

PROJECT DOCUMENTATION NETWORK SIMULATOR

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1 Information page

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Changelog

Version	Date	Author	Description
0.1	2020-08-26	All	Template
0.9	2020-08-27	Jani	Majority written. TODO: Dancun info on GUI.
0.9.1	2020-08-27	Jani	Requirement B5 was implemented, changed to Yes
1.0	2020-08-27	Jani and Dancun	GUI info
1.1	2020-08-27	Jani	Added external library info
1.2	2020-08-28	Jani	Added notes about cmake in build and Valgrind errors in tests.

Table 1: Document changelog.

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2 Introduction

The purpose of this document is to be the final documentation of the project in the *ELEC-A7151 - Object oriented programming with C++* course. The output of the project was a network simulator where it is possible to build simple networks and simulate traffic between nodes. The project plan outlined the features that we aimed to implement:

Module	Req#	Requirement	Implemented
Compatibility	S1	It shall be possible to compile and run the program on Ubuntu 18.04.	Yes
	S2	A CMake file shall be provided together with the source code upon completion.	Yes
Network model	B1	The network shall be modeled by nodes and links between nodes. Communication between nodes shall be done by (data) packets over the links.	Yes
	B1.1	Links shall be defined by a transmission speed and a propagation delay, which shall govern: 1. how fast new packets can be sent; and 2. how fast they propagate over the link. There shall be a way to queue packets at the node before the link.	Yes
	B1.2	Nodes shall be defined by an address and are of a type: router or end-host.	Yes
	B1.2.1	Routers shall be able to route packets between other nodes.	Yes
	B1.2.2	End-hosts shall be able to run applications that can send and/or receive packets to/from other end-hosts for a specified length of time.	Yes ¹
	B2	The model code shall be written in such a way that it is easy to extend with e.g. new kinds of links or applications.	Yes
Program	B3	Running simulations shall be "easily configurable" for different network scenarios, through e.g. configuration files.	Yes
	B4	It shall be possible to collect statistics on the simulated network, e.g. packet to destination times, link utilization, queue lengths, etc.	No
	B5	From the applications user interface, it shall be possible to follow the progress of simulation, including statistics and states for links, queues and packets.	Yes
GUI	A1	There shall be a graphical user interface (GUI) for the program to interact with all other functionalities.	No
	A1.1	B5 shall be expanded to an animation on the GUI.	No
Expanded functionality	A2	B1.1 shall be expanded to create different queue behaviours, including limited queues and as a result, dropped packets.	No
	A3	B1.1 and B1.2 shall be expanded to include mobile hosts, i.e. wireless links.	No
	A3.1	Communication parameters of wireless links shall be defined by signal strength.	No
	A3.2	Mobile hosts shall be able to move around in a 2D map with obstacles that reduce the signal strength of the wireless link.	No

Table 2: The programs functional requirements and implementation status. (1: Only one application was implemented.)

3 Software structure

The architecture is very straight forward and shown in figure 1. Note that the diagram doesn't show absolutely everything, e.g. some getters and setters are excluded together with unimportant data types and some helper methods. An explanation of each classes role in the architecture follows below.

The root class is **Simulatable**, which handles the simulations timesteps through **evt_times[]** and **AdvanceTime()**. Each simulatable point in the inherited classes has an entry in **evt_times[]**, which basically determines how many timesteps to go until it can be executed. A value of -1 indicates nothing to simulate and once every **evt_times[]** entry of every **Simulatable** is equal to -1, the simulations is ran.

The **NetworkInterface** class handles the IP address and every **Node** holds one. Initially the plan was for a node to be able to hold multiple network interfaces and a full LAN / WAN implementation for routing packets.

The **Packet** class is an arbitrarily simplified TCP packet, holding the important (to our simulation) headers, such as source and target addresses and a time-to-live value, which gets reduced by 1 on each routing event.

The **Node** class inherits from **Simulatable** and has multiple functions. For instance, it holds a reference to all neighboring nodes and which links are used to connect to those in the **connected[]** variable. Packets are handled in separate **receive[]** and **transmit[]** queues, the latter of which also holds a reference to which currently connected node the packet is to be transferred to. Multiple helper methods exist, e.g. for connecting or disconnecting from neighboring nodes and moving packets. The **RunApplication()** method is overloaded by inherited classes to implement application specific functionality.

The **Link** class inherits from **Simulatable** and is used to link nodes together. The main parameters are **transmissionspeed** and **propagationdelay**, which ultimately result in the timestamp written back to **Simulatable.evt_times[]**. The link also holds two **transmissionqueue** variables, which are the currently in transfer packets.

The **EndHost** class inherits from **Node** and is the node that ultimately generates packets that will be sent to another endhost. The implemented functionality simply generates random sized packets (amount equal to **packetcount**) with the specified **targetadr**. If the target address is set to self (as it is by default) then no packets are generated.

The **Router** class inherits from **Node** and is the node responsible for routing packets between other nodes. The way this is done, is by going through the **Node.receive** queue and looking up the self, target address in a routing table generated by the **Network**. If no route exists, the packet is dropped.

The **Network** class ties everything else together. It is the interface to creating and removing nodes, linking and unlinking them and other graph behaviour. The **routingtable** map is generated by running Dijkstra's shortest path algorithm from every source node to every target node. The **Network** also holds the functionality to **Save** and **Load** JSON files which contain the network configuration.

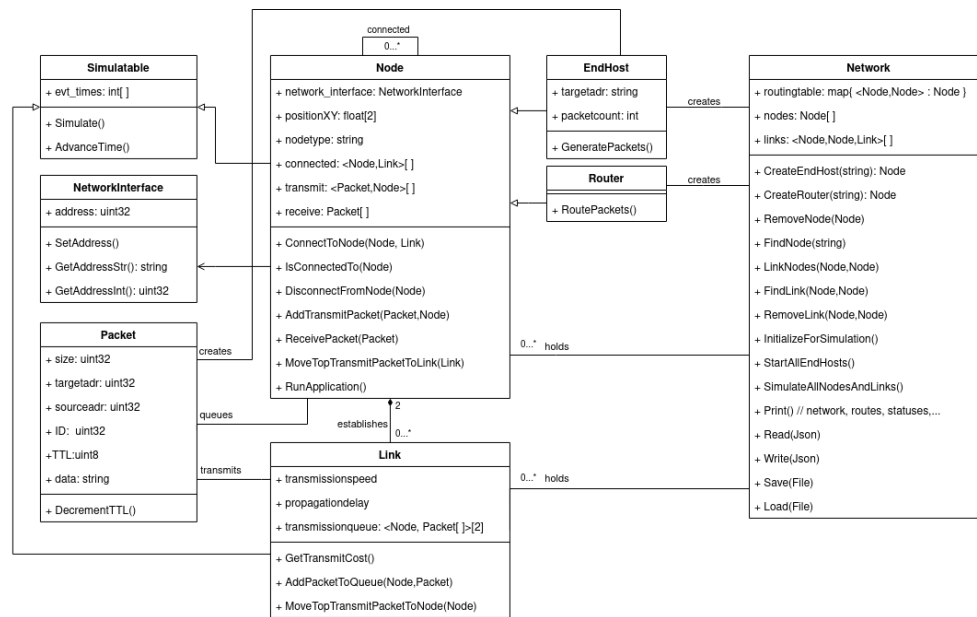


Figure 1: Network simulator class diagrams.

3.1 External libraries

The GUI portion and the JSON parser are both external libraries provided by Qt. As the GUI was ultimately dropped, only the file saving and loading requires external libraries.

4 Build instructions

1. Clone the project repository to your machine, or download and unzip.
2. Open terminal and navigate to the project root, run `cd src/nwsim`
3. Build the software by first generating the Makefile with `cmake CMakeLists.txt` and then running `make`
 - (a) If you get Qt related errors running `cmake`, see below.
4. The software is built to the projects root/bin and the executables name is `nwsim-cli`

Building the software requires the `Qt5::Core` library from Qt. The location of this library depends on your setup, but we have included the following possible paths. If running `cmake` produces library related errors for you, please include the correct path² in the `src/nwsim/CMakeLists.txt` file.

```

3 # Appends the location of qt5 to CMAKE_PREFIX_PATH **UNIQUE TO HOST**
4 list (APPEND CMAKE_PREFIX_PATH "~/usr/lib/")
5 list (APPEND CMAKE_PREFIX_PATH "~/Qt/5.15.0/gcc_64/lib/cmake")

```

²Apparently on Aalto Linux machines the Qt libraries are found under `/usr/lib` (?)

5 Running the software

The software is a CLI implementation and has rather intuitive usage. For usage, please run the **help** command, or see the compiled version below in section 5.2.

5.1 Example on running the simulator

1. Open a terminal and navigate to the project root. Run the simulator with `./bin/nwsim-cli`
2. At any point, type **help** for usage.
3. Create an endhost node with `add e 1.1.1.1`, you will enter edit mode for this node:
 - (a) Run `list` to see all changeable parameters.
 - (b) `exit` or `quit` or `q` to drop out of editmode.
4. Create a router node with `add r 2.2.2.2`, drop out of editmode.
5. Create another endhost node with `add e 3.3.3.3`, in editmode configure:
 - (a) `set target 1.1.1.1` to set target to the first endhost.
 - (b) `set count 100` to send 100 packets from this endhost.
6. Edit the first endhost with `edit 1.1.1.1` and configure:
 - (a) `set target 3.3.3.3`
 - (b) `set count 50`
7. Link the first endhost to the router with `link 1.1.1.1 2.2.2.2`, and enter links edit-mode:
 - (a) Run `list` to see all changeable parameters.
 - (b) `set ts 100` to set transmission speed to 100 timeunits.
 - (c) `set pd 2` to set propagation delay to 2 timeunits / byte.
 - (d) `exit` or `quit` or `q` to drop out of editmode.
8. To finish the network, link the remaining endhost and the router `link 2.2.2.2 3.3.3.3` and configure:
 - (a) `set ts 50`
9. If you created unnecessary nodes, they can be removed with `rem <adr>`
10. If you linked the wrong nodes, they can be disconnected with `unlink <adr> <adr>`
11. If you wish to edit the links parameters, run `edit <adr> <adr>`
12. Run `list` to see the current network configuration.

13. Enter the simulation mode with **sim**
 - (a) Run **list** to see all endhosts that will be sending packets during the simulation.
 - (b) Run **routes** to see the routing table and check that your network isn't missing a crucial link.
 - (c) Start the simulation with the **run** command. You will go back to the simulation mode once the simulation has finished.
 - (d) To exit simulation mode, use **exit** or **quit** or **q**
14. To save the current network configuration, run **save <filename>**
15. To load a new network configuration from a file, run **load <filename>**, NOTE: this will overwrite the current configuration.
16. To exit the program, use **exit**

5.2 Help documentation

LEGEND:

<mode> – edit, sim
 <filename> – JSON file to save/load network config
 <adr> – IP address in octet format, e.g. 192.168.0.1
 <int> – integer, note that parameters are capped between valid values.

NWSIM HELP:

help – Print this manual.
 <mode> – Prints mode specific usage.
 save <filename> – Save current network configuration to given file. Possible file formats: .json .dat
 load <filename> – Discard current network configuration and load from specified file. Possible file formats: .json .dat
 exit – Exit current mode or if at root, exits the program.
 list – Lists all current nodes and what other nodes they are linked to.
 add e|r <adr> – Adds an [e]ndhost or [r]outer with given address.
 NOTE: Address must be IP format and unique in network.
 rem <adr> – Removes an endhost or router that matches the given address, and severs affected links. If node doesn't exist, nothing happens.
 link <adr> <adr> – Links given nodes, if they exist.
 unlink <adr> <adr> – Unlinks given nodes, if they are currently linked.
 edit <adr> – Enter node (endhost, router) edit mode.
 edit <adr> <adr> – Enter link edit mode.
 sim – Enter simulation mode.
 tests – Prints result of all tests and exit program.

EDIT MODE HELP:

help – Print this help for edit mode.
 exit – Exit edit mode.
 list – List all changeable parameters.

NODE SPECIFIC EDIT MODE HELP:

set address <adr> – Changes this nodes to use the given address.
 NOTE: Address must be IP format and unique in network.

ENDHOST SPECIFIC EDIT MODE HELP:

set target <adr> – Requires endhost source and endhost target. Sets target address.
 NOTE: Address must be IP format and exist in current network.
 If set to self, no packets sent in simulation.

set count <int> – Requires endhost. Sets amount of packets sent to target.

LINK SPECIFIC EDIT MODE HELP:

set ts <int> – Sets links transmission speed to given value (timeunit). Value


```

        determines the interval at which new packets can be transmitted
        to the link.
set pd <int>    - Sets links propagation delay to given value (timeunit / byte).
                  Value determines the time it takes for a packet to travel across
                  the link. time = propagation_delay * packet_size

SIM MODE HELP:
help            - Print this help for sim mode.
list            - Lists all endhosts that are configured to send packets.
routes         - Prints current network routing table.
run            - Starts simulation.

```

6 Tests

The software was tested while it was being written and refactored, by writing unit tests and updating as necessary when the underlying logic changed. The `src/nwsim/tests/testroutines.hpp` file holds all testcases and they can be executed in software by running the `tests` command. The program output was then simply searched for the flag `false` for any tests that didn't pass, e.g:

1. `./bin/nwsim-cli | tee testout.txt`
2. Run the `tests` command for test output and `exit`
3. Search for tests that didnt pass with `grep false testout.txt`

6.1 Test output

All tests that pass hold value `true`. If it was not possible to write simple and quick enough tests, e.g. for the routing table or actual simulation output, then a manual look is needed. In the simulation test output not all packets have moved to their corresponding nodes. This is because the test is only run for `n` timesteps, and the packet counts are too high to be transferred during this period.

6.2 Valgrind

Running the network simulator with valgrind shows, that there is some memory leak still present. This was introduced in merging the feature of saving / loading the network to / from a file. After spending (too) many hours hunting this issue, we have decided to leave it as is.

```

# No memory leaks in commit 1e911efa9b i.e. before JSON
==45226==
==45226== HEAP SUMMARY:
==45226==    in use at exit: 0 bytes in 0 blocks
==45226==   total heap usage: 6,514 allocs, 6,514 frees, 263,917 bytes allocated
==45226==
==45226== All heap blocks were freed — no leaks are possible
==45226==
==45226== For lists of detected and suppressed errors, rerun with: -s
==45226== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)

# Memory leak in latest commit
==58572==
==58572== HEAP SUMMARY:
==58572==    in use at exit: 19,092 bytes in 12 blocks
==58572==   total heap usage: 7,290 allocs, 7,278 frees, 350,221 bytes allocated
==58572==

```

```

==58572== 4 bytes in 1 blocks are still reachable in loss record 1 of 12
==58572== at 0x483B7F3: malloc (in /usr/lib/x86_64-linux-gnu/valgrind/
vgpreload_memcheck-amd64-linux.so)
==58572== by 0x7766743: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x7766D63: g_private_get (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so
.0.6400.3)
==58572== by 0x77382A0: g_slice_alloc (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so
.0.6400.3)
==58572== by 0x7707181: g_hash_table_new_full (in /usr/lib/x86_64-linux-gnu/libglib
-2.0.so.0.6400.3)
==58572== by 0x772A602: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x4011B89: call_init.part.0 (dl-init.c:72)
==58572== by 0x4011C90: call_init (dl-init.c:30)
==58572== by 0x4011C90: _dl_init (dl-init.c:119)
==58572== by 0x4001139: ??? (in /usr/lib/x86_64-linux-gnu/ld-2.31.so)
==58572==
==58572== 16 bytes in 1 blocks are still reachable in loss record 2 of 12
==58572== at 0x483BE63: operator new(unsigned long) (in /usr/lib/x86_64-linux-gnu/
valgrind/vgpreload_memcheck-amd64-linux.so)
==58572== by 0x48FC6F6: QThreadData::current(bool) (qthread_unix.cpp:225)
==58572== by 0x4B1B0C0: QObject::QObject(QObjectPrivate&, QObject*) (qobject.cpp
:919)
==58572== by 0x4A17148: QIODevice::QIODevice(QIODevicePrivate&, QObject*) (qiodevice
.cpp:489)
==58572== by 0x4A0EA68: QFileDevice::QFileDevice(QFileDevicePrivate&, QObject*) (
qfiledevice.cpp:219)
==58572== by 0x4A2FA02: QSaveFile::QSaveFile(QString const&) (qsavefile.cpp:119)
==58572== by 0x188B77: NWSim::Network::Save(std::cxx11::basic_string<char, std::
char_traits<char>, std::allocator<char> >, NWSim::fileType) (in /home/jani/c++/
project/nwsim/bin/nwsim-cli)
==58572== by 0x16BD73: TestNetworkSave() (in /home/jani/c++/project/nwsim/bin/nwsim-
cli)
==58572== by 0x175111: main (in /home/jani/c++/project/nwsim/bin/nwsim-cli)
==58572==
==58572== 32 bytes in 1 blocks are still reachable in loss record 3 of 12
==58572== at 0x483DD99: calloc (in /usr/lib/x86_64-linux-gnu/valgrind/
vgpreload_memcheck-amd64-linux.so)
==58572== by 0x771FD30: g_malloc0 (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so
.0.6400.3)
==58572== by 0x7705F8F: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x77071C0: g_hash_table_new_full (in /usr/lib/x86_64-linux-gnu/libglib
-2.0.so.0.6400.3)
==58572== by 0x772A602: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x4011B89: call_init.part.0 (dl-init.c:72)
==58572== by 0x4011C90: call_init (dl-init.c:30)
==58572== by 0x4011C90: _dl_init (dl-init.c:119)
==58572== by 0x4001139: ??? (in /usr/lib/x86_64-linux-gnu/ld-2.31.so)
==58572==
==58572== 56 bytes in 1 blocks are still reachable in loss record 4 of 12
==58572== at 0x483B7F3: malloc (in /usr/lib/x86_64-linux-gnu/valgrind/
vgpreload_memcheck-amd64-linux.so)
==58572== by 0x597F1C9: UDataMemory_createNewInstance_56 (in /home/jani/Qt/5.15.0/
gcc_64/lib/libicuuc.so.56.1)
==58572== by 0x597D6B3: doLoadFromCommonData(signed char, char const*, char const*,
char const*, char const*, char const*, char const*, signed char *) (
void*, char const*, char const*, UDataInfo const*), void*, UErrorCode*, UErrorCode
*) (in /home/jani/Qt/5.15.0/gcc_64/lib/libicuuc.so.56.1)
==58572== by 0x597E437: doOpenChoice(char const*, char const*, char const*, signed
char *) (void*, char const*, char const*, UDataInfo const*), void*, UErrorCode*) (
in /home/jani/Qt/5.15.0/gcc_64/lib/libicuuc.so.56.1)
==58572== by 0x598ED3B: initAliasData(UErrorCode&) (in /home/jani/Qt/5.15.0/gcc_64/
lib/libicuuc.so.56.1)

```

```

==58572== by 0x598FA20: ucnv_getStandardName_56 (in /home/jani/Qt/5.15.0/gcc_64/lib/
libicuuc.so.56.1)
==58572== by 0x4B4A0BD: QIcuCodec::codecForNameUnlocked(char const*) (qicucodec.cpp
:474)
==58572== by 0x4B4AE8C: QIcuCodec::defaultCodecUnlocked() (qicucodec.cpp:451)
==58572== by 0x4B480C6: QTextCodec::codecForLocale() (qtextcodec.cpp:719)
==58572== by 0x4990E36: qt_convert_to_local_8bit (qstring.cpp:5283)
==58572== by 0x4990E36: QString::toLocal8Bit_helper(QChar const*, int) (qstring.cpp
:5275)
==58572== by 0x4A48AAF: toLocal8Bit (qstring.h:683)
==58572== by 0x4A48AAF: encodeName (qfile.h:94)
==58572== by 0x4A48AAF: resolveNativeFilePath (qfilesystementry.cpp:168)
==58572== by 0x4A48AAF: QFileSystemEntry::nativeFilePath() const (qfilesystementry.
cpp:136)
==58572== by 0x4A7AF9F: qIsFilenameBroken (qfilesystemengine_p.h:80)
==58572== by 0x4A7AF9F: QFileSystemEngine::fillMetaData(QFileSystemEntry const&,
QFileSystemMetaData&, QFlags<QFileSystemMetaData::MetaDataFlag>) (
qfilesystemengine_unix.cpp:880)
==58572==
==58572== 56 bytes in 1 blocks are still reachable in loss record 5 of 12
==58572== at 0x483B7F3: malloc (in /usr/lib/x86_64-linux-gnu/valgrind/
vgpreload_memcheck-amd64-linux.so)
==58572== by 0x597F1C9: UDataMemory_createNewInstance_56 (in /home/jani/Qt/5.15.0/
gcc_64/lib/libicuuc.so.56.1)
==58572== by 0x597D74E: doLoadFromCommonData(signed char, char const*, char const*,
char const*, char const*, char const*, char const*, signed char*)(
void*, char const*, char const*, UDataInfo const*), void*, UErrorCode, UErrorCode
*) (in /home/jani/Qt/5.15.0/gcc_64/lib/libicuuc.so.56.1)
==58572== by 0x597E437: doOpenChoice(char const*, char const*, char const*, signed
char*)(void*, char const*, char const*, UDataInfo const*), void*, UErrorCode*) (
in /home/jani/Qt/5.15.0/gcc_64/lib/libicuuc.so.56.1)
==58572== by 0x598ED3B: initAliasData(UErrorCode&) (in /home/jani/Qt/5.15.0/gcc_64/
lib/libicuuc.so.56.1)
==58572== by 0x598FA20: ucnv_getStandardName_56 (in /home/jani/Qt/5.15.0/gcc_64/lib/
libicuuc.so.56.1)
==58572== by 0x4B4A0BD: QIcuCodec::codecForNameUnlocked(char const*) (qicucodec.cpp
:474)
==58572== by 0x4B4AE8C: QIcuCodec::defaultCodecUnlocked() (qicucodec.cpp:451)
==58572== by 0x4B480C6: QTextCodec::codecForLocale() (qtextcodec.cpp:719)
==58572== by 0x4990E36: qt_convert_to_local_8bit (qstring.cpp:5283)
==58572== by 0x4990E36: QString::toLocal8Bit_helper(QChar const*, int) (qstring.cpp
:5275)
==58572== by 0x4A48AAF: toLocal8Bit (qstring.h:683)
==58572== by 0x4A48AAF: encodeName (qfile.h:94)
==58572== by 0x4A48AAF: resolveNativeFilePath (qfilesystementry.cpp:168)
==58572== by 0x4A48AAF: QFileSystemEntry::nativeFilePath() const (qfilesystementry.
cpp:136)
==58572== by 0x4A7AF9F: qIsFilenameBroken (qfilesystemengine_p.h:80)
==58572== by 0x4A7AF9F: QFileSystemEngine::fillMetaData(QFileSystemEntry const&,
QFileSystemMetaData&, QFlags<QFileSystemMetaData::MetaDataFlag>) (
qfilesystemengine_unix.cpp:880)
==58572==
==58572== 64 bytes in 1 blocks are still reachable in loss record 6 of 12
==58572== at 0x483B723: malloc (in /usr/lib/x86_64-linux-gnu/valgrind/
vgpreload_memcheck-amd64-linux.so)
==58572== by 0x483E017: realloc (in /usr/lib/x86_64-linux-gnu/valgrind/
vgpreload_memcheck-amd64-linux.so)
==58572== by 0x771FD7F: g_realloc (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so
.0.6400.3)
==58572== by 0x7705F7A: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x77071C0: g_hash_table_new_full (in /usr/lib/x86_64-linux-gnu/libglib
-2.0.so.0.6400.3)

```

```

==58572== by 0x772A602: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x4011B89: call_init.part.0 (dl-init.c:72)
==58572== by 0x4011C90: call_init (dl-init.c:30)
==58572== by 0x4011C90: _dl_init (dl-init.c:119)
==58572== by 0x4001139: ??? (in /usr/lib/x86_64-linux-gnu/ld-2.31.so)
==58572==
==58572== 96 bytes in 1 blocks are still reachable in loss record 7 of 12
==58572== at 0x483B7F3: malloc (in /usr/lib/x86_64-linux-gnu/valgrind/
vgpreload_memcheck-amd64-linux.so)
==58572== by 0x771FCD8: g_malloc (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so
.0.6400.3)
==58572== by 0x77382C5: g_slice_alloc (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so
.0.6400.3)
==58572== by 0x7707181: g_hash_table_new_full (in /usr/lib/x86_64-linux-gnu/libglib
-2.0.so.0.6400.3)
==58572== by 0x772A602: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x4011B89: call_init.part.0 (dl-init.c:72)
==58572== by 0x4011C90: call_init (dl-init.c:30)
==58572== by 0x4011C90: _dl_init (dl-init.c:119)
==58572== by 0x4001139: ??? (in /usr/lib/x86_64-linux-gnu/ld-2.31.so)
==58572==
==58572== 96 bytes in 1 blocks are still reachable in loss record 8 of 12
==58572== at 0x483BE63: operator new(unsigned long) (in /usr/lib/x86_64-linux-gnu/
valgrind/vgpreload_memcheck-amd64-linux.so)
==58572== by 0x4903994: QWaitCondition::QWaitCondition() (qwaitcondition_unix.cpp
:175)
==58572== by 0x48FB691: QThreadPrivate::QThreadPrivate(QThreadData*) (qthread.cpp
:170)
==58572== by 0x48FB871: QAdoptedThread::QAdoptedThread(QThreadData*) (qthread.cpp
:137)
==58572== by 0x48FC704: QThreadData::current(bool) (qthread_unix.cpp:225)
==58572== by 0x4B1B0C0: QObject::QObject(QObjectPrivate&, QObject*) (qobject.cpp
:919)
==58572== by 0x4A17148: QIODevice::QIODevice(QIODevicePrivate&, QObject*) (qiodevice
.cpp:489)
==58572== by 0x4A0EA68: QFileDevice::QFileDevice(QFileDevicePrivate&, QObject*) (
qfiledevice.cpp:219)
==58572== by 0x4A2FA02: QSaveFile::QSaveFile(QString const&) (qsavefile.cpp:119)
==58572== by 0x188B77: NWSim::Network::Save(std::__cxx11::basic_string<char, std::
char_traits<char>, std::allocator<char>>, NWSim::fileType) (in /home/jani/c++/project/nwsim/bin/nwsim-
cli)
==58572== by 0x16BD73: TestNetworkSave() (in /home/jani/c++/project/nwsim/bin/nwsim-
cli)
==58572== by 0x175111: main (in /home/jani/c++/project/nwsim/bin/nwsim-
cli)
==58572==
==58572== 120 bytes in 1 blocks are still reachable in loss record 9 of 12
==58572== at 0x483BE63: operator new(unsigned long) (in /usr/lib/x86_64-linux-gnu/
valgrind/vgpreload_memcheck-amd64-linux.so)
==58572== by 0x48FC6A8: QThreadData::current(bool) (qthread_unix.cpp:222)
==58572== by 0x4B1B0C0: QObject::QObject(QObjectPrivate&, QObject*) (qobject.cpp
:919)
==58572== by 0x4A17148: QIODevice::QIODevice(QIODevicePrivate&, QObject*) (qiodevice
.cpp:489)
==58572== by 0x4A0EA68: QFileDevice::QFileDevice(QFileDevicePrivate&, QObject*) (
qfiledevice.cpp:219)
==58572== by 0x4A2FA02: QSaveFile::QSaveFile(QString const&) (qsavefile.cpp:119)
==58572== by 0x188B77: NWSim::Network::Save(std::__cxx11::basic_string<char, std::
char_traits<char>, std::allocator<char>>, NWSim::fileType) (in /home/jani/c++/project/nwsim/bin/nwsim-
cli)
==58572== by 0x16BD73: TestNetworkSave() (in /home/jani/c++/project/nwsim/bin/nwsim-
cli)
==58572== by 0x175111: main (in /home/jani/c++/project/nwsim/bin/nwsim-
cli)

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==58572==
==58572== 136 bytes in 1 blocks are still reachable in loss record 10 of 12
==58572== at 0x483BE63: operator new(unsigned long) (in /usr/lib/x86_64-linux-gnu/
    valgrind/vgpreload_memcheck-amd64-linux.so)
==58572== by 0x48FB863: QAdoptedThread::QAdoptedThread(QThreadData*) (qthread.cpp
    :137)
==58572== by 0x48FC704: QThreadData::current(bool) (qthread_unix.cpp:225)
==58572== by 0x4B1B0C0: QObject::QObject(QObjectPrivate&, QObject*) (qobject.cpp
    :919)
==58572== by 0x4A17148: QIODevice::QIODevice(QIODevicePrivate&, QObject*) (qiodevice
    .cpp:489)
==58572== by 0x4A0EA68: QFileDevice::QFileDevice(QFileDevicePrivate&, QObject*) (
    qfiledevice.cpp:219)
==58572== by 0x4A2FA02: QSaveFile::QSaveFile(QString const&) (qsavefile.cpp:119)
==58572== by 0x188B77: NWSim::Network::Save(std::__cxx11::basic_string<char, std::
    char_traits<char>, std::allocator<char>>, NWSim::fileType) (in /home/jani/c++/
    project/nwsim/bin/nwsim-cli)
==58572== by 0x16BD73: TestNetworkSave() (in /home/jani/c++/project/nwsim/bin/nwsim-
    cli)
==58572== by 0x175111: main (in /home/jani/c++/project/nwsim/bin/nwsim-cli)
==58572==
==58572== 2,032 bytes in 1 blocks are still reachable in loss record 11 of 12
==58572== at 0x483DD99: calloc (in /usr/lib/x86_64-linux-gnu/valgrind/
    vgpreload_memcheck-amd64-linux.so)
==58572== by 0x771FD30: g_malloc0 (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so
    .0.6400.3)
==58572== by 0x77439C5: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x7738512: g_slice_alloc (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so
    .0.6400.3)
==58572== by 0x7707181: g_hash_table_new_full (in /usr/lib/x86_64-linux-gnu/libglib
    -2.0.so.0.6400.3)
==58572== by 0x772A602: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x4011B89: call_init.part.0 (dl-init.c:72)
==58572== by 0x4011C90: call_init (dl-init.c:30)
==58572== by 0x4011C90: _dl_init (dl-init.c:119)
==58572== by 0x4001139: ??? (in /usr/lib/x86_64-linux-gnu/ld-2.31.so)
==58572==
==58572== 16,384 bytes in 1 blocks are still reachable in loss record 12 of 12
==58572== at 0x483B7F3: malloc (in /usr/lib/x86_64-linux-gnu/valgrind/
    vgpreload_memcheck-amd64-linux.so)
==58572== by 0x771FCD8: g_malloc (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so
    .0.6400.3)
==58572== by 0x772A613: ??? (in /usr/lib/x86_64-linux-gnu/libglib-2.0.so.0.6400.3)
==58572== by 0x4011B89: call_init.part.0 (dl-init.c:72)
==58572== by 0x4011C90: call_init (dl-init.c:30)
==58572== by 0x4011C90: _dl_init (dl-init.c:119)
==58572== by 0x4001139: ??? (in /usr/lib/x86_64-linux-gnu/ld-2.31.so)
==58572==
==58572== LEAK SUMMARY:
==58572== definitely lost: 0 bytes in 0 blocks
==58572== indirectly lost: 0 bytes in 0 blocks
==58572== possibly lost: 0 bytes in 0 blocks
==58572== still reachable: 19,092 bytes in 12 blocks
==58572== suppressed: 0 bytes in 0 blocks
==58572==
==58572== For lists of detected and suppressed errors, rerun with: -s
==58572== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)

```

7 Work log

The amount of hours for each week for every group member is described here.

Week	Dates	Hours	What was done?
1	July 6 - July 12	2	Project plan
2	July 13 - July 19	3	Weekly meeting, node, link and network design.
3	July 20 - July 26	11	Weekly meeting, studying CMake and Qt Creator. initial work on IP address handling helpers, NetworkInterface, Packet, Node, Link and Application classes. Test cases for NetworkInterface and Packet.
4	July 27 - Aug 2	6	Weekly meeting. Continued work on Node and Link classes. Tests for Nodes, Links and initial packet transfer. Node position variables + tests for Dancun.
5	Aug 3 - Aug 9	2	Weekly meeting. Mid-term meeting with Pasi.
6	Aug 10 - Aug 16	0	Nothing
7	Aug 17 - Aug 23	25	Weekly meeting. Major refactor and cleanup of Node and Link classes, dropped Application as a separate class. Network class to hold Nodes and Links, routing, EndHost, Router, Packet generation. Testcases for Node, Link, Network. Moved testcases to separate file and introduced assert checks to grep for fails.
8	Aug 24 - Aug 30	40	Weekly meeting. Simulatable nodes and links, packet transfer between them, fix routing, testcases. Wrote CLI as GUI was abandoned. Final documentation. Reviewing file save/load implementation from Brian. Demo with Pasi and group 1. Hunting for memory leak in file save/load. Integrating to CLI.
Total	All	99	-

Table 3: Jani's work log. Hours are rough estimates from git commit history, stopped tracking on week 7 to keep up.

Week	Dates	Hours	What was done?
1	July 6 - July 12	4	Studied about Qt and how to use it in making GUIs in C++
2	July 13 - July 19	2	Tried making nodes which would represent the routers plus the necessary buttons needed to add nodes
3	July 20 - July 26	4	Researched on a ways in which to connect the nodes to each other so that traffic could be implemented in the network between the nodes
4	July 27 - Aug 2	2	Changed the GUI as the original setup I had was not able to send any communication over the link between the two nodes
5	Aug 3 - Aug 9	1	Worked on improving the GUI by adding the needed buttons and other features needed
6	Aug 10 - Aug 16	2	Came with nodes that can display on the screen and can be connected to each other
7	Aug 17 - Aug 23	2	Tried adding the source code but did not find the expected results on how to tie the GUI to the code
8	Aug 24 - Aug 30	1	GUI works but still problems trying to get the code and GUI to work
Total	All	18	-

Table 4: Dancun's work log.

Week	Dates	Hours	What was done?
1	July 6 - July 12	4	UML for Project Plan, studied network basics
2	July 13 - July 19	1	Weekly meeting.
3	July 20 - July 26	5	Weekly meeting. Studied the use of CMake and linking libraries
4	July 27 - Aug 2	3	Weekly meeting. Decided on the use of Qt's own JSON libraries.
5	Aug 3 - Aug 9	4	Weekly meeting. Figured out how to use QJson-classes, some preliminary implementations for reading/writing to JSON.
6	Aug 10 - Aug 16	0	Nothing
7	Aug 17 - Aug 23	2	Weekly Meeting.
8	Aug 24 - Aug 30	5	Implemented save/load functionality for user-configurable attributes of the network in JSON file format.
Total	All	24	-

Table 5: Brian's work log.

Week	Dates	Hours	What was done?
1	July 6 - July 12	3	Project plan, studied network protocols
2	July 13 - July 19	2	Attended weekly meeting, planned parts of the implementation
3	July 20 - July 26	2	Attended weekly meeting, wrote initial version of event queue
4	July 27 - Aug 2	2	Attended weekly meeting, rewrote event queue
5	Aug 3 - Aug 9	1	Attended weekly meeting
6	Aug 10 - Aug 16	1	Attended weekly meeting
7	Aug 17 - Aug 23	3	Attended weekly meeting, created routing table for the network
8	Aug 24 - Aug 30	0	nothing
Total	All	14	-

Table 6: Leo's work log.

8 Post mortem

It is quite obvious from the output of the project that we did not meet the goal that we set for ourselves and what was expected from the project description. There are many reasons for why this was the case, but the core issues were:

1. Work was probably divided wrong from the start, e.g. Jani had work until the last 2 weeks of the project, but everyone else was waiting for the results of his code. Similarly, Leo had free time at the start, but less towards the end. See figure 2 for the original schedule from the project plan.
2. Design of the software was only done superficially and at a too high level. The approach was to design further as we progressed, but this turned out to be a bad decision. Ad-hoc approach to design rarely works, and here it didn't either.
3. Related to the design, but the architecture was started from the bottom up, which introduced some unnecessary issues, which could have been averted if the network was immediately designed as a graph and the necessary interfaces implemented early, such that other

group members wouldn't have to worry about ever-changing code.

- The GUI portion was started early and progressed fine, but it was never properly integrated with the core functionality. This is why, in the end, a CLI approach was taken as there was not enough time left to write a shorter implementation and integration.

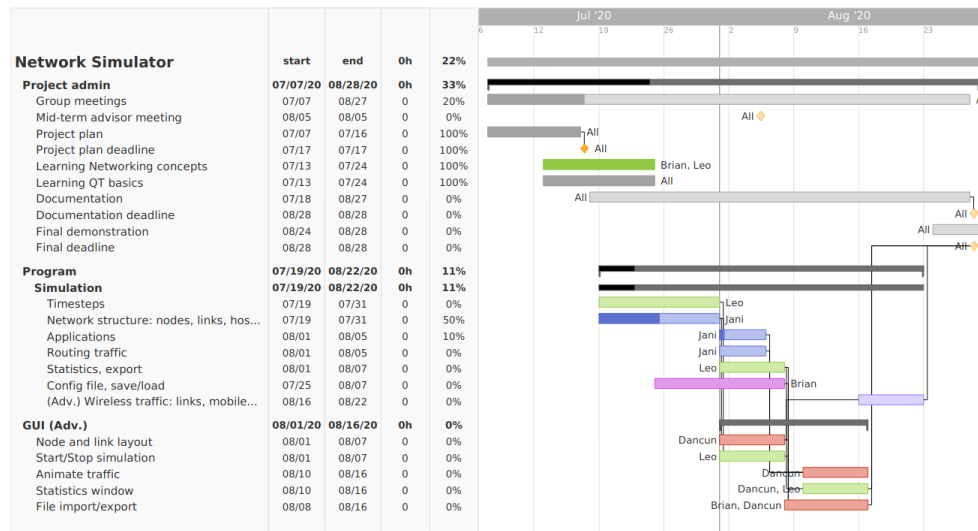


Figure 2: Original schedule from the project plan.

8.1 GUI

The GUI was being worked on as mentioned, and some functionality was achieved:

- The GUI we have so far has the ability to add nodes on the screen. The nodes can be connected to each other and a given node can be deleted. The implementation is simple and does not include 2D or 3D
- For the time being the functionality that exist, is one to add nodes and connect them. There is not any additional functionalities that have been implemented as of now

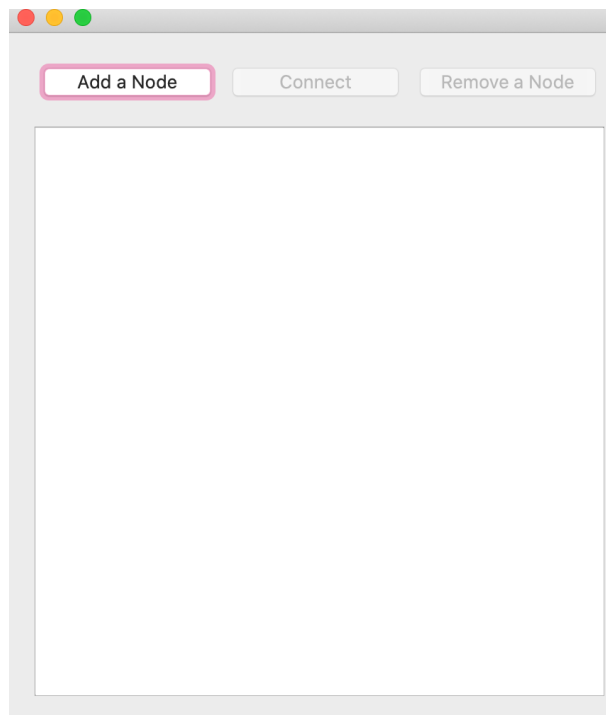


Figure 3: Screenshot 1 from the GUI.

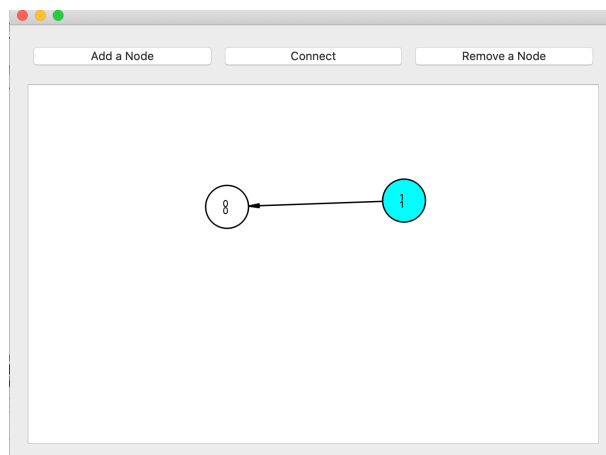


Figure 4: Screenshot 2 from the GUI.