ESD Electronic Systems Design

Synthesis Verification Testing Power Communication

Toolchain for Optimal Network Synthesis

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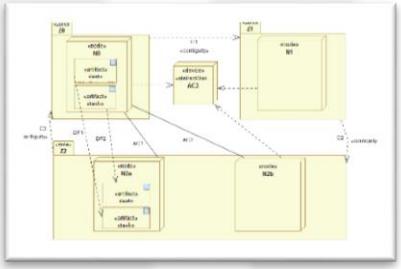
Introduction

Introduction

- Optimal Network Synthesis
  - Methodology, which, starting from a high level description of the communication infrastructure, finds a network configuration as closest as possible to the optimal with respect to pre-fixed parameters.
    - This is done by exploring the space of possible solutions through manipulations on the network configuration.
- Network Manipulation
  - Network manipulation is a process that takes a network configuration and generates another configuration which preserves some properties and alters some others, but employs a different combination of channels and nodes.

Methodology

Flow for optimal Network Synthesis



Network scenario high-level description

Optimization

- Economic cost
- Power consumption
- Transmission delay
- Error rate

Network scenario simulation model

Optimization Strategies

Optimized Network scenario simulation model

Simulation-based refinement

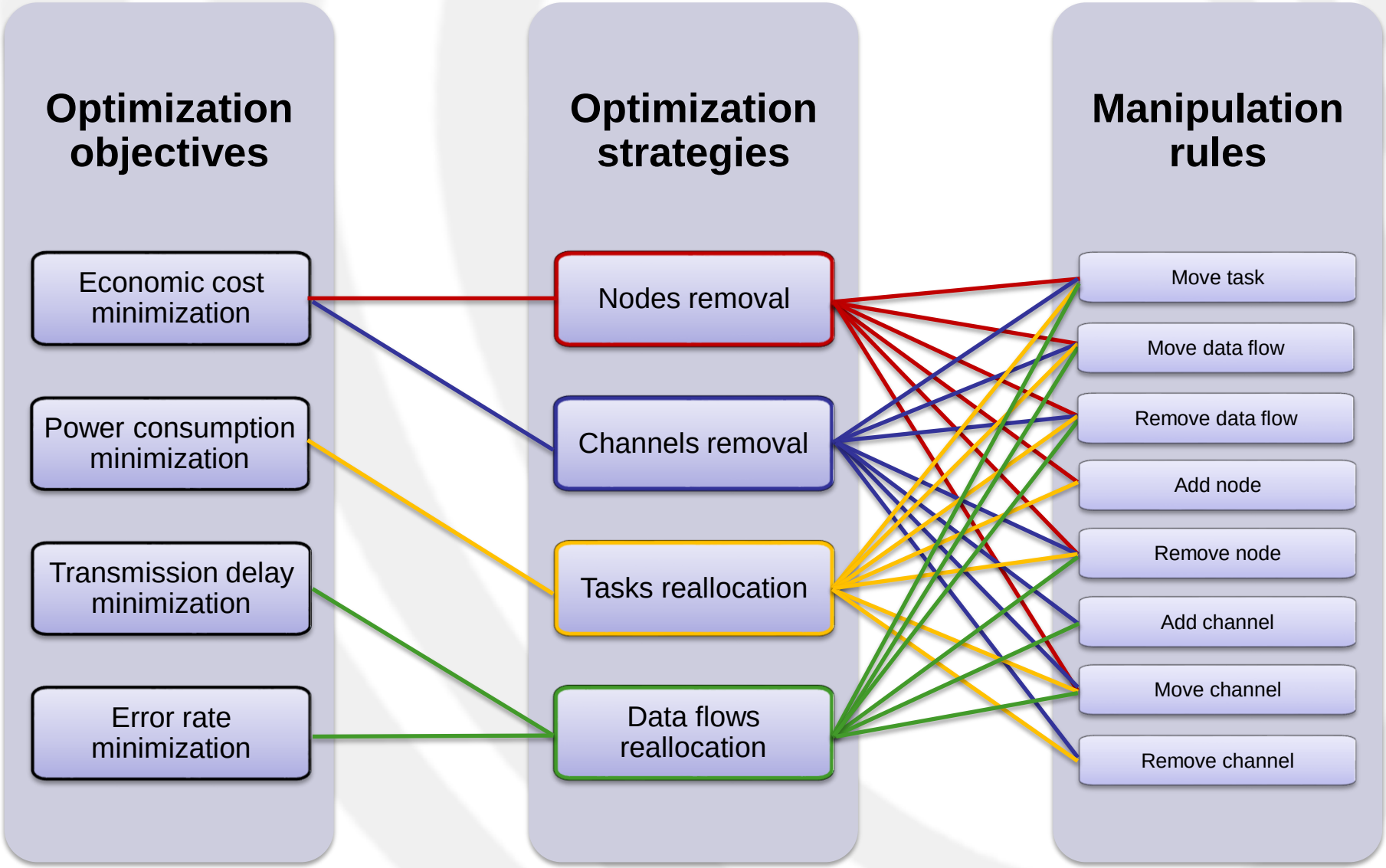
Manipulation

- Move task
- Move data flow
- Remove data flow
- Add node
- Remove node
- Move channel
- Add channel
- Remove channel

NW-Aware Optimization (1)

- The process consists of 3 steps:
  1. Definition of an ***optimization objective***
  2. Application of the ***optimization strategies*** specific to the chosen optimization metric
  3. Use of ***manipulation rules***, driven by the specific optimization strategies

NW-Aware Optimization (2)



Optimization objectives

- Optimization objectives define the metric that should be taken into account in the network synthesis of DES.
  - Economic cost minimization
  - Power consumption minimization
  - Transmission delay minimization
  - Error rate minimization

Optimization strategies

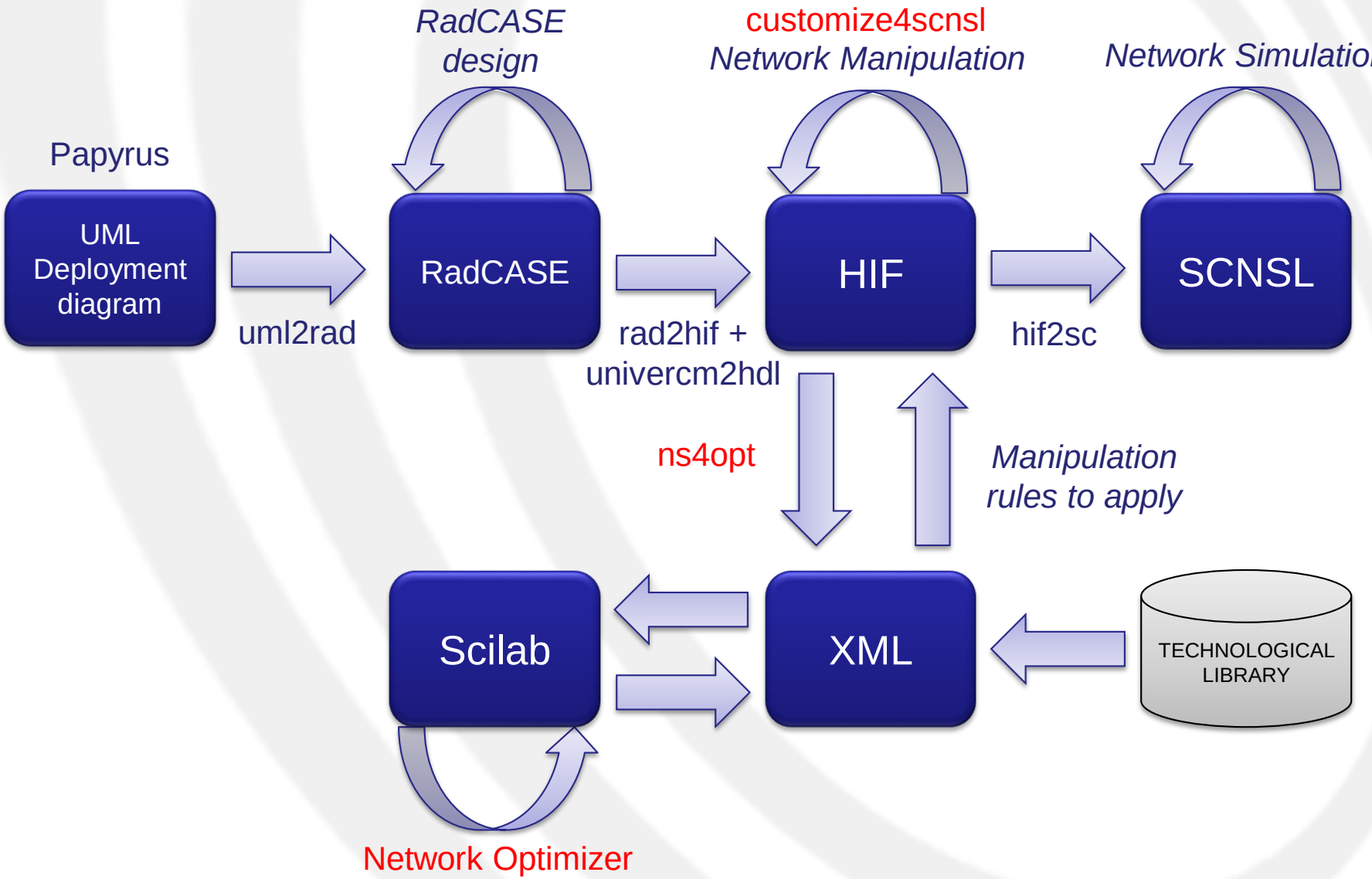
- Optimization strategies are sets of manipulation rules to apply to the network in order to achieve a certain goal. These rules should be used with a certain logic and a certain order, so as to produce a correct and consistent network configuration.
  - Nodes removal
  - Channels removal
  - Tasks reallocation
  - Data flows reallocation

Manipulation rules

- Manipulations are basic operations on the network entities of a DES, which alter the current configuration of the network structure. These manipulations on the network topology will be used for design space exploration to find an optimal configuration of the network.
  - Move task
  - Move data flow
  - Remove data flow
  - Add node
  - Remove node
  - Move channel
  - Add channel
  - Remove channel

Toolchain

Extended UML2SCNSL Toolchain



New tools

- HIFSuite
  - customize4scnsl *–m*
  - ns4opt
- Scilab
  - Network Optimizer

New tools (1)

- customize4scnsl *–m*
  - `customize4scnsl` has been extended with a "*–m*" option in order to apply the manipulations on the current network scenario description.
    - An extra XML input file, containing the manipulation rules to apply, is required.
  - The tool provides a HIF file ready for the SCNSL conversion.
- ns4opt
  - `ns4opt` (Network Scenario for Optimization) is a tool which generates a generic XML Network Scenario description from a HIF description of the scenario.

New tools (2)

- Network Optimizer
  - `Network Optimizer` is a set of scripts written in the Scilab environment.
    - ***Scilab*** is free and open source software for numerical computation (including *mathematical optimization*) providing powerful computing environment for engineering and scientific applications.
  - It is the tool that given an optimization objective, applies the appropriate strategies to find a set of network manipulations that make the scenario optimal (or near the optimal) in respect to the pre-fixed objective.
  - The tool takes in input the XML file describing the network scenario (i.e., the result of `ns4opt`) and returns another XML file containing the list of manipulation rules to apply to the initial network scenario.

Exercises

Setup Exercises

- In order to setup the tools for the exercises, first you need to untar the «*exercises_nesLab4.tar.gz*».
  - Preferably in the "*/tmp/*" directory because we have also to setup the HIFSuite tools of the previously laboratory.

```
1$ tar -xzvf exercises_nesLab4.tar.gz
```

- "*exercises_nesLab4*" contains the following directories:
  - *Tools*
    - *hifsuite* → contains only the `ns4opt` directory and an updated version of the `customize4scnsl` directory
    - *NetworkOptimizer*
  - *uml2scnsl*
    - 0.UML_Examples → where to put the «*.uml*» files
    - 1.uml2rad → files generated by `uml2rad` tool
    - 2.rad2hif → files generated by `rad2hif` tool
    - 3.univercm2hdl → files generated by `univercm2hdl` tool
    - 4.customize4scnsl → files generated by `customize4scnsl` tool
    - 5.hif2sc → files generated by `hif2sc` tool
    - 6.ns4opt → files generated by `ns4opt` tool
    - 7.scnsl → SCNSL source codes

Setup Exercises - HIFSuite

- After you have installed the HIFSuite tools as in the previously laboratory, you have to copy "*ns4opt*" and "*customize4scnsl*" directory in the "*Tools*" directory.
- Edit the "*env-setup.sh*" script uncommenting the following line:

```
export PATH=$PATH:<HIFSUITE_PATH>/ns4opt/bin
```

  - Replace *<HIFSUITE_PATH>* with your current path to the hifsuite directory (e.g., "*/tmp/exercises_nesLab4/Tools/hifsuite*").
- Source the script

```
1$ source env-setup.sh
```

Setup Exercises - Scilab

- Download Scilab:
  - http://www.scilab.org/download/5.5.2/scilab-5.5.2.bin.linux-x86_64.tar.gz
- Untar it in the "*Tools*" directory and export in the environment the path to Scilab.

```
1$ export PATH=$PATH:<SCILAB_PATH>/bin
```

  - Replace *<SCILAB_PATH>* with your current path to the scilab directory (e.g., "*/tmp/exercises_nesLab4/Tools/scilab-5.5.2*").
- Now you can launch Scilab from anywhere.

```
1$ scilab
```

Setup Exercises – NetworkOptimizer (1)

- "*NetworkOptimizer*" contains the following directories:
  - *inputs*
    - *XML files generated by the* `ns4opt` tool of the Network Scenarios you want to optimize.
    - XML files containing the lists of nodes and channels available from the technological library.
  - optimizations
    - Scripts for optimization objectives, optimization strategies and manipulation rules.
  - *output*
    - XML files generated by the `NetworkOptimizer`, containing the manipulation rules to apply on the initial Network Scenario in order to obtain an optimal configuration of the network infrastructure.

Setup Exercises – NetworkOptimizer (2)

- To run the main script, launch Scilab inside the "*NetworkOptimizer*" directory and digit the exec command in the Scilab console:

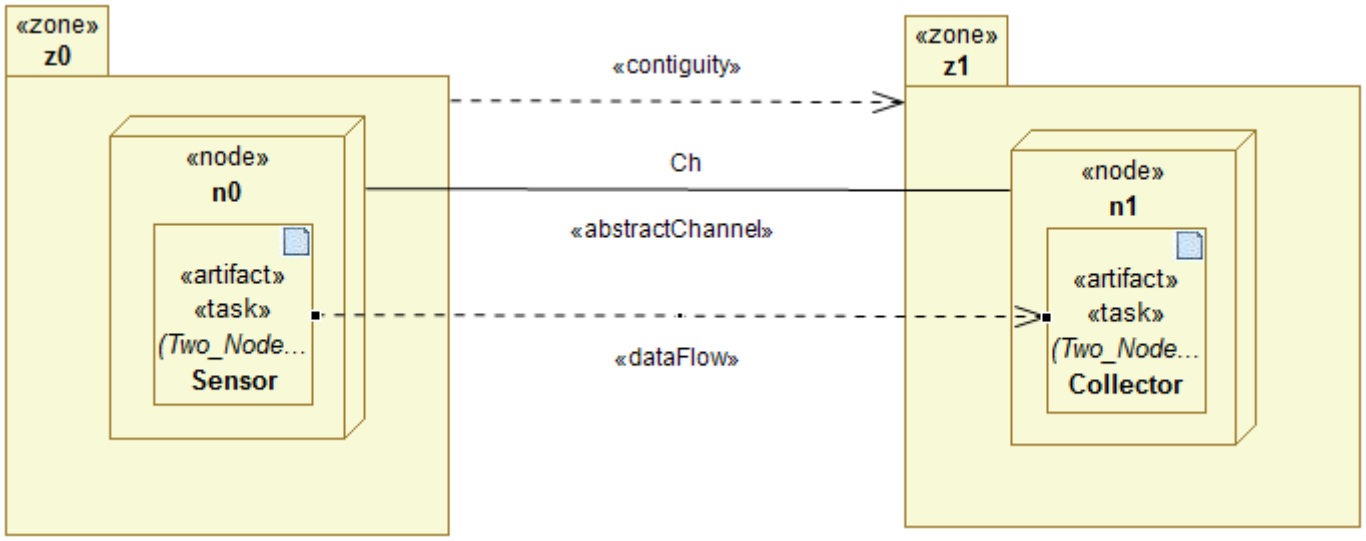
```
-->exec('networkOptimizer.sce',0)
```

- The tool will ask as inputs:
  - The optimization objective
  - The name of the XML file containing the network scenario description (i.e., the one provided by `ns4opt`)
  - The name of the XML file containing the technological library

Setup Exercises – uml2scnsl

- "*uml2scnsl*" directory contains 2 scripts:
  1. *uml2scnsl.sh*
     - Runs the toolchain from UML to SCNSL, generating also the XML Network Scenario description in the "*6.ns4opt*" directory.
  2. *uml2scnsl_man.sh*
     - Runs the toolchain from UML to SCNSL, applying the manipulation rules obtained by the `NetworkOptimizer` optimization process; the XML file with the manipulation rules has to be put in "*3.univercm2hdl/manipulations/*"
- Remember to edit both the scripts with the current HIFSuite path, and source them.

Exercise 1: Two Nodes (1)



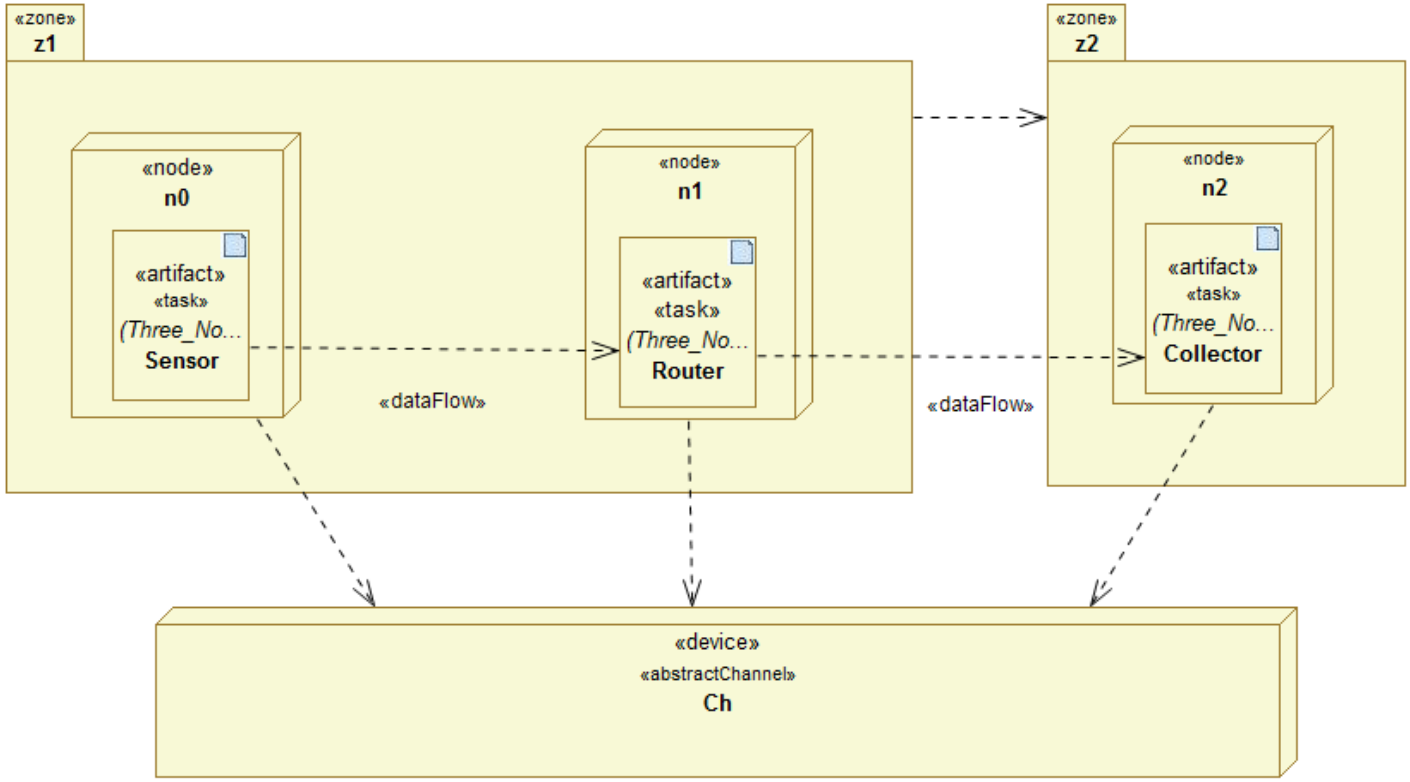
- Channel «Ch» → delay = 10
- The Technological Library contains:
  - Node «A»
    - cost = 20
  - Channel «X»
    - delay = 2
  - Channel «Y»
    - delay = 20

N.B.: only the attributes of interest for the exercise have been reported here.

Exercise 1: Two Nodes (2)

1. Generate the corresponding SCNSL code by using the *uml2scnsl* toolchain.
2. Simulate the result.
3. Optimize the NW Scenario choosing the «*Transmission delay minimization*» as optimization objective.
   - Which manipulation rules have been applied?
4. Simulate the result and observe the delay of each transmission.
   - How is the new delay in respect to the initial one?

Exercise 2: Three Nodes with Router (1)



- Channel «Ch» → cost = 10
- Nodes «n0», «n1», «n2» → cost = 10
- The Technological Library contains the same nodes and channels of the one of Exercise 1.

Exercise 2: Three Nodes with Router (2)

1. Generate the corresponding SCNSL code by using the *uml2scnsl* toolchain.
2. Optimize the NW Scenario choosing the «*Economic cost minimization*» as optimization objective.
   - Which manipulation rules have been applied?
   - Does the optimization change the network configuration?
   - How is the new global economic cost in respect to the initial one?

N.B.: it is not necessary to use simulation in order to verify the global economic cost.