Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Distributed Computing

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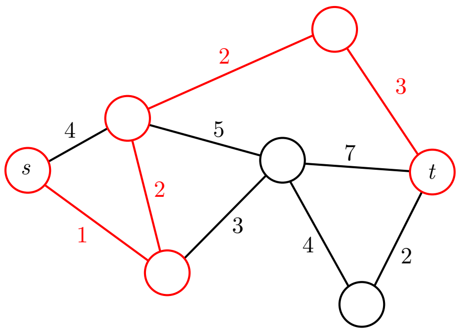
Computer Engineering II

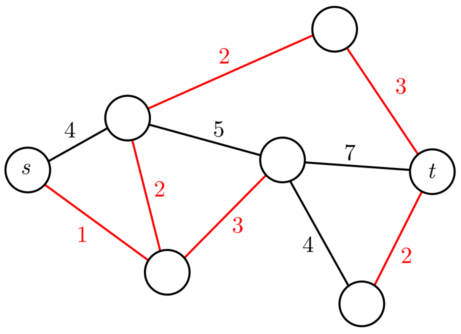
Solution to Exercise Sheet 1

1 Quiz Questions

a) $1 + 2 + 2 + 3 = 8$:



b) $1 + 2 + 2 + 2 + 3 + 3 = 13$:



c) That is indeed possible. However, the `127.*.*.*` (and not only `127.0.0.1`!) is reserved to be used as a *loopback address*. Thus, if a computer A is assigned the address `127.0.0.1` no other computer will be able to reach A; i.e., if a computer B sends packets to `127.0.0.1`, all those packets will directly be routed back to B itself (without ever leaving the B).

d) Any network interface that supports IPv6 has always at least one IPv6 address: The *link-local* IPv6 address. To distinguish them from other IPv6 addresses, they always start with the prefix `fe80::/64`.

e) There are many use-cases, this is a non-exhaustive list:

- The computer is running virtual machines that have to be reachable using own addresses.
- The computer is acting as a proxy/gateway for other machines connected on a second interface.
- The computer administrator has set up virtual interfaces, and different applications use different virtual interfaces.

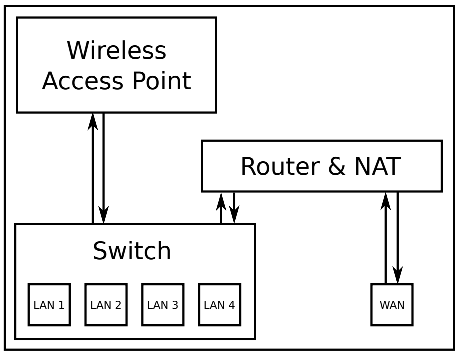
2 Basic IP Networking

a) Routers, as presented in the lecture, are devices which are between different subnets. They operate on the network layer (OSI layer 3, see *OSI Model*), i.e., they work with IP addresses.

A similar device is a *switch*; however, a switch operates on a lower level (OSI layer 2), i.e., does not work with IP addresses. Hence, a switch *switches* packets *within* a subnet.

A typical "home router" is a multi-functional device: It includes a router, but usually also a switch, a wireless access point, a NAT component, ...

A high level view of such a device is as follows:



b) Depending on your operating system and installed software there are many possibilities. In Linux you can for example run `ip address` on the console, which will you list the IP addresses of all available interfaces.

c) There are many ways to determine this address:

- In a typical home network, all traffic that is not sent to a destination within the network is sent "outwards". In order for you computer to know where "outwards" is, your computer has an entry called *default gateway*. This entry is used if there is no other route available for a packet. As the "router" is responsible for those packets, this address is the address of your "router". You can inspect the routing table to determine the *default gateway*. On Linux you can determine the default gateway e.g. with `ip route`.
- Your home router typically runs a DHCP server to assign IP addresses. Hence, the router address will be the same as the one which runs the DHCP server. On Linux you can determine the DHCP server e.g. using `dhclient -v` (needs root).

d) No, it is not a good idea. If you use `8.8.8.*` as local addresses, you will not be able to access the computers which legitimately using these addresses. I.e., you have a collision: There are more than one machine which is using the same address. Why do you not run into any problems with e.g. `192.168.0.*`? Because these addresses are reserved for the very purpose of being used as local network addresses, and no server on the internet will ever use these addresses.

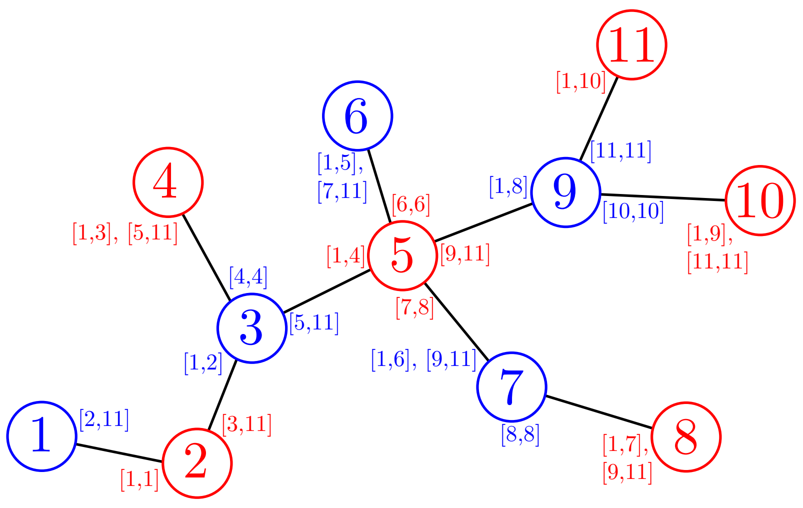
e) No, the server will see the public address of the home router. Many routers will display this address somewhere in the user interface. However, it is often easier to access a website which tells you the IP address with which it got accessed – for example, google "what's my IP".

3 Using an SSH Tunnel

If you run Linux, you can run `ssh -D 9988 slab1.ethz.ch` and configure your browser such that it uses a SOCKS proxy on port 9988. Please refer to the many short tutorials available on the internet for further information.

4 Simple Routing

a) We assigned the addresses as follows (the red/blue coloring is just to improve readability). Note that we also added the intervals stored for each node/edge to the respective node/edge:



b) We can assign the addresses by performing a depth-first search (DFS) on the graph, and we assign addresses to the nodes in the order in which we visit them.

Let us show that assigning the addresses in DFS-manner will require us to put at most two intervals on each edge. For that, we look at any arbitrary node which will be visited during the DFS, and we will argue that the claim holds.

Let u be the addresses of the node, which is assigned to it once it is visited. The DFS continues to assign addresses by following all edges of u that have not yet been visited. The first node in the first subtree is assigned $u+1$. Once the subtree is completely assigned, the DFS returns to u. We can then look at the largest address in that subtree, which we call v. Since all nodes in this subtree are given addresses with values from $u+1$ to v, we can simply use that as the interval for this outgoing edge of u. This argument also applies to all subsequent subtrees, except that the first address of the following subtree is not $u+1$, but $v+1$, where v is the maximum assigned address in the previously visited subtree.

After assigning addresses to all subtrees and adding the according interval, there is only one edge which has no intervals yet: The one on which u was reached when the DFS reached u for the first time. We can put (at most) two intervals to that edge: All addresses in $[1, u-1]$ (they have been assigned before u was reached), and all addresses in $[v_{\max}+1, \infty]$, where

$v_{\max}$ is the maximum address assigned in the subtree rooted at u (these addresses will be assigned afterwards).

Remark: The assignment of the labels is not unique: It depends on the order in which the nodes are visited during the DFS - but the reasoning applies to all possible orders, as long as the DFS is executed correctly.