



Estonian Information
Technology College

Network configuration

Operating systems 1800

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Networking in Ubuntu Linux

- Network configuration will be done during OS installation
- when there is DHCP (*Dynamic Host Control Protocol*) used, network is configured automatically
- to configure network manually, there is needed:
 - IP address
 - default gateway, network mask, name servers
- network settings are stored in folder ***/etc/network***
- in file ***/etc/network/interfaces*** are settings of network interfaces

Main commands of networking

- The names of network interfaces can be different. Usually the first one is **eth0** and second **eth1**
- interface names can be redefined (e.g. using udev rules)
- information about network settings in Linux can be retrieved
 - ***ifconfig -a*** (-a shows also unconfigured interfaces)
 - ***ip a***
- ***ifconfig eth0*** shows information about specific interface

Internal network addresses

- IPv4 addresses ([RFC 1918](#))
 - 10.0.0.0 – 10.255.255.255, qty: 16 777 216 (24 bit = 2^{24})
 - 172.16.0.0 – 172.31.255.255, qty: 1 048 576 (20 bit = 2^{20})
 - 192.168.0.0 – 192.168.255.255, qty: 65 536 (16 bit = 2^{16})
- IPv6 addresses ([RFC 4193](#))
 - fc00::/7, qty: 2^{121}
- device itself (*localhost*):
 - IPv4 127.0.0.1
 - IPv6 ::1
- check also reserved IP-addresses
https://en.wikipedia.org/wiki/Reserved_IP_addresses

Network configuration

- for network configuration change the file */etc/network/interfaces*
- *man interfaces* (*man -f interfaces*) for more information
- in file there are rows (0-n) *ifup* and *ifdown* commands
 - ***auto***
 - ***iface***
 - ***mapping***
 - ***allow-***
 - ***source***
 - ***source-directory***

Graphical *Network Manager* in case of desktop, settings are */etc/NetworkManager/* and will be replace */etc/network/* settings.

Network configuration

- */etc/network/interfaces*
 - **auto** line will bring up the interface when **ifup -a** will be used, also automatically when computer is booting up
 - e.g.: **auto lo eth0**
 - **allow-** beginning allows handling with certain subsystem (e.g. hotplug)
 - e.g.: **allow-hotplug eth1**

Network configuration

- */etc/network/interfaces*
 - Iface will configure interface parameters
 - static network

```
iface eth0 inet static
address 192.168.1.10
netmask 255.255.255.0
broadcast 192.168.1.255
gateway 192.168.1.1
dns-search example.com
dns-nameservers 194.126.115.18 194.126.101.34 194.126.97.30 195.250.187.46
```

- dynamic network

```
auto eth0
iface eth0 inet dhcp
```

- computer itself (*loopback*)
- ```
iface lo inet loopback
address 127.0.0.1
netmask 255.0.0.0
```

manual configuration:

```
iface eth0 inet manual
```

...then system will not wait DHCP if the interface is not configured and DHCP is not available

in current example the Telia Estonian nameservers are used:

```
dns.estpak.ee [194.126.115.18]
dns2.estpak.ee [194.126.101.34]
dns3.estpak.ee [194.126.97.30]
dns4.estpak.ee [195.250.187.46]
```

can be also as separate row:

```
dns-nameserver <IP>
dns-nameserver <IP>
```

when nameservers etc settings has been changed then network interfaces should be restarted

```
ifdown eth0
ifup eth0
```

**NB! When you are logged in over SSH then please be careful (better restart the whole server)!**

# DNS in manual network configuration

- in Ubuntu usually there is *resolvconf* installed by default – in such case name servers should be manually through */etc/network/interfaces* configured as described in previous slide
- when there is not *resolvconf* installed then there is manually needed to configure the file */etc/resolv.conf* (here is an example using Telia Estonian DNS server addresses)
  - *nameserver 194.126.115.18*
  - *nameserver 194.126.101.34*
  - *nameserver 194.126.97.30*
  - *nameserver 195.250.187.46*



# Public nameservers

- usually the ISP (*Internet Service Provider*) will provide name servers
- Google Public DNS
  - <https://developers.google.com/speed/public-dns/>
  - <https://developers.google.com/speed/public-dns/docs/using>
  - <https://dns.google.com/>
  - 8.8.8.8
  - 8.8.4.4
- OpenDNS (Cisco) offers (<https://www.opendns.com/>)
  - 208.67.222.222
  - 208.67.220.220
- more choices  
<http://pcsupport.about.com/od/tipstricks/a/free-public-dns-servers.htm>

**NB! Beware of random public name servers boundless trusting!**

please see:

<http://www.networkworld.com/article/2886283/security0/top-10-dns-attacks-likely-to-infiltrate-your-network.html>

OpenDNS (part of Cisco) offers additional features:

<https://use.opendns.com/>

<https://umbrella.cisco.com/products/features>

<https://www.opendns.com/home-internet-security/>

# network interface alias

- network interface can have multiple addresses
- e.g. the following lines in file ***interfaces***:
  - ***iface eth1 inet dhcp***
  - ***iface eth1:0 inet static***  
***address 192.168.2.2***  
***netmask 255.255.255.0***
- there will be for eth1 also alias interface eth1:0, which has fixed IP-address

# Pre-UP

- sometimes there is needed to run scripts before network interface is activated, e.g. for firewall rules. To file `/etc/network/interfaces` there can be added into iface section the ***pre-up*** line
- one example how to restore firewall pre-up rules
  - *pre-up iptables-restore < /etc/iptables/iptables.conf*
- more examples
  - */usr/share/doc/ifupdown/examples/network-interfaces.gz*
  - for viewing e.g. *less* can be used

# Network configuration

- with iface settings there can be set up the commands that will be done before and after interface configuration
- after changing the */etc/network/interfaces* file there has to be network service restarted

- older than Ubuntu 14.04

- */etc/init.d/networking restart*
- *service networking restart*
- *sudo invoke-rc.d networking restart*

- since Ubuntu 14.04 (*systemd*)

- *systemctl restart networking*
- *sudo systemctl restart networking.service*
- *sudo systemctl status networking*
- *sudo systemctl restart network-manager* (in case of desktop computer)
- *systemctl status NetworkManager.service* (in case of desktop computer)

in case of *systemctl* there is *less* used – same as in case of *man* - to quit, please use *q*

# Network configuration

- network interfaces can be configured
  - by changing configuration files and restarting network service
  - by configuring parameters manually from command line e.g. using *ifconfig*, *ip* command
    - in such case changes are not stored permanently after restarting network service
    - also in case of computer restarting such manual settings are lost

# Network configuration

- some examples with ***ifconfig***
  - ***ifconfig*** without parameters displays current settings
  - e.g.  
***ifconfig eth0 10.0.0.12 netmask 255.255.255.0 up***  
will configure IP address, netmask for the interface eth0 and will bring up the network interface
  - e.g. ***ifconfig eth0 down*** will bring down the eth0 interface

# Network configuration

- activating network interface
  - ***ifup*** **<interface>** - will activate the interface
    - e.g. ***ifup eth0*** activates eth0 interface
  - ***Ifdown*** **<interface>** - will stop the interface
    - e.g. ***ifdown eth0*** will stop the eth0 interface

# Asking the TCP/IP settings from DHCP server

- dynamic TCP/IP settings can be asked in command-line:
  - ***dhclient*** <*network interface, e.g. eth0*>
- release the settings asked via DHCP
  - ***dhclient -r*** <*interface*>
- information about the machine (**DNS lookup**)
  - *host -a neti.ee* (more information: *man host*) – in the end also used ISP name server IP will be shown
  - *host -a neti.ee 194.126.115.18* (querying exact DNS)
  - *host -aC neti.ee* (shows also **SOA record**)
    - *host -a -t SOA neti.ee* (-t CNAME, NS, SOA, SIG, KEY, AXFR, MX etc - [https://en.wikipedia.org/wiki/List\\_of\\_DNS\\_record\\_types](https://en.wikipedia.org/wiki/List_of_DNS_record_types) )



# Wireless networks

- usually in server there are no wireless networks and in wearable computers can be configured using GUI (can safely */etc/network/interfaces* leave intact). However there might be a need to configure WiFi networks from command-line
  - ***man iwconfig***
  - e.g. ***iwconfig eth1 essid itcollege*** will configure wireless network interface eth1 into EITC WiFi network

# MAC relationship with network interface

- *sometimes there is a need to bind MAC-address with specific network interface name*
  - *Ubuntu Server* does it with the help of `/etc/udev/rules.d/70-persistent-net.rules` file (see next slide) – also aliases can be configured through the same file ( if autodetected names do not correspond to your needs)
  - **NB! Binding MAC-address with specific IP address is configured in DHCP server, please see an example**
- when copying (also importing) virtual machine to another host there might be MAC-addresses changed and udev rules should be reconfigured
- to see network interface MAC-addresses:
  - `ifconfig -a | grep -i --color hwaddr`

# MAC and a network card exchange

- when a network card will be exchanged in server then there in file */etc/udev/rules.d/70-persistent-net.rules* could be a reference:

```
This file was automatically generated by the /lib/udev/write_net_rules
program, run by the persistent-net-generator.rules rules file.
You can modify it, as long as you keep each rule on a single
line, and change only the value of the NAME= key.
PCI device 0x8086:0x1004 (e1000)
SUBSYSTEM=="net", ACTION=="add", DRIVERS=="?*", ATTR{address}=="0a:03:27:c2:b4:eb",
ATTR{type}=="1", KERNEL=="eth*", NAME="eth0"
```

- commenting out (#) or deleting last rows and reboot server
- added NIC will recognized and added with correct MAC-address
- in Ubuntu 16.04 the file has to be created manually
- do not forget to change also */etc/network/interfaces* file

<http://unix.stackexchange.com/questions/39370/how-to-reload-udev-rules-without-reboot>

<http://askubuntu.com/questions/689070/network-interface-name-changes-after-update-to-15-10-udev-changes>

<http://askubuntu.com/questions/767786/changing-network-interfaces-name-ubuntu-16-04>

<http://enos.itcollege.ee/~edmund/osadmin/materials/net/70-persistent-net.rules>

# Route

- to check route, following commands can be used:
  - *route*
  - *netstat -r*
  - *ip route show*
- configure default gateway:
  - ***route add default gw <router IP>***
  - ***route add default gw 10.0.0.1***
- to add static route
  - ***route add -net <IP> netmask <MASK> <INTERFACE>***
    - ***e.g. route add -net 10.0.0.0 netmask 255.255.255 eth0***
- ...to delete:
  - ***route del -net 10.0.0.0 netmask 255.255.255.0 eth0***

# Network Address Translation (NAT)

- By default Linux is not acting as router. This means that not forwarding packets that are not meant for it.
- when there is needed to configure server as firewall (e.g. simple NAT) then there has to be set up packet forwarding
- */etc/sysctl.conf*
  - *net.ipv4.ip\_forward=1*  
will forward IPv4 packets
  - *net.ipv6.ip\_forward=1*  
will forward IPv6 packets
- “Martian” packet for special purposes, also cyber attacks  
[https://en.wikipedia.org/wiki/Martian\\_packet](https://en.wikipedia.org/wiki/Martian_packet)

# Network operation test

- look at **ifconfig** output (will see the IP address)
- look at **route** output (will see the default gateway)
- try to ping default gateway
- check the /etc/resolv.conf for retrieved DNS addresses
- check also the output of **arp -a** (do you see recently pinged default gateway MAC address)
  - watch the neighbourhood  
**ip neigh show**  
**avahi-browse -a -t -d local**  
(if needed: *sudo apt install avahi-discover*)
- in desktop to view acquired DNS addresses:
  - Ubuntu >= 15: nmcli device show <interfacename> | grep IP4.DNS
    - *nmcli device show* (shows all interfaces)
  - Ubuntu <= 14: nmcli dev list iface <interfacename> | grep IP4
  - <http://askubuntu.com/questions/152593/command-line-to-list-dns-servers-used-by-my-system>

# Network operation test

- sometimes you need to see active connections between server and client – this can be retrieved using **netstat** (*man netstat*)
- **netstat -l** will list active (listening) ports/services in server
- **netstat -ant** disable reverse DNS lookup for faster output (**-anu** for UDP)
- **netstat -tnl** list all listening TCP connections (**-unl** for UDP)
- **sudo netstat -nlpt** shows also process/PID (**-nlpu** for UDP)
- **sudo netstat -ltpe** shows also process owner (**-lupe** for UDP)
- In the file **/etc/services** there are listed all services with corresponding ports
- **netstat** without parameters will display connections with other machines and local sockets

# Network operation test

- when there is needed a path used and where the traffic will be dropped then **traceroute** would help (more information: *man traceroute*, to install: *sudo apt install traceroute*) also **tracpath** (more information: *man tracpath*)
- **traceroute <host or IPv4>** (IPv6: *traceroute6*)
  - **traceroute [www.itcollege.ee](http://www.itcollege.ee)**
- **tracpath <IPv4>** (**tracpath6 <IPv6>**)



# IPv6

- IPv4 address space 32-bit:  $2^{32}$  (~4,3 billion)
- IPv6 address space 128-bit:  $2^{128}$  (~ $3,4 \cdot 10^{38}$ )
  - different understanding among different countries  
[https://en.wikipedia.org/wiki/Names\\_of\\_large\\_numbers](https://en.wikipedia.org/wiki/Names_of_large_numbers)
- IPv6 intended to replace IPv4
- many new features compared with IPv4 toward simplicity, more secure (IPsec mandatory)
  - <https://www.youtube.com/watch?v=2wa7y3W2DI0>
- NAT is temporary solution for IPv4 which will be simplified by IPv6 – it is not needed anymore
- in Estonia:
  - <http://www.ipv6-test.com/stats/country/EE>
  - [https://labs.ripe.net/Members/tarko\\_tikan/ipv6-deployment-in-estonia](https://labs.ripe.net/Members/tarko_tikan/ipv6-deployment-in-estonia)
  - <https://www.youtube.com/watch?v=13pieNC25P8>
  - [http://whatmyip.co/view/countries/EST/Internet\\_Usage\\_Statistics\\_Estonia.html](http://whatmyip.co/view/countries/EST/Internet_Usage_Statistics_Estonia.html)

# IPv6

- IPv6 ([RFC3513](#), [RFC4291](#)) divided into eight 16-bit group, separated by colon – [hex number](#)
- can be reduced to: from a group take zeros off, in case of large volume of zeros replaced by double colons (just once)
- in terminal ([IEEE EUI-64](#) stillis IPv6 address, [please see also here](#)):  
**ip a (ip addr)**

```
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UP group default qlen 1000
```

```
link/ether 00:25:ad:2c:af:17 brd ff:ff:ff:ff:ff:ff
```

```
inet 192.168.1.2/24 scope global eth0
```

```
inet6 fe80::225:adff:fe2c:af17/64 scope link
```

```
valid_lft forever preferred_lft forever
```

# IPv6 addresses

- **::/128** unspecified address
- **::1/128** loopback
- **fe80::** *link-local* address
  - <http://www.iana.org/assignments/iana-ipv6-special-registry/iana-ipv6-special-registry.xhtml>
  - <http://ipv6.com/articles/general/IPv6-Addressing.htm>
  - <https://wiki.kubuntu.org/IPv6>
- from IPv6 *link-local* address can be derived a MAC address
- e.g. IPv6 address: *fe80::be5f:f4ff:fe19:ad18*
  - MAC address: *bc:5f:f4:19:ad:18*
  - *fe80::* – link-local address (routers do not use)
  - *ff:fe* – automatically inserted in the middle
- *MAC to IPv6 link-local converter*
  - <http://ben.akrin.com/?p=1347>
  - <http://www.sput.nl/internet/ipv6/ll-mac.html>
  - <https://duckduckgo.com/?q=MAC+to+IPv6+link-local+converter>

# IPv6

- in terminal (in IEEE EUI-64 style IPv6 address):  
**ifconfig**

```
eth0 Link encap:Ethernet HWaddr 00:25:ad:2c:af:17
```

```
inet address:192.168.1.2 bcast:192.168.1.255 mask:255.255.255.0
```

```
inet6 addr: fe80::225:adff:fe2c:af17/64 scope:link
```

....

- IPv6 network discovery (neighboring IPv6 addresses)
  - **ip -6 neigh show** (IPv4: **arp -a**)
    - <http://itkia.com/how-to-arp-a-in-ipv6/> - in MS Windows
      - *netsh int ipv6 show neigh*
- IPv6 record query with IPv4 address (please see [unreachable problem, link2](#))
  - **host -t AAAA ipv6.google.com**
    - look also: *host -a www.google.com*

# IPv6

- let us check whether the IPv6 is in use

- ***cat /proc/net/if\_inet6***

```
000000000000000000000000000000000001 01 80 10 80 lo
fe800000000000000002179afffe0af644 03 40 20 80 ra0
fe80000000000000000219d1fffe2abaa8 02 40 20 80 eth0
```

- ***lsmod | grep ipv6*** (if needed: *sudo modprobe ipv6*)

```
nf_log_ipv6 16384 5
nf_conntrack_ipv6 20480 8
nf_defrag_ipv6 36864 1 nf_conntrack_ipv6
nf_reject_ipv6 16384 1 ip6t_REJECT
nf_log_common 16384 2 nf_log_ipv4,nf_log_ipv6
nf_conntrack 118784 8
nf_nat_ftp,nf_conntrack_netbios_ns,nf_nat,xt_conntrack,nf_conntrack_broadcast,nf_contra
ck_ftp,nf_conntrack_ipv4,nf_conntrack_ipv6
```

# IPv6 in ufw firewall

- allowing */etc/default/ufw*
  - IPV6=yes
- allowing the IPv6 to SSH server:
  - *sudo ufw allow proto ipv6 to <server ip v4 address>*
  - *sudo ufw allow to <server ipv6 address> port 22*

# IPv6 static address

- to file `/etc/network/interfaces` there has been added for example:

```
Start IPV6 static configuration
```

```
iface eth0 inet6 static
```

```
address 2607:f0d0:2001:000a:0000:0000:0000:0010
```

```
netmask 64
```

```
gateway 2607:f0d0:2001:000a:0000:0000:0000:0001
```

Google Public  
DNS



```
dns-nameservers 2001:4860:4860::8888 2001:4860:4860::8844
```

```
END IPV6 configuration
```

- restart network: `sudo systemctl restart networking`
- Ubuntu 12.04 and older: `sudo service networking restart`

# IPv6 check

- check the eth0 network interface
  - **ifconfig eth0 | grep "inet6 addr:"**
  - **ip -6 address show eth0 (ip -6 a show eth0)**
- **ping6 <IPv6-address>**
  - **ping6 -c 1 ::1 (ping6 -I eth0 -c 1 ::1)**
- whenever in ping there is a message: *connect: Invalid argument* rhwn define also network interface: *ping6 -I eth0 fe80::212:34ff:fe12:3456*
  - **ip -6 neigh show** (IPv6 addresses in neighbourhood)
  - **host -t AAAA [www.google.com](http://www.google.com)** (querying IPv6 by IPv4)
- IPv6 routing table
  - **netstat -nr -6**
  - **ip -6 r**
- IPv6 ping in web
  - <http://www.subnetonline.com/pages/ipv6-network-tools/online-ipv6-ping.php>



# IPv6 in applications

- IPv6 in applications
  - *ping6* (in MS Windows *ping -6*)
  - *ip -6*
  - *ifconfig <interface> inet6....*
  - *traceroute6*
  - *tracpath6*
  - *ssh -6 (ssh user@IPv6%eth0)*
  - *scp -6 (scp test.txt user@[fe80::221:97ff:feed:ef01%eth0]:)*

# Links

- <https://wiki.debian.org/NetworkConfiguration>
- <https://help.ubuntu.com/lts/serverguide/network-configuration.html>
- <https://help.ubuntu.com/community/InternetAndNetworking>
- [https://wiki.itcollege.ee/index.php/Ubuntu\\_server\\_v%C3%B5rgu\\_seadistamine](https://wiki.itcollege.ee/index.php/Ubuntu_server_v%C3%B5rgu_seadistamine)
- </usr/share/doc/ifupdown/examples/network-interfaces.gz>
  - <http://www.cyberciti.biz/faq/setting-up-an-network-interfaces-file/>
- updating the name server settings when logged into machine over network
  - <http://askubuntu.com/questions/203261/editing-dns-nameservers-in-etc-network-interfaces-without-a-restart>
  - <http://askubuntu.com/questions/224966/how-do-i-get-resolvconf-to-regenerate-resolv-conf-after-i-change-etc-network-in/225100#225100>
- creating IP alias in Ubuntu (in Estonian)  
[https://wiki.itcollege.ee/index.php/IP\\_aliase\\_loomine\\_Ubuntus](https://wiki.itcollege.ee/index.php/IP_aliase_loomine_Ubuntus)
- IP address ranges by country
  - <http://www.ip2location.com/free/visitor-blocker>
- Subnets
  - IPv4 [https://en.wikipedia.org/wiki/IPv4\\_subnetting\\_reference](https://en.wikipedia.org/wiki/IPv4_subnetting_reference)
  - IPv6 [https://en.wikipedia.org/wiki/IPv6\\_subnetting\\_reference](https://en.wikipedia.org/wiki/IPv6_subnetting_reference)
- Reserved IP addresses [https://en.wikipedia.org/wiki/Reserved\\_IP\\_addresses](https://en.wikipedia.org/wiki/Reserved_IP_addresses)

# Links (IPv6)

- [https://wiki.itcollege.ee/index.php/IPv6\\_v%C3%B5rguparameetrite\\_seadistamine](https://wiki.itcollege.ee/index.php/IPv6_v%C3%B5rguparameetrite_seadistamine)
- <https://en.wikipedia.org/wiki/IPv6>
- <https://et.wikipedia.org/wiki/IPv6>
- <http://tldp.org/HOWTO/Linux+IPv6-HOWTO/>
- <https://www.linux.com/learn/ipv6-crash-course-linux>
- Google <https://www.google.com/intl/en/ipv6/>
  - <https://ipv6test.google.com/> - readiness test
- <http://www.worldipv6launch.org/> , <https://getipv6.info/>
- <http://ipv6leak.com/> - leak test
- <http://www.differencebetween.net/technology/internet/difference-between-ipv4-and-ipv6/>
- <http://electronicdesign.com/embedded/whats-difference-between-ipv4-and-ipv6>
- [http://www.webopedia.com/DidYouKnow/Internet/ipv6\\_ipv4\\_difference.html](http://www.webopedia.com/DidYouKnow/Internet/ipv6_ipv4_difference.html)
- <http://www.networkworld.com/article/2692482/ipv6/infographic-ipv4-vs-ipv6.html>
- <https://help.ubuntu.com/community/WebBrowsingSlowIPv6IPv4>
- <http://www.itcollege.ee/en/blog/2015/01/19/ipv6-council-estonia-has-been-founded/>
- <https://duckduckgo.com/?q=IPv6+to+IPv4+calculator> (<http://ipv6.ztsoftware.net/ipv4-to-ipv6/>)
- <https://duckduckgo.com/?q=IPv6+calculator>

# Links (IPv6)

- IPv6 tests
  - <http://ipv6-test.com/>
  - <http://test-ipv6.com/>
  - <http://ismyipv6working.com/>
  - <http://www.ipv6now.com.au/tools.php>
  - <http://www.ipv6scanner.com/>
  - <http://ipv6locator.net/>
  - <https://www.site24x7.com/tools.html>
  - <http://www.whatismyipv6.com/>
  - <http://ip.bieringer.de/>
  - <http://netalyzr.icsi.berkeley.edu/>

Questions?

Thank you for your attention!

