Computer Forensics

Andrej Brodnik

Computer network basics

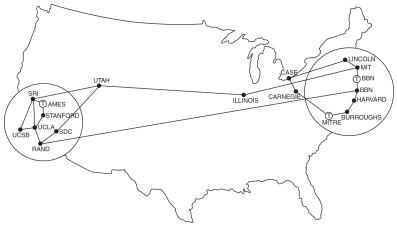
chapters 21, 23, 24 and 25

- from history

ENIAC	ARPANET	Intel 8080	Mac & IBM PCs	WWW	Internet2
1946	1969	1974	1980s	1991	1999

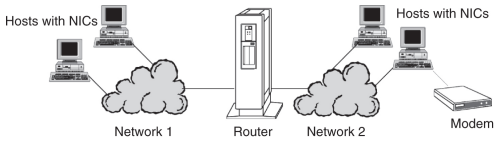
Computer network basics

- from history: ARPANET
- TCP/IP: 1973/74



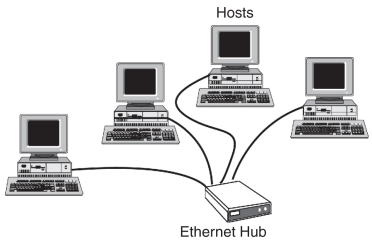
Computer network basics

• network, internet



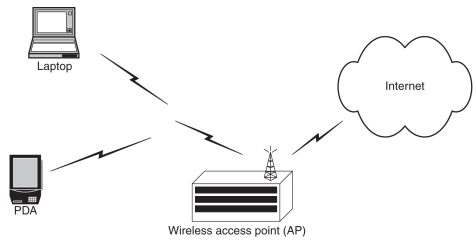
Network

• IEEE 802.3 Ethernet



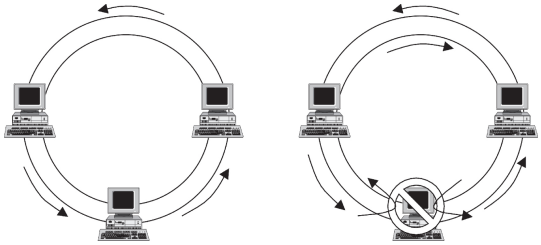
Network

• IEEE 802.11 Ethernet



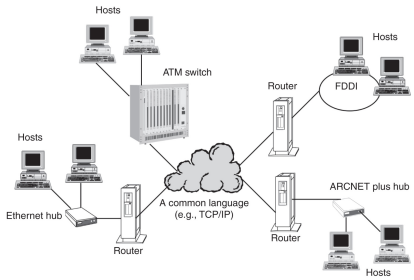
Network

- FDDI



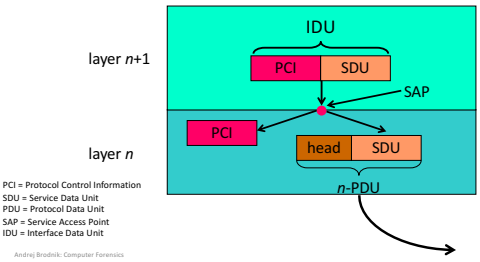
Network

- network of dissimilar networks and common language



Layer model

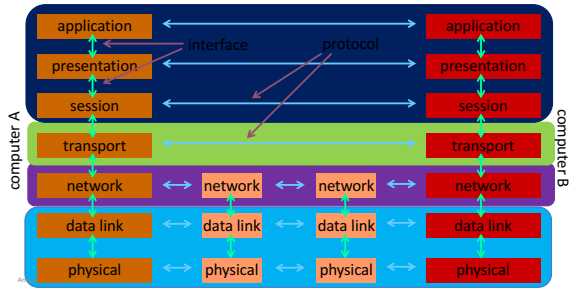
- each layer is independant from others
- It serves the layers above and is served by layers below



PCI = Protocol Control Information
SDU = Service Data Unit
PDU = Protocol Data Unit
SAP = Service Access Point
IDU = Interface Data Unit

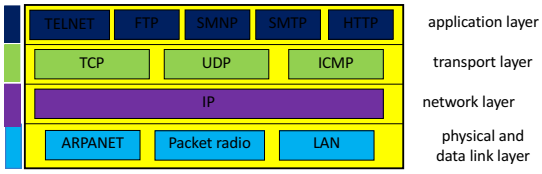
Reference models

- layers of OSI reference model: physical, data link, network, transport, session, presentation, application.



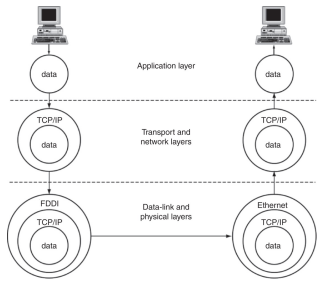
Reference model – TCP/IP

- TCP/IP reference model
  - is the foundation of the internet and *de facto* standard
  - no presentation or session layers
  - physical and data link layers are combined in so called "Host-to-network" layer
  - data link layer is composed of MAC and LLC (IEEE 802)



Containers

- TCP/IP example



Physical and data link layers

- physical: transmission of physical signals
- data link:
  - IEEE 802.11 is the most common
  - encompasses different technologies
    - among the most well known are IEEE 802.3, 11, 15, 16, ...
  - composed of MAC and LLC sublayers
    - MAC – *media access control*: unique for a particular technology
    - LLC – *link layer control*: equal for all technologies

Network layer

- IP (*internet protocol*) is used for transparently relaying packets across networks
- best-effort and out-of-order delivery
- shared address space (IPv4, IPv6)
- connected to the data link layer through ARP (arp tool)
- *Challenge:* determine which computers are in your network. How would the protocol be used in a forensic investigation? How would the protocol (possibly with additional tools) be used in finding out what is happening in our network?

Transport layer

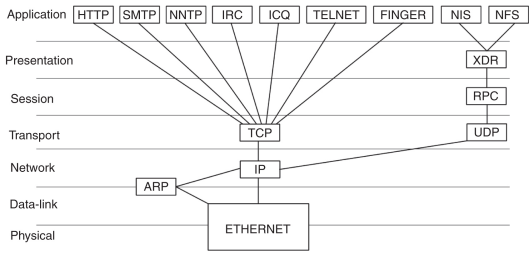
- fundamental protocols TCP and UDP: connection-oriented and connectionless communication
- TCP represents a stream of data between two processes on different computers

Application layer

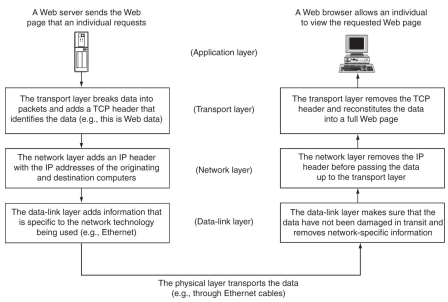
- standard applications: mail, web, news, IRC, ...
- non-standard applications: defined by the user

TCP/IP example

- example of protocol taxonomy



Protocol stack TCP/IP



Some fundamental tools

- basic tools made available by the operating system
  - arp:

```
Andy@svarun:~[122]%> arp -an
? (192.168.127.7) at 00:1f:5b:f2:e1:da on rl0 expires in 1189
  seconds [ethernet]
? (192.168.127.1) at 00:13:f7:39:d8:d1 on rl0 permanent
  [ethernet]
```


Some fundamental tools ...

- netstat:

```
Andy@svarun:~[124]%> netstat -rn
Routing tables

Internet:
Destination        Gateway            Flags    Refs      Use  Netif Expire
default            213.250.19.90      UGS         0 15915184   tun0
10.0.0.1           link#11            UHS         0        0   lo0
10.0.0.2           link#11            UHS         0        0   tun0
127.0.0.1          link#10            UH          0   168729   lo0
192.168.127.0/24   link#7             U           0  3843148   rl0
192.168.127.1      link#7             UHS         0   134062   lo0
193.77.156.167     link#11            UHS         0        0   lo0
213.250.19.90      link#11            UHS         0        0   tun0

Internet6:
Destination                       Gateway                       Flags      Netif Expire
::/96                             ::1                           UGRS        lo0
::1                               ::1                           UH          lo0
::ffff:0.0.0.0/96                 ::1                           UGRS        lo0
fe80::/10                         ::1                           UGRS        lo0
fe80::%rl0/64                     link#7                        U           rl0
fe80::213:f7ff:fe39:d8d1%rl0      link#7                        UHS         lo0
fe80::%rl1/64                     link#8                        U           rl1
fe80::213:f7ff:fe39:dac7%rl1      link#8                        UHS         lo0
fe80::%lo0/64                     link#10                       U           lo0
fe80::1%lo0                       link#10                       UHS         lo0
ff01::%rl0/32                     fe80::213:f7ff:fe39:d8d1%rl0  U           rl0
ff01::%rl1/32                     fe80::213:f7ff:fe39:dac7%rl1  U           rl1
ff01::%lo0/32                     ::1                           U           lo0
ff02::/16                         ::1                           UGRS        lo0
ff02::%rl0/32                     fe80::213:f7ff:fe39:d8d1%rl0  U           rl0
ff02::%rl1/32                     fe80::213:f7ff:fe39:dac7%rl1  U           rl1
ff02::%lo0/32                     ::1                           U           lo0
```


Some fundamental tools ...

- sockstat:

```
Andy@svarun:~[128]%> sockstat
USER     COMMAND    PID   FD PROTO  LOCAL ADDRESS         FOREIGN
  ADDRESS
....     imap       97205 0  stream -> ??
dovecot  imap-login 97204 3  stream -> ??
dovecot  imap-login 97204 4  tcp4   *:143               *:*
dovecot  imap-login 97204 5  tcp4   *:993               *:*
dovecot  imap-login 97204 11 stream -> /var/run/dovecot/login/default
bind     named      1750  513 udp4  127.0.0.1:53         *:*
bind     named      1750  514 udp4  10.0.0.1:53          *:*
root     syslogd    1649  4  dgram  /var/run/log
root     syslogd    1649  5  dgram  /var/run/logpriv
...
```

Some fundamental tools …

- ifconfig:

```
Andy@svarun:~[131]%> ifconfig
alc0: flags=8802<BROADCAST,SIMPLEX,MULTICAST> metric 0 mtu 1500

  options=c3198<VLAN_MTU,VLAN_HWTAGGING,VLAN_HWCSUM,TSO4,WOL_MCAST,WOL_
  MAGIC,VLAN_HWTSO,LINKSTATE>
        ether 54:04:a6:94:54:0b
        nd6 options=23<PERFORMNUD,ACCEPT_RTADV,AUTO_LINKLOCAL>
        media: Ethernet autoselect
rl0: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> metric 0 mtu
  1500
        options=3808<VLAN_MTU,WOL_UCAST,WOL_MCAST,WOL_MAGIC>
        ether 00:13:f7:39:d8:d1
        inet6 fe80::213:f7ff:fe39:d8d1%rl0 prefixlen 64 scopeid 0x7
        inet 192.168.127.1 netmask 0xffffff00 broadcast
  192.168.127.255
        nd6 options=23<PERFORMNUD,ACCEPT_RTADV,AUTO_LINKLOCAL>
        media: Ethernet autoselect (100baseTX <full-duplex>)
        status: active
rl1: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> metric 0 mtu
  1500
        options=3808<VLAN_MTU,WOL_UCAST,WOL_MCAST,WOL_MAGIC>
        ether 00:13:f7:39:da:c7
        inet6 fe80::213:f7ff:fe39:dac7%rl1 prefixlen 64 scopeid 0x8
        nd6 options=23<PERFORMNUD,ACCEPT_RTADV,AUTO_LINKLOCAL>
        media: Ethernet autoselect (100baseTX <full-duplex>)
        status: active
```


Some fundamental tools …

- ifconfig:

```
lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> metric 0 mtu 16384
        options=3<RXCSUM,TXCSUM>
        inet6 ::1 prefixlen 128
        inet6 fe80::1%lo0 prefixlen 64 scopeid 0xa
        inet 127.0.0.1 netmask 0xff000000
        nd6 options=23<PERFORMNUD,ACCEPT_RTADV,AUTO_LINKLOCAL>
ipfw0: flags=8801<UP,SIMPLEX,MULTICAST> metric 0 mtu 65536
        nd6 options=23<PERFORMNUD,ACCEPT_RTADV,AUTO_LINKLOCAL>
tun0: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> metric 0 mtu
  1492
        options=80000<LINKSTATE>
        inet 10.0.0.1 --> 10.0.0.2 netmask 0xffffff00
        inet 193.77.156.167 --> 213.250.19.90 netmask 0xffffff00
        nd6 options=21<PERFORMNUD,AUTO_LINKLOCAL>
        Opened by PID 85187
```


Some fundamental tools …

- tcpdump / pcap:

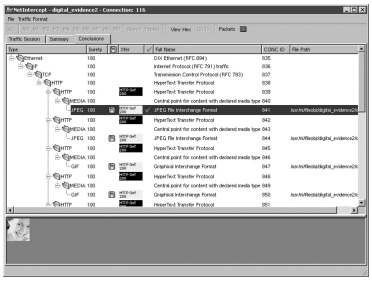
```
Andy@svarun:~[129]%> svarun# tcpdump -i rl0 -n
tcpdump: verbose output suppressed, use -v or -vv for full protocol
  decode
listening on rl0, link-type EN10MB (Ethernet), capture size 65535
  bytes
08:10:33.878428 IP 193.77.156.167.22 > 192.168.127.7.53945: Flags
  [P.], seq 1108677235:1108677427, ack 2653943873, win 1040, options
  [nop,nop,TS val 2243985208 ecr 1042431634], length 192
08:10:33.878574 IP 192.168.127.7.53945 > 193.77.156.167.22: Flags [.],
  ack 192, win 33208, options [nop,nop,TS val 1042431634 ecr
  2243985208], length 0
08:10:34.379667 IP 192.168.127.7.47895 > 195.221.158.190.56534: UDP,
  length 137
08:10:34.429933 IP 192.168.127.7.47895 > 111.221.74.19.40012: UDP,
  length 32
08:10:34.441387 IP 195.221.158.190 > 192.168.127.7: ICMP
  195.221.158.190 udp port 56534 unreachable, length 156
08:10:34.712616 IP 111.221.74.19.40012 > 192.168.127.7.47895: UDP,
  length 434
08:10:34.878466 IP 193.77.156.167.22 > 192.168.127.7.53945: Flags
  [P.], seq 192:736, ack 1, win 1040, options [nop,nop,TS val
  2243986208 ecr 1042431634], length 544
...
```

Some fundamental tools ...

- *Challenge:* use basic tools to explore your neighborhood.
- *Challenge:* examine your system and determine which services it offers to the devices in the neighborhood?
- *Challenge:* the tcpdump tool allows for storage of captured data for later usage. The analysis of this data can be done using the wireshark tool. Try to perform this procedure.
- *Challenge:* in a forensically sound manner capture the data in your network and post the results on the forum. A colleague should then perform the analysis.

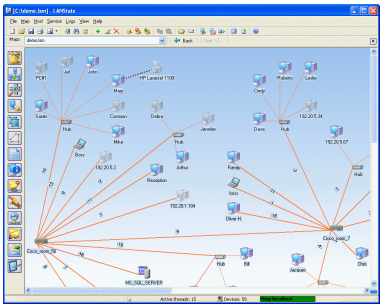
Professional and other tools

- Niksun forensics tools http://www.niksun.com/sandstorm.php: netintercept



Professional and other tools

- network management protocols: snmp, rmon, ...



Protocol SNMP

- snmp v2 and v3
- connectionless data transfer: UDP
- two types of commands:
  - on-demand data transfer and
  - event based data transfer
- the status of the network is stored in the MDB and in the log files
- *Challenge:* find tools for network exploration that employ the snmp protocol and explore your neighborhood.

Strength in numbers

- www.fri.uni-lj.si = 212.235.188.25
- DNS service maps strings to numbers
  - a mapping table in /etc/hosts can alternatively be used
- a DNS server inquires other DNS servers if there is a string it can't map
  - file /etc/namedb/named.root
- tools *dig* and *nslookup*

DNS server

- file /etc/namedb/named.root (excerpt):

```
; formerly NS.INTERNIC.NET
;
.                       3600000  IN  NS    A.ROOT-SERVERS.NET.
A.ROOT-SERVERS.NET.     3600000      A     198.41.0.4
A.ROOT-SERVERS.NET.     3600000      AAAA  2001:503:BA3E::2:30
;
; FORMERLY NS1.ISI.EDU
;
.                       3600000      NS    B.ROOT-SERVERS.NET.
B.ROOT-SERVERS.NET.     3600000      A     192.228.79.201
;
; FORMERLY C.PSI.NET
;
.                       3600000      NS    C.ROOT-SERVERS.NET.
C.ROOT-SERVERS.NET.     3600000      A     192.33.4.12
;
; FORMERLY TERP.UMD.EDU
;
.                       3600000      NS    D.ROOT-SERVERS.NET.
D.ROOT-SERVERS.NET.     3600000      A     128.8.10.90
D.ROOT-SERVERS.NET.     3600000      AAAA  2001:500:2D::D
;
; FORMERLY NS.NASA.GOV
;
.                       3600000      NS    E.ROOT-SERVERS.NET.
E.ROOT-SERVERS.NET.     3600000      A     192.203.230.10
;
; FORMERLY NS.ISC.ORG
```

DNS server

- *Challenge:* with an appropriate tool find your DNS server and examine its records.
- *Challenge:* with your colleagues set up an isolated network with its own root name servers.
- *Challenge*: assume that the following packet was captured on the network:

```
09:13:01.839003 IP (tos 0x10, ttl 64, id 13571,
offset 0, flags [DF], proto TCP (6), length 180)
    www.brodnik.org.ssh >
AndyMac.gotska.brodnik.org.53945: Flags [P.], cksum
0xf181 (correct), seq 1108696419:1108696547, ack
2653946897, win 1040, options [nop,nop,TS val
2247733168 ecr 1042469077], length 128
```

comment on the contents and determine the sender and the recipient.

Strength in numbers

- DNS service uses port 53
- there is no service that would map DNS to 53
  - there is however a mappign table in /etc/services
- the system binds the application to the process (program) at startup

Application names

```
#
# Network services, Internet style
#
# WELL KNOWN PORT NUMBERS
#
rtmp              1/ddp    #Routing Table Maintenance
 Protocol
tcpmux            1/udp     # TCP Port Service
 Multiplexer
tcpmux            1/tcp     # TCP Port Service
 Multiplexer

                            ...
domain           53/tcp    #Domain Name Server
domain           53/udp    #Domain Name Server
imap            143/tcp    imap2 imap4  #Interim Mail
 Access Protocol v2
imap            143/udp    imap2 imap4  #Interim Mail
 Access Protocol v2
imaps           993/tcp    # imap4 protocol over TLS/SSL
imaps           993/udp
                           ...
```

Application names

- sockstat

```
Andy@svarun:~[128]%> sockstat
USER     COMMAND    PID   FD PROTO  LOCAL ADDRESS         FOREIGN
  ADDRESS
....     imap       97205 0  stream -> ??
dovecot  imap-login 97204 3  stream -> ??
dovecot  imap-login 97204 4  tcp4   *:143               *:*
dovecot  imap-login 97204 5  tcp4   *:993               *:*
dovecot  imap-login 97204 11 stream -> /var/run/dovecot/login/default
bind     named      1750  513 udp4  127.0.0.1:53         *:*
bind     named      1750  514 udp4  10.0.0.1:53          *:*
root     syslogd    1649  4  dgram  /var/run/log
root     syslogd    1649  5  dgram  /var/run/logpriv
...
```


Application names

- *Challenge:* what is the actual name of the DNS service in the said table?
- *Challenge:* add/modify an entry in the table. Do you notice any changes when running sockstat, netstat, tcpdump?
- *Challenge:* how does the operating system bind an application to a service port? How is this done on Windows, FreeBSD and on Linux?

Protocol names

- excerpt:

```
ip      0       IP              # internet protocol,
 pseudo protocol number
icmp    1       ICMP            # internet control
 message protocol
igmp    2       IGMP            # internet group
 management protocol
ggp     3       GGP             # gateway-gateway
 protocol
tcp     6       TCP             # transmission control
 protocol
udp     17      UDP             # user datagram protocol
ddp     37      DDP             # Datagram Delivery
 Protocol
ipv6    41      IPV6            # ipv6
mobile  55      MOBILE          # IP Mobility
ipv6-icmp       58      IPV6-ICMP       icmp6   # ICMP
 for IPv6
etherip 97      ETHERIP         # Ethernet-within-IP
 Encapsulation
```

Names ...

- *Challenge:* which protocol is denoted by the number 50 ans what is it used for?
- *Challenges:* what are the formats of all three etc files – hosts, protocols, services?
- *Challenge:* what is cifs/smb? In which folder would you look for its definition?

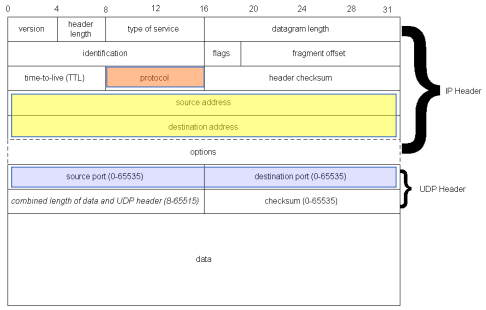
Where are the numbers from?

- global number assignment agreement
- numbers stored and allocated by IANA – *The Internet Assigned Numbers Authority*, www.iana.org
  - root DNS servers: www.iana.org/domains/root/db/arpa.html
  - *ports: www.iana.org/assignments/port-numbers*
  - *protocols: www.iana.org/protocols/*
- *Challenge:* write a program which can produce a services file from the available information on the IANA server
- *Challenge:* what information does the following webpage contain: www.iana.org/domains/root/db/si.html?

Going further

- so far, we understand the following:
  - what is an IP address and how is it mapped from a name (FQN – *fully qualified name*) (*hosts*, *DNS*)
  - what is the name of the protocol we are using (*protocols*)
  - what service do we want from a remote computer and what is its name (*services*)
  - what application offers a particular service (*sockstat*, *netstat*)

Going further



Going further

- who is the service provider?
- we can identify the provider by its IP or by the FQN bound to it
  - or directly through the application layer

WHOIS service

- service

```
nicname          43/tcp    whois
nicname          43/udp    whois
```

- we need a whois server
  - whois.iana.org, whois.arnes.si
  - tools: telnet, whois

WHOIS service

```
Andy@svarun:~[171]%> whois fri.uni-lj.si
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% This is ARNES whois database
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Rights restricted by copyright.
% See http://www.arnes.si/domene/whois-legal.html
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% The WHOIS service offered by Arnes, .si Registry, is
% provided for information purposes only. It allows persons
% to check whether a specific domain name is still available
% or not and to obtain information related to the registration
% records of existing domain names.
%
% This WHOIS service accepts and displays only ASCII characters.
%
% Arnes cannot be held liable should the stored information
% prove to be wrong, incomplete or inaccurate in any sense.
%
% By submitting a query you agree not to use the information
% made available to:
%       o Allow, enable or otherwise support the transmission
%         of unsolicited, commercial advertising or other solicitations
%         whether via email or otherwise;
%       o Target advertising in any possible way;
%       o Cause nuisance in any possible way to the registrants
%         by sending (whether by automated, electronic processes
%         capable of enabling high volumes or other possible
%         means) messages to them;
%       o copy, extract and/or publish contents of the WHOIS database.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% No entries found for the selected source(s).
```


WHOIS service

```
Andy@svarun:~[172]%> whois uni-lj.si
                                                    ...

domain:             uni-lj.si
registrar:    Arnes
registrar-url:      http://www.arnes.si/storitve/splet-posta-
  strezniki/registracija-si-domene.html
nameserver:   dns1.uni-lj.si (193.2.1.90,2001:1470:8000::90)
nameserver:   dns2.uni-lj.si (193.2.1.89,2001:1470:8000::89)
nameserver:   dns3.uni-lj.si (193.2.1.94,2001:1470:8000::94)
registrant:   G39085
status:             ok
created:      1992-11-23
expire:             2015-06-06
source:             ARNES

Domain holder:
NOT DISCLOSED

Tech:
NOT DISCLOSED

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% For more information, please visit http://www.registry.si/whois.html
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```


WHOIS service

```
Andy@svarun:~[173]%> whois ul.si
                                                    ...

domain:             ul.si
registrar:    Arnes
registrar-url:      http://www.arnes.si/storitve/splet-posta-
  strezniki/registracija-si-domene.html
nameserver:   dns1.uni-lj.si (193.2.1.90,2001:1470:8000::90)
nameserver:   dns2.uni-lj.si (193.2.1.89,2001:1470:8000::89)
nameserver:   dns3.uni-lj.si (193.2.1.94,2001:1470:8000::94)
registrant:   G39085
status:             ok
created:      2010-10-20
expire:             2015-10-20
source:             ARNES

Domain holder:
NOT DISCLOSED

Tech:
NOT DISCLOSED

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% For more information, please visit http://www.registry.si/whois.html
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

WHOIS service

DOMAIN	
name	uni-lj.si
registrar	Arnes
registrar-url	http://www.arnes.si/storitve/splet-posta-strezniki/registracija-si-domene.html
nameserver:	dns1.uni-lj.si 193.2.1.90 2001:1470:8000::90
nameserver:	dns2.uni-lj.si 193.2.1.89 2001:1470:8000::89
nameserver:	dns3.uni-lj.si 193.2.1.94 2001:1470:8000::94
status:	ok
created:	1992 - 11 - 23
expire:	2015 - 06 - 06
expires in:	53 days
source:	ARNES

WHOIS service

DOMAIN HOLDER	
organization	Univerza v Ljubljani
nic-hdl	G39085
email	rektorat@uni-lj.si
telefon	+386.12418500
fax	+386.12518650
address	Kongresni trg 12
address	SI
source	ARNES

WHOIS service

TECH	
nic-hdl	O167923
email	anton.jagodic@uni-lj.si
address	SI
source	ARNES

WHOIS service

- *Challenge:* looking up information about the gov.si domain should not be difficult. What about other, foreign domains?
- *Challenge:* google.si is no challenge, what about google.com?
- *Challenge:* rkc.si – one would not have thought.
- *Challenge:* keeping in mind the sources of information we have talked about today, examine and comment on the following packets:

```
14:59:26.608728 IP xx.domain.netbcp.net.52497 >
 valh4.lell.net.ssh: . ack 540 win 16554
14:59:26.610602 IP resolver.lell.net.domain >
 valh4.lell.net.24151: 4278 1/0/0 (73)
14:59:26.611262 IP valh4.lell.net.38527 >
 resolver.lell.net.domain: 26364+ PTR?
 244.207.104.10.in-addr.arpa. (45)
```