SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

Doctoral School of Multidisciplinary Engineering Sciences
(MMTDI)

Performance Analysis of ICT Systems

Lecture 3

The OMNeT++ Discrete-Event Modelling and Simulation Framework

https://www.tilb.sze.hu/cgi-bin/tilb.cgi?0=m&1=targyak&2=NGD_MDA64_1

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Agenda

- Free and open source software, licenses.
- A short introduction to OMNeT++
  - OMNeT++ / Omnest
  - The architecture of the OMNeT++ System
  - Modelling in the OMNeT++ System
  - How OMNeT++ supports Experimenting?
  - The features of the Eclipse based OMNeT++ IDE
    - Demo: http://www.omnest.com/webdemo/ide/
- A PDES research using OMNeT++

Free Software and Companions

- The meanings of the English word “free”
  - free beer (There is no free beer!)
  - freedom (FSF uses this meaning)
- Two mayor advocates
  - FSF: Free Software Foundation
    - https://www.gnu.org/philosophy/free-sw.en.html
  - OSI: Open Source Initiative
    - https://opensource.org/osd

The ultimate meaning of the two definitions is quite similar, but they put the emphasis on different things.

The Four Essential Freedoms (FSF)

1. The freedom to run the program as you wish, for any purpose.
2. The freedom to study how the program works, and change it so it does your computing as you wish.

   Access to the source code is a precondition for this.

3. The freedom to redistribute copies so you can help others.
4. The freedom to distribute copies of your modified versions to others.

   By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.

   – copyleft: the original license MUST be used

   – non-copyleft: a different license may be used

https://www.gnu.org/philosophy/free-sw.html.en

Important Free Licenses

- For software (and its documentation)
  - GPL, LGPL, GNU FDL (copylefted)
  - Modified BSD license (non-copylefted, permissive)

https://www.gnu.org/licenses/licenses.html

- For other creative works (including research papers)
  - Creative Commons
    - CC BY, CC BY-SA, CC BY-ND,
    - CC BY-NC, CC BY-NC-SA, CC BY-NC-ND

https://creativecommons.org/licenses/

OMNeT++ and Omnest

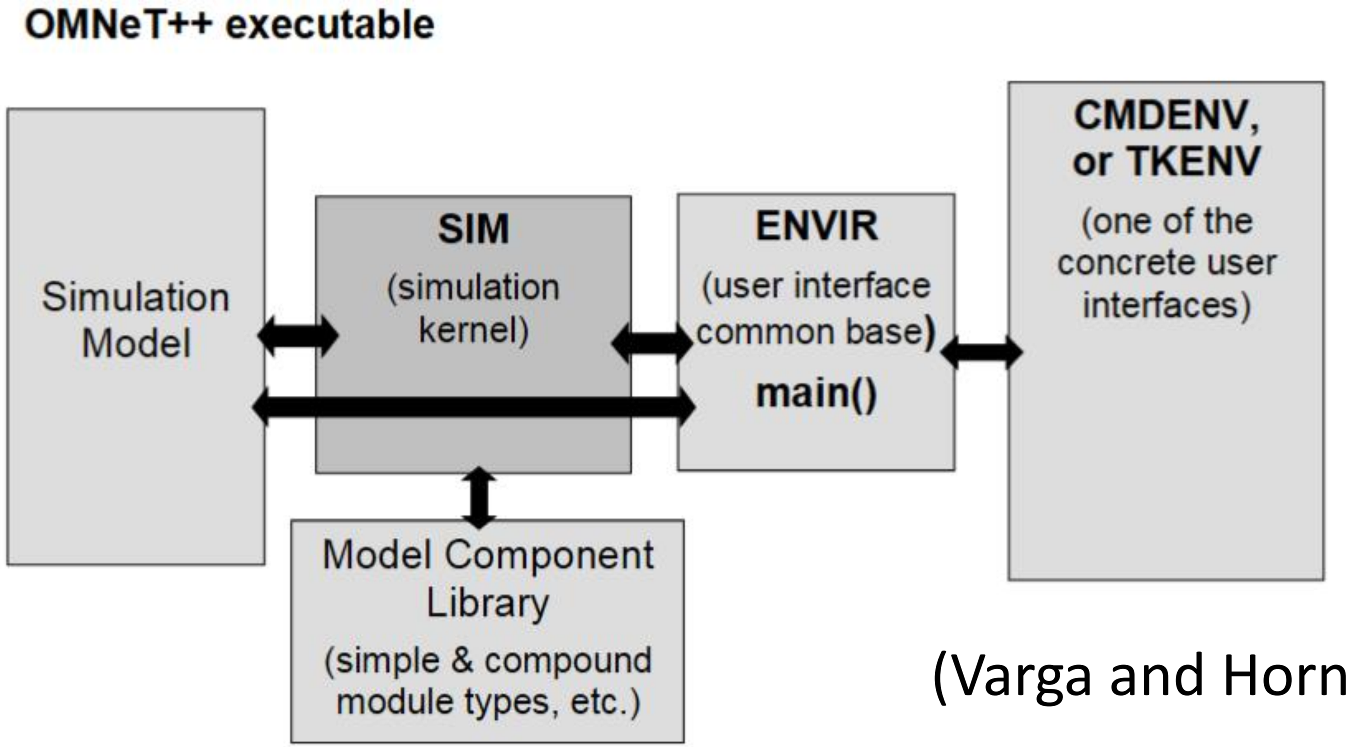
- “One software and two licenses”
  - Not exactly, but the simulation kernel is the same
    - https://omnest.com/comparison.php
- OMNeT++: Academic Public License
  - for non-commercial purposes
  - Like GPL with the above limitations
  - https://omnetpp.org
- Omnest: Commercial license
  - With the usual conditions
  - https://omnest.com

What is OMNeT++?

- Discrete-Event Simulation System
  - Open source, general purpose simulator
  - Especially suitable for the analysis of ICT systems
- C++ based simulation kernel
- Libraries, tools
- GUI and command line user interface
- Integrated development environment to support the whole modelling and simulation process
- Multiple platforms
  - Linux, Windows, Mac OS, Docker, etc.

The architecture of OMNeT++

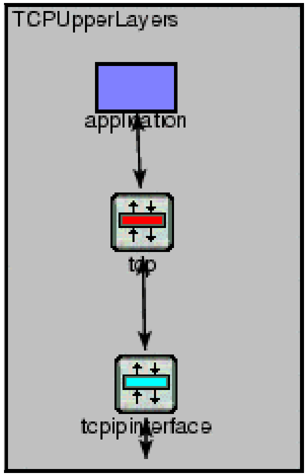
- Separate parts
  - User interface (multiple interfaces, embeddable)
  - Simulation kernel, model component library, model

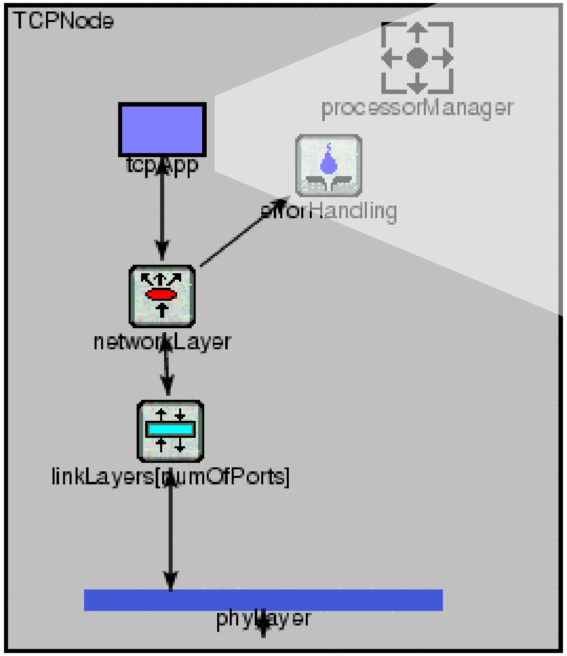


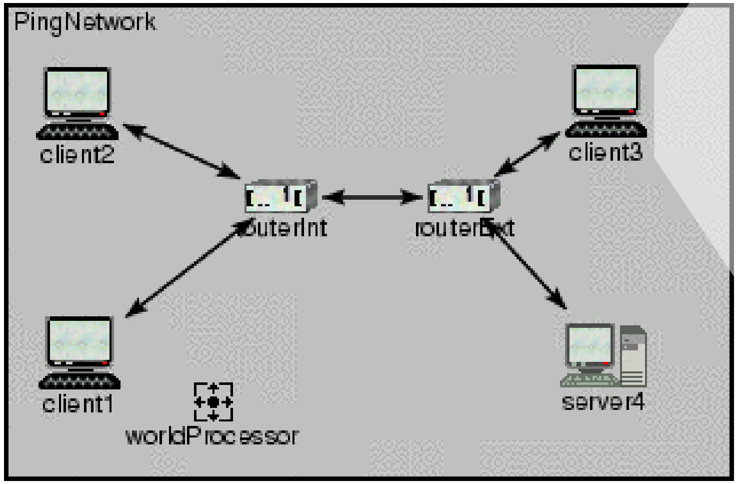
(Varga and Hornig 2008)

Model building

- Models are built up hierarchically
  - Simple / Compound modules
  - Connections
  - Gates





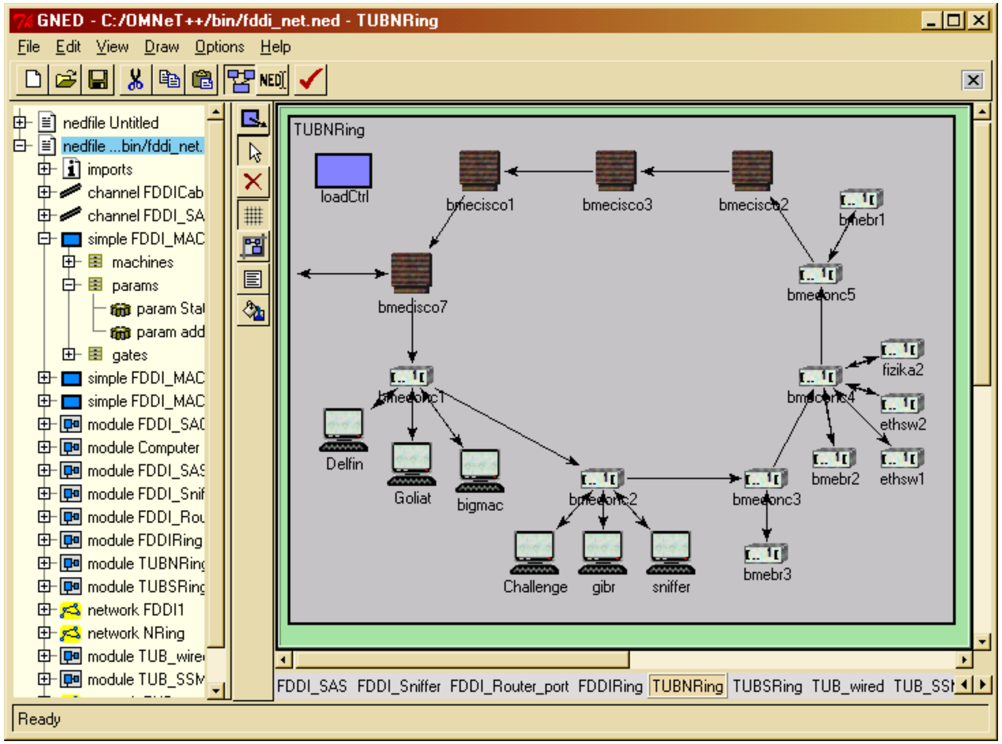


(Sekercioglu, Varga, Egan 2003)

Description of the Topology

- NeD (Network Description Language)

```
// Host with an Ethernet interface
module EtherStation
    parameters: ...
    gates: ...
    submodules:
        app: EtherTrafficGen;
        llc: EtherLLC;
        mac: EtherMAC;
    connections:
        app.out --> llc.hl_in;
        app.in <-- llc.hl_out;
        llc.ll_in <-- mac.hl_out;
        llc.ll_out --> mac.hl_in;
        mac.ll_in <-- in;
        mac.ll_out --> out;
endmodule
```



Description of the operation – 1

- Operation is implemented by the simple modules
  - The compound modules are only containers
- A simple module
  - Sends messages
  - Reacts to messages
  - Collects statistics
- Simple modules are implemented in C++
  - Either process oriented (old style: **`activity()`**)
  - Or event oriented (new style: **`handleMessage()`**)

Description of the operation – 2

- Library functions exist for the typical tasks
  - Creating, sending and receiving messages
  - Generating random numbers
  - Collecting statistics (e.g. histogram)
  - Handling queues
  - Discovering topology, routing support
  - etc.

Support for experimenting (GUI)

- Different running modes including step-by-step
- Inspection of the different elements of the model
  - Modules and its parts
  - Queues
  - FES
  - state variables
  - statistics collection objects
  - etc.

Features of the new Eclipse based IDE

- Support for model preparation
  - Topology description: both graphical and text format
  - Preparation of .ini files
- Support for simulation execution
  - Parameter study
  - Batch executions
- Evaluation of the results
  - Graphs from Scalar and Vector files
  - Examination of the Event Sequence Chart

Further materials

- OMNeT++ IDE webdemo
  - http://www.omnest.com/webdemo/ide/
- A PDES research using OMNeT++
  - See the slides and the paper (Lencse and Varga 2010) in separate files.

References – 1

- G. Lencse and A. Varga, "Performance prediction of conservative parallel discrete event simulation", *Proceedings of the 2010 Industrial Simulation Conference (ISC'2010),* Budapest, Hungary, 2010, EUROSIS-ETI, pp. 214-219.
- Y. A. Sekerciouglu, A. Varga, G.K. Egan, "Parallel simulation made easy with OMNeT++", *Simulation in Industry: Proceedings of the 15th European Simulation Symposium (ESS 2003)*, Delft, Netherlands, 2003, SCS Europe, pp. 493-499.
- A. Varga, R. Hornig, "An overview of the OMNeT++ simulation environment“, *Proceedings of the 1st international conference on Simulation tools and techniques for communications, networks and systems & workshops (SIMUTools)*, Marseille, France, 2008. Article no. 60, pp. 1-10 https://dl.acm.org/doi/10.5555/1416222.1416290

Thank you for your attention!

Questions?

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