispad
    - Nrp. Uspješno pisanje na korumpirani sektor nakon drugog pokušaja
  - Information: uspješno obavljena operacija
    - Npr. Uspješna prijava na bazu
- Aplikacija odlučuje hoće li koristiti Windows događaje
  - te kako će klasificirati svoje događaje prema postojećim smjernicama
- Korisno kada se istražuje određena aplikacija

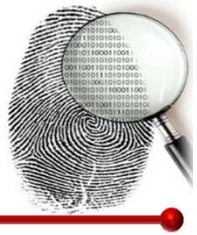
Za sve logove



- „Glasni”
  - = sadrže obilje informacije
- Ovise o konfiguraciji
- Više potencijalnih točaka za neovlašteni pristup
  - Izmjena biblioteka (DLL) drugih proizvođača
- Obično ne predstavljaju primarne dokaze
  - Ali korisno za korelaciju s drugim dokazima

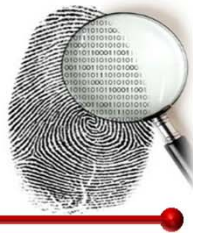

Windows Registry

Windows registry je ...



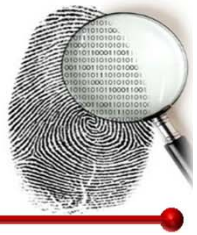
- jedna od osnovnih komponenti svakog operacijskog sustava Windows
- dio sustava od verzije Windows 3.1 (1992!)
- hijerarhijska baza podataka
  - kojom upravlja operacijski sustav
  - a služi za pohranu konfiguracijskih podataka
    - komponenti sustava i korisničkih aplikacija
- zamjena za “ini datoteke”
  - iz ranijih verzija Microsoftovih sustava (DOS)
- zanimljiv izvor tragova
  - u forenzičkoj analizi strojeva s Windows OS-om

Programski pristup živom registry-u

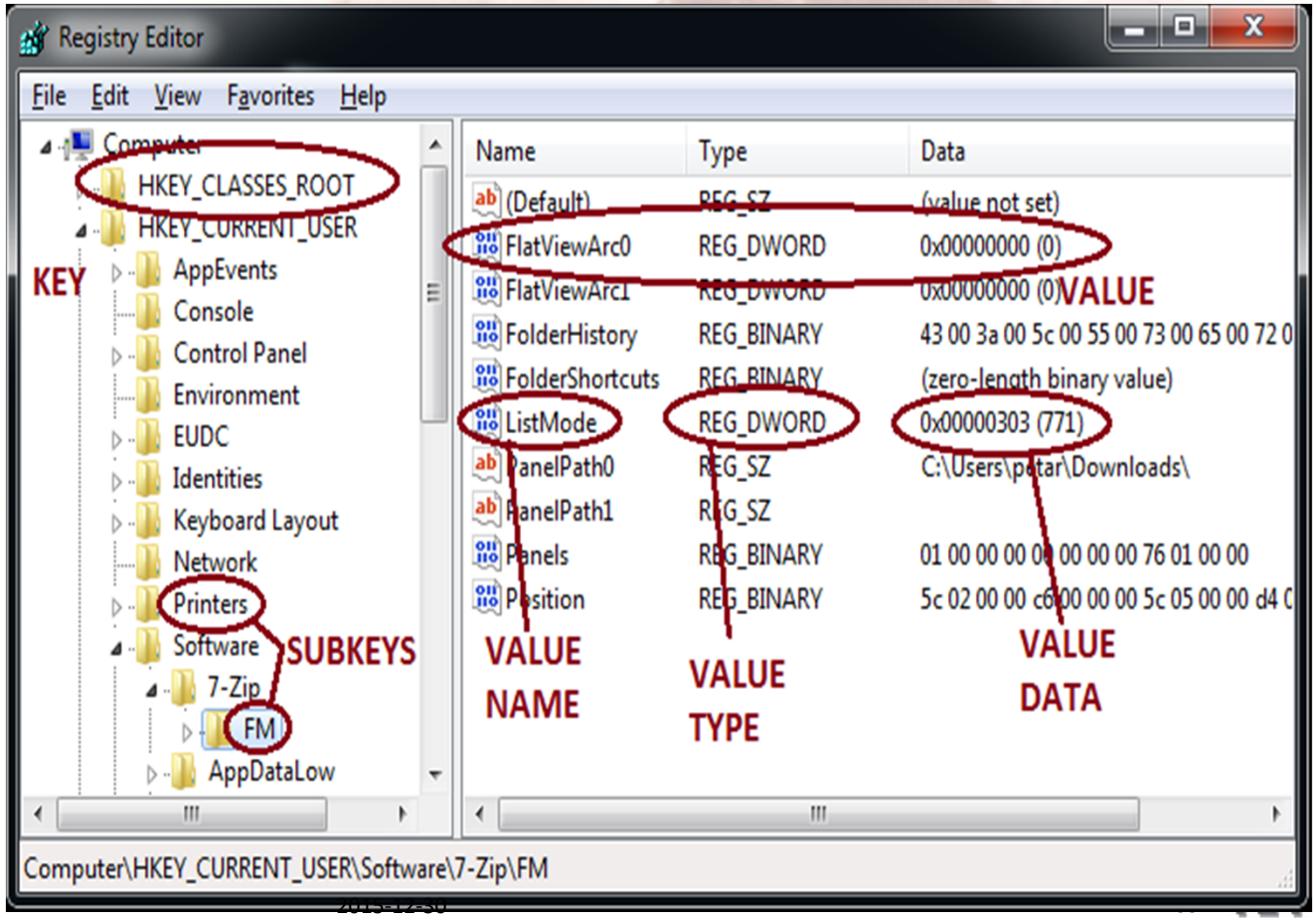


- Windows API (win32/win64):
  - https://msdn.microsoft.com/en-us/library/windows/desktop/ms724875(v=vs.85).aspx
- .NET API (C# &friends):
  - https://msdn.microsoft.com/en-us/library/microsoft.win32.registry(v=vs.110).aspx
- Windows Script Host: WshShell Object
  - https://msdn.microsoft.com/en-us/library/aew9yb99(v=vs.84).aspx)
- Windows PowerShell: razni Cmdlet-i
  - e.g. https://technet.microsoft.com/en-us/library/ee176852.aspx)
- Ostali jezici :
  - mapiranje na C funkcije
    - većina jezika omogućava nekim mehanizmom
      - npr JNA za Javu, COM razred u PHP-u i sl.
  - preko “native” 3rd party biblioteka ili modula
    - npr. Win32::Registry ili Win32::TieRegistry na CPAN

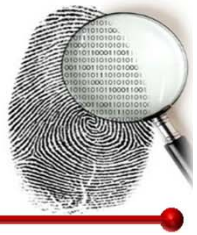
Logička organizacija



- podaci su pohranjeni u stablastu strukturu max. dubine 512 razina, koja se sastoji od:
  - Ključeva (*keys*) i potključeva (*subkeys*)
  - Vrijednosti (*values*)
    - ime vrijednosti (value name)
    - tip vrijednosti (value type)
    - podatci (value data)



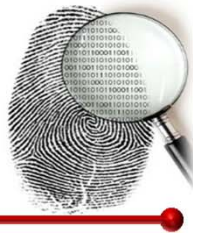
Ključevi i vrijednosti



- Svaki čvor stabla je ključ ili potključ
  - ključ može sadržavati potključeve i vrijednosti (jednu ili više)
  - ime svakog potključa je jedinstveno unutar nadređenog ključa
  - ključ: vrhovi hijerarhija kao HKEY_CLASSES_ROOT, HKEY_CLASSES_USER
  - ostalo su potključevi
    - iako u literaturi se često koristi termin "*key*" u kontekstu roditelja bilo kojeg potključa te korištenje termina "*root key*" za vršne ključeve
- vrijednost (*value*) ima naziv (*name*), tip (*type*) i "vrijednost" (podatke, *data*)
  - Za ograničenja veličina vidi: https://msdn.microsoft.com/en-us/library/windows/desktop/ms724872(v=vs.85).aspx
- TTip:
  - string (ASCII/Unicode),
  - DWORD (32-bit),
  - QWORD(64 bita), binary etc.

  https://msdn.microsoft.com/en-us/library/windows/desktop/ms724884(v=vs.85).aspx
- Preporuka:
  - duge binarne vrijednosti (>2,048 byte) pohraniti u datoteku,
  - a punu putanju datoteke u registry

Sadržaj registry-a



- Sistemski artefakti
  - kreira i uređuje OS prvenstveno za vlastite potrebe
  - aplikacije mogu vidjeti neke od vrijednosti, ovisno o ovlastima
  - OS verzija, korisnici, grupe, liste pristupa (ACL), policies, putanje sistemskih datoteka, instaliran softver i komponente itd

- Korisnički artefakti
  - kreiraju i uređuju aplikacije i alati, pristup ovisi o ovlastima

➔ Zajednički (za sve korisnikers)

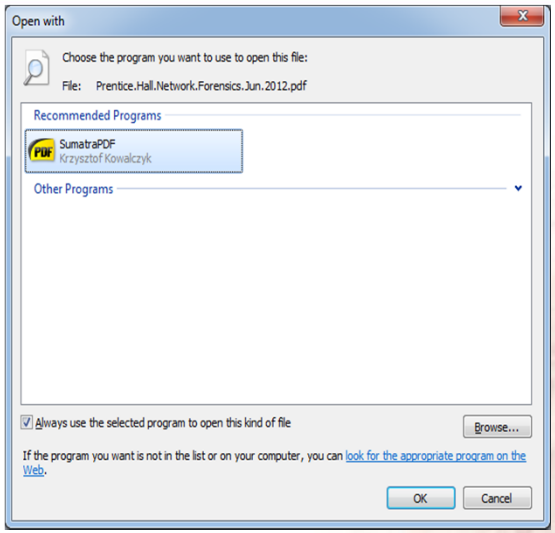
◆Konfiguracije instaliranih aplikacija (“for all users”, zahtjeva admin ovlasti)

➔ Pojedinog korisnika

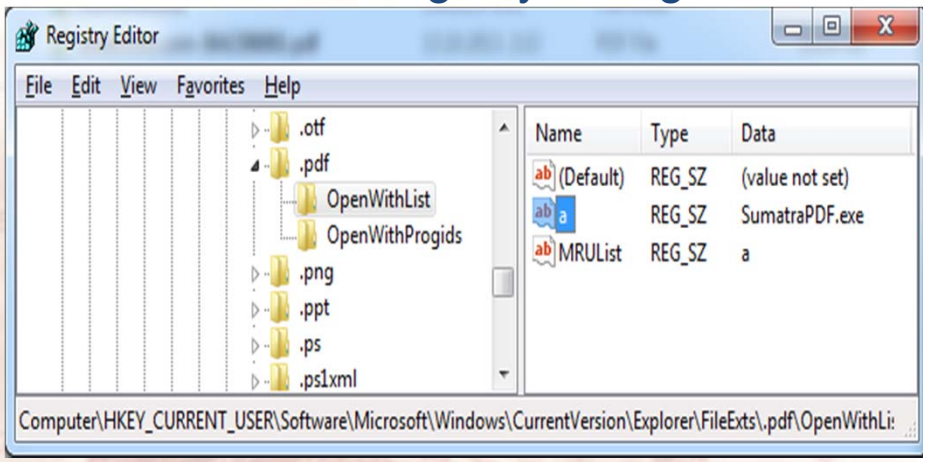
◆recent documents, konfiguracija aplikacije “za mene” (npr web history za IE, veličina i pozicija prozora ili hash passworda za neku uslugu)

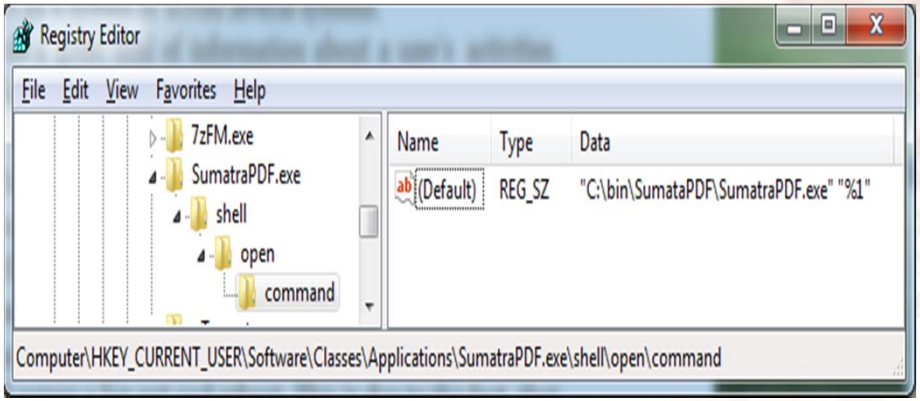
Sadržaj registry-a, primjer

Trenutno prijavljeni korisnik je definirao program kojim se otvaraju datoteke određene ekstenzije

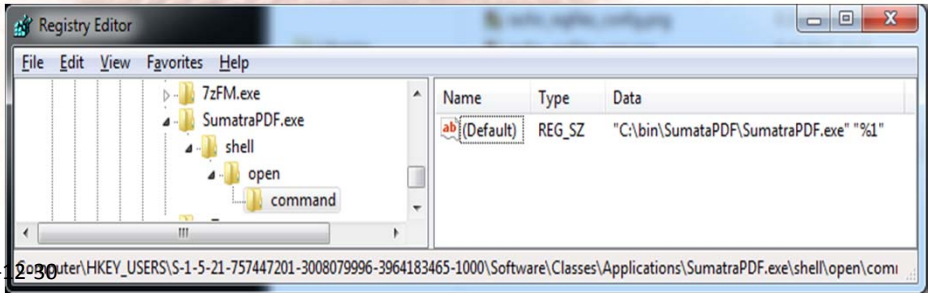


...što OS (win explorer)bilježi u registry za tog korisnika:





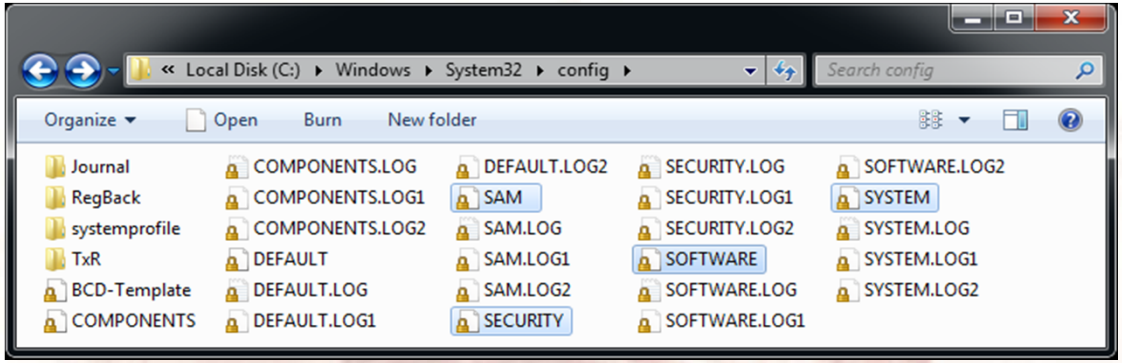
OS mora znati kako može pokrenuti taj program u ljusci s ispravnim argumentima (zadanu vrijednost originalno je upisala instalacijska rutina programa),...



Fizička organizacija - datoteke (*hive files*)

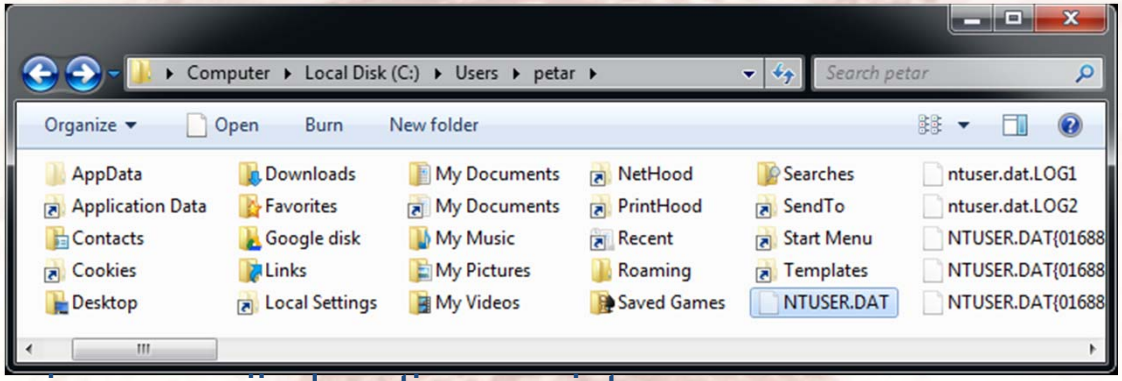
Na putanji <windows>\system32\config\

- ➔ SAM
- ➔ SECURITY
- ➔ SOFTWARE
- ➔ SYSTEM



Za svakog korisnika:

- ➔ NTUSER.DAT u korisničkoj mapi
  - za pregled datoteka u “folder options” odznačiti checkbox “hide protected operating system files”
- ➔ USRClass.dat
  - u Local Settings\Application data\Microsoft \Windows

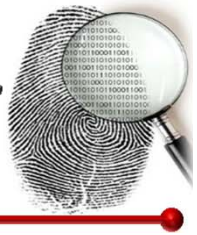


dodatne datoteke mogu biti referencirane u vrijednostima registry-a

datoteke ←→ ključevi nisu 1:1!

npr. HKEY_CURRENT_USER su podaci iz HKEY_USERS/<I D trenutnog korisnika>
ovi podaci formirani su iz obje spomenute datoteke za korisnika

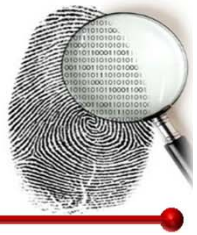
Fizička organizacija - *hives vs. hive files*



Hive Registry Path	Hive File Path
HKEY_LOCAL_MACHINE \SYSTEM	\winnt\system32\config\system
HKEY_LOCAL_MACHINE \SAM	\winnt\system32\config\sam
HKEY_LOCAL_MACHINE \SECURITY	\winnt\system32\config\security
HKEY_LOCAL_MACHINE \SOFTWARE	\winnt\system32\config\software
HKEY_LOCAL_MACHINE \HARDWARE	Volatile hive
HKEY_LOCAL_MACHINE \SYSTEM \Clone	Volatile hive
HKEY_USERS \UserProfile	Profile; usually under \winnt\profiles\users
HKEY_USERS.DEFAULT	\winnt\system32\config\default

Mark Russinovich, "Inside the Registry", Windows NT Magazine, available at
https://technet.microsoft.com/en-us/library/cc750583.aspx

Fizička organizacija - *bins, cells*



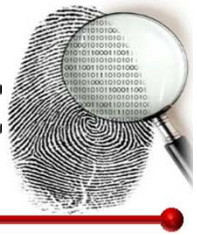
- svaka hive datoteka se sastoji od blokova veličine 4KiB (tzv. bins)
  - olakšavajuća okolnost: 4Ki = 2^{12} = $(2^4)^3$ = $1000_{(16)}$
- svaki blok (osim prvog) počinje "*magic*" nizom 68 62 69 6E 00
  - (ASCII za "hbin")
- Zapis u bloku
  - tzv. ćelije, *cells*
  - odnosi se na ključ
    - ili vrijednost
- zapravo je više vrsta zapisa,
  - detaljnije na
    - https://technet.microsoft.com/en-us/library/cc750583.aspx)

NTUSER.DAT

```
Offset(h)  00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
00000FC0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000FD0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000FE0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000FF0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00001000   68 62 69 6E 00 00 00 00 00 00 10 00 00 00 00 00  hbin............
00001010   00 00 00 00 F0 34 43 B1 29 00 D1 01 00 00 00 00  ....ð4C±).Ñ.....
00001020   78 FF FF FF 6E 6B 2C 00 00 00 17 71 99 29 00 D1  xÿÿÿnk,....q™).Ñ
00001030   00 00 00 00 00 06 00 00 0B 00 00 00 01 00 00 00  ................
00001040   20 20 01 00 68 02 00 80 00 00 00 00 FF FF FF FF    ..h..€....ÿÿÿÿ
...
00001FF0   A8 29 07 00 43 6F 6E 74 F8 FF FF FF 80 50 06 00  ¨)..Contř...€P..
00002000   68 62 69 6E 00 00 10 00 00 00 10 00 00 00 00 00  hbin............
00002010   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00002020   20 00 FF FF FF 6E 6B 20 00 8B 1F 1B 1D 0C D0 CE 01  .ÿÿÿnk .‹....ĐÎ.
00002030   00 00 00 00 48 0F 00 00 02 00 00 00 00 00 00 00  ....H...........
00002040   50 8E 01 00 FF FF FF FF 00 00 00 00 FF FF FF FF  PŽ..ÿÿÿÿ....ÿÿÿÿ
00002050   90 8D 03 00 FF FF FF FF 10 00 00 00 00 00 00 00  .Ť..ÿÿÿÿ........
00002060   00 00 00 00 00 00 00 00 00 00 00 00 11 00 00 00  ................
```

načelno zapisi ne prelaze granice bloka (bin-a) nego je jedan zapis sadržan unutar bloka

Format zapisa o ključu - key cell format



poz	vel	opis
0	4	veličina zapisa
4	2	NodeID
6	2	tip čvora
8	8	LastWriteTime (kasnije više o tome)
20	4	pomak od roditelja

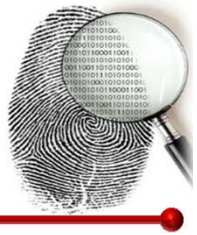
24	4	Broj potključeva
32	4	pomak zapisima o potključevima
36	4	broj vrijednosti
44	4	pomak prema listi vrijednosti
48	4	pomak prema sigurnosnom zapisu
76	2	duljina imena ključa

(lista nije potpuna, samo navodi forenzički najzanimljivije elemente)

Nakon ove strukture slijedi ime ključa (duljine definirane posljednjim poljem) te eventualna popuna (*padding*) do "okrugle" veličine

veličina zapisa = ovih 80 bajtova + duljina imena + padding

Korisni tragovi u *key cell*-u



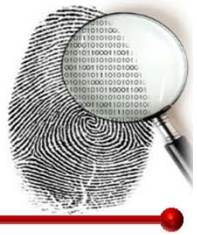
LastWriteTime

- ➔64 bitna FILETIME struktura
- ➔OS vodi evidenciju (ne upisuje aplikacija/korisnik)
- ➔broj 100-nanosekundnih intervala od ponoći 1.1.1601.
  - ❾Od ponoći 1.1.1601

Veličina

- ➔za aktivne zapise negativna vrijednost prave veličine zapisa
  - ❾kao signed integer
    - ➔4-bajtni dvojni komplement,
      npr. za zapis veličine 102 bajta je DWORD_MAX-101
- ➔brisanje ključa = **logičko brisanje**
  - ❾postavljanjem ove vrijednosti na pozitivan broj
    - ➔dodatno prostor ćelije postaje nealocirani prostor registry-a!

Value cell format



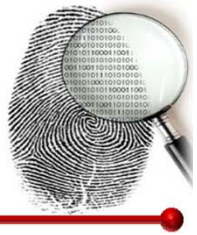
Nema timestamp polja!

Vrijedi li za veličinu slično kao kod keycell strukture? Isprobati za vježbu...

poz	vel	opis
0	4	veličina (kao negativan broj)
4	2	NodeID
6	2	Duljina naziva vrijednosti
8	4	Duljina podatka
12	4	Pomak podatka
16	4	Tip podatka

(not an exhaustive list)

Alati



Bitne podjele: online vs. offline,
API vs. gotovi alati,
free vs. proprietary

Pristup živom (online) registry-u

➔važan u incident response scenarijima

➔ograničen osnovnim win32 API:

- obično pristup samo logičkoj strukturi

Pristup offline registry-u

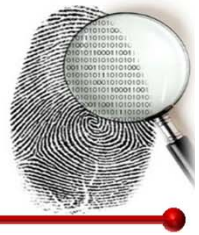
➔pristup (forenzičkoj) kopiji datoteka registry-a

➔potraga za poznatim fenomenima

- (pobrisani ključevi, konkretni ključevi i vrijednosti, nekonzistencije, malware signatures itd.)

Best friends: Google & Github

Alati, nastavak



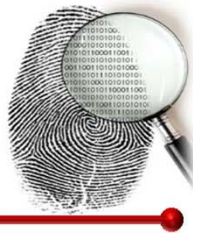
Cjeloviti alati

- ➔mali specijalizirani alati (npr. perl skripte)
  - ❾ili dijelovi cjelokupnih forenzičkih rješenja
    - ➔*suites* i *toolkits*, npr. FTK, enCase, Sleuth itd.
- ➔često plugin arhitektura:
  - ❾laka nadogradnja komponentama
  - ❾temeljenim na novostečenim spoznajama o sadržajima u registry-u
    - ➔nove aplikacije, novo pronađeni tragovi zloćudnog koda i sl.

API

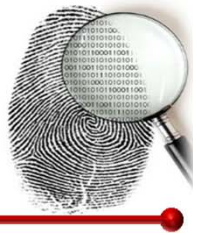
- ➔Za izradu novih alata po potrebi
- ➔live analiza: wrapperi oko win32 API-a
- ➔analiza offline datoteka:
  - ❾parseri datoteka,
    - ➔predstavljaju podatke na organiziran način
      - ➔npr. kroz objektni model registry artefakata

Pristup živom registry-u



- Registry editor (regedit.exe)
  - je dio svake Windows instalacije
- Reg – alat za poziv znakovnog korisničkog sučelja
  ➔koristan za uključivanje u skripte
  ➔Reg <operation> [key] (todo: dodati ostatak)
- Ranije spomenuti wrapperi oko win32 API poziva, npr:
  ➔Win32::TieRegistry (Perl)
  ➔_winreg/winreg (Python)
  ➔WMI (wrapperi u .NET, MFC itd)
  ➔Windows Script Host
  ➔...

Pristup hladnom registryu: regscan.pl



➔perl skripta uključena u CPAN modul Parse::Win32Registry

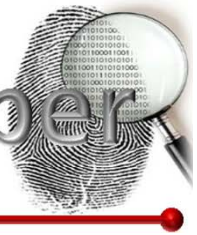
➔ispisuje postojeće zapise
s pripadajućim vremenom izmjene (ako postoji)

➔`perlscan.pl --help` za više

Primjer:

```
petar@asus$ regscan.pl NTUSER.DAT | head -n 10
0x1020 CMI-CreateHive{D43B12B8-09B5-40DB-B4F6-F6DFEB78DAEC} [2015-09-02T06:07:01Z]
0x10a8 CMI-CreateHive{D43B12B8-09B5-40DB-B4F6-F6DFEB78DAEC}\Software\Microsoft [2015-09-02T06:07:01Z]
0x1108 (subkey list entry)
0x1120 (subkey list entry)
0x1130 IE5_UA_Backup_Flag (REG_SZ) = 5.0
0x1160 CMI-CreateHive{D43B12B8-09B5-40DB-B4F6-F6DFEB78DAEC}\Software [2015-09-02T06:07:01Z]
0x11b8 (unidentified entry)
0x11c8 CMI-CreateHive{D43B12B8-09B5-40DB-B4F6-F6DFEB78DAEC}\Software\Policies [2015-05-25T20:53:16Z]
0x1220 (unidentified entry)
0x1228 (unidentified entry)
```

Pristup hladnom registryu: RegRipper



➔https://github.com/keydet89/RegRipper2.8/

➔Perl command-line alat

➔aktivno održavanje: posljednja izmjena (izmjena jednog plugina) prije >30 dana

➔jednostavna plugin arhitektura:

- mapa plugins
- 1 plugin = 1 logička funkcionalnost
- 1 plugin = 1 perl skripta = 1 “pluginmain“ procedura
- rujan 2015.: 325 pluginova
- bundle datoteke: all/security/sam/ntuser/… (sve razumne pretrage za odabranu datoteku)

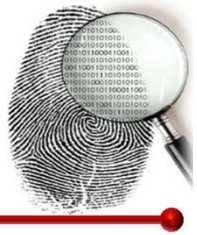
➔dostupni i perl2exe generirani PE-ovi rip.exe i rr.exe (GUI za pokretanje) za Windows bez Perl-a

➔koristi se kao dio nekoliko forenzičkih toolset-a

- Revealer Toolkig, SANS, PlainSight itd

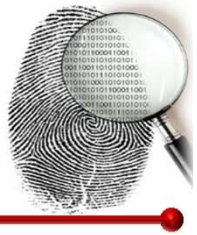
➔`perl rip.pl -help` for more

RegRipper primjer



```
petar@asus$ perl rip.pl -r ~/fer/racfor/registry/myfiles/petar/NTUSER.DAT -p winlogon_u
Launching winlogon_u v.20130425
winlogon_u v.20130425
(NTUSER.DAT) Get values from the user's WinLogon key

Software\Microsoft\Windows NT\CurrentVersion\Winlogon
LastWrite Time Sun May 31 09:16:58 2015 (UTC)
  FirstLogon = 0
  ParseAutoexec = 1
  BuildNumber = 7601
  ExcludeProfileDirs = AppData\Local;AppData\LocalLow;$Recycle.Bin

Software\Wow6432Node\Microsoft\Windows NT\CurrentVersion\Winlogon not found.
Analysis Tip: Existence of RunGrpConv = 1 value may indicate that the
  system had been infected with Bredolab (Symantec).  Also, check the
  contents of a "shell" value - should only include Explorer.exe, if
  it exists.
petar@asus$
```

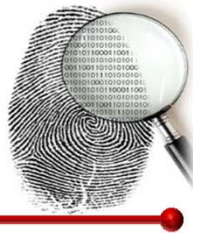
Pristup hladnom registryu: regslack.pl



- perl skripta za otkrivanje logički pobrisanih ključeva i nealociranog prostora
  - https://github.com/keydet89/Tools/
  - originalni autori regslack i regripper skripti su različite osobe
  - ali trenutno se oba alata uz neke druge mogu naći u github repozitorijima Harlana Carveya
    - forenzičara i autora više knjiga o Windows forenzici
- Example:

```
petar@asus$ perl regslack.pl ../../win7IE10/NTUSER.DAT | head -26
"\??\C:\Users\IEUser\ntuser.dat"
[Tue Oct  6 11:25:23 2015]

### Deleted Key  ###

CMI-CreateHive{6A1C4018-979D-4291-A7DC-
7AED1C75B67C}\Software\Microsoft\Windows\CurrentVersion\Explorer\CD Burning\Drives\Volume{a509785a-
75af-11e4-b72d-806e6f6e6963}\Current Media
Offset: 0x85e30 [Tue Oct  6 11:24:57 2015]
Number of values: 0
```

regslack.pl (nastavak)



```
Recovered 1 keys and 0 values: #0 keys from allocated space.

Rejected 0 keys and 0 values.

### Unallocated Space ###

Offset 0x71f70 - 0x71f90:
20 00 00 00 76 6b 07 00 04 00 00 80 00 00 00 00 ....vk..........
04 00 00 00 01 00 4c 73 4c 69 76 65 20 46 53 00 ......LsLive.FS.

Offset 0x72e08 - 0x72e18:
10 00 00 00 50 4f 08 00 88 50 08 00 70 51 08 00 ....PO...P..pQ..

Offset 0x73cf8 - 0x73d08:
10 00 00 00 6c 66 01 00 90 2c 07 00 66 38 2d 31 ....lf...,..f8-1

Offset 0x754e8 - 0x75500:
(...)
```


ComFor.zesoi.fer.hr
ComFor@zesoi.fer.hr