A Toolchain for UML-based Modeling and Simulation of Networked Embedded Systems

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Outline

- Introduction
- UML/Deployment diagrams
- UML/ NW Profile
- Toolchain
  - UML2HIF
  - HIF2UML
  - NSM
  - HIF2SystemC
- Experimental results

Introduction (1)

```
#include <tlm.h>
#include <exception>

#include <scnsl.hh>
#include "MyTask_t.hh"
#include "MyTask_tr.hh"
#include <fstream>
#include <iostream>

using namespace Scnsl::Setup;
using namespace Scnsl::Builtin
using Scnsl::Tracing::Traceabl

int sc_main( int argc, char *
{
 try {



        unsigned int NODESNUMBER_ROW=0;
        if ( argc == 2 )
        {
            std::stringstream ss;
            ss << argv[ 1 ];
            ss >> NODESNUMBER_ROW;

        }

        // Singleton.
        Scnsl::Setup::Scnsl_t * scnsl = Scnsl::Setup::Scnsl_t::get_instance();
```

LoC> 1500

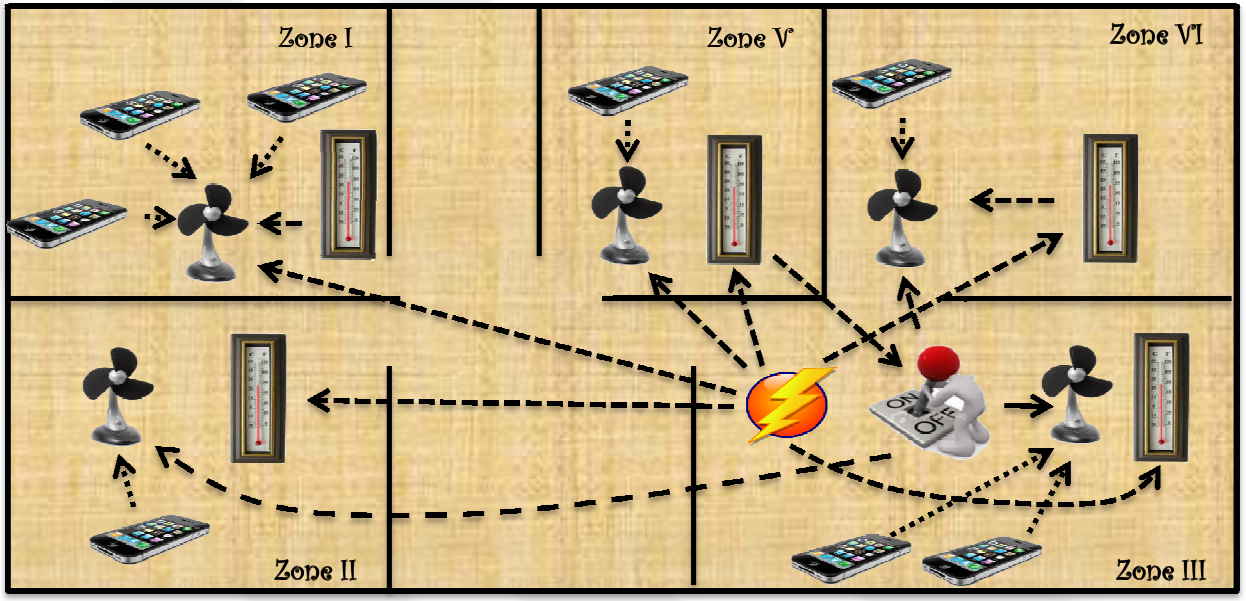
```
////////////////////////////////////////////////////////////////////////////////
// Creating the protocol 802.15.4:
////////////////////////////////////////////////////////////////////////////////
        CoreCommunicatorSetup_t ccoms;
        ccoms.extensionId = "core";
                                                    MAC_802_15_4;
                                                    ccoms );

        Scnsl::Core::Communicator_if_t * mac1;
        ccoms.name = "Mac1";
        ccoms.node = n1;
        mac1 = scnsl->createCommunicator( ccoms );
////////////////////////////////////////////////////////////////////////////////
//Tracing
////////////////////////////////////////////////////////////////////////////////
        // Adding tracing features:
        CoreTracingSetup_t cts;
        cts.extensionId = "core";
        // - Setting the formatter:
        cts.formatterExtensionId = "core";
        cts.formatterName = "basic";
```

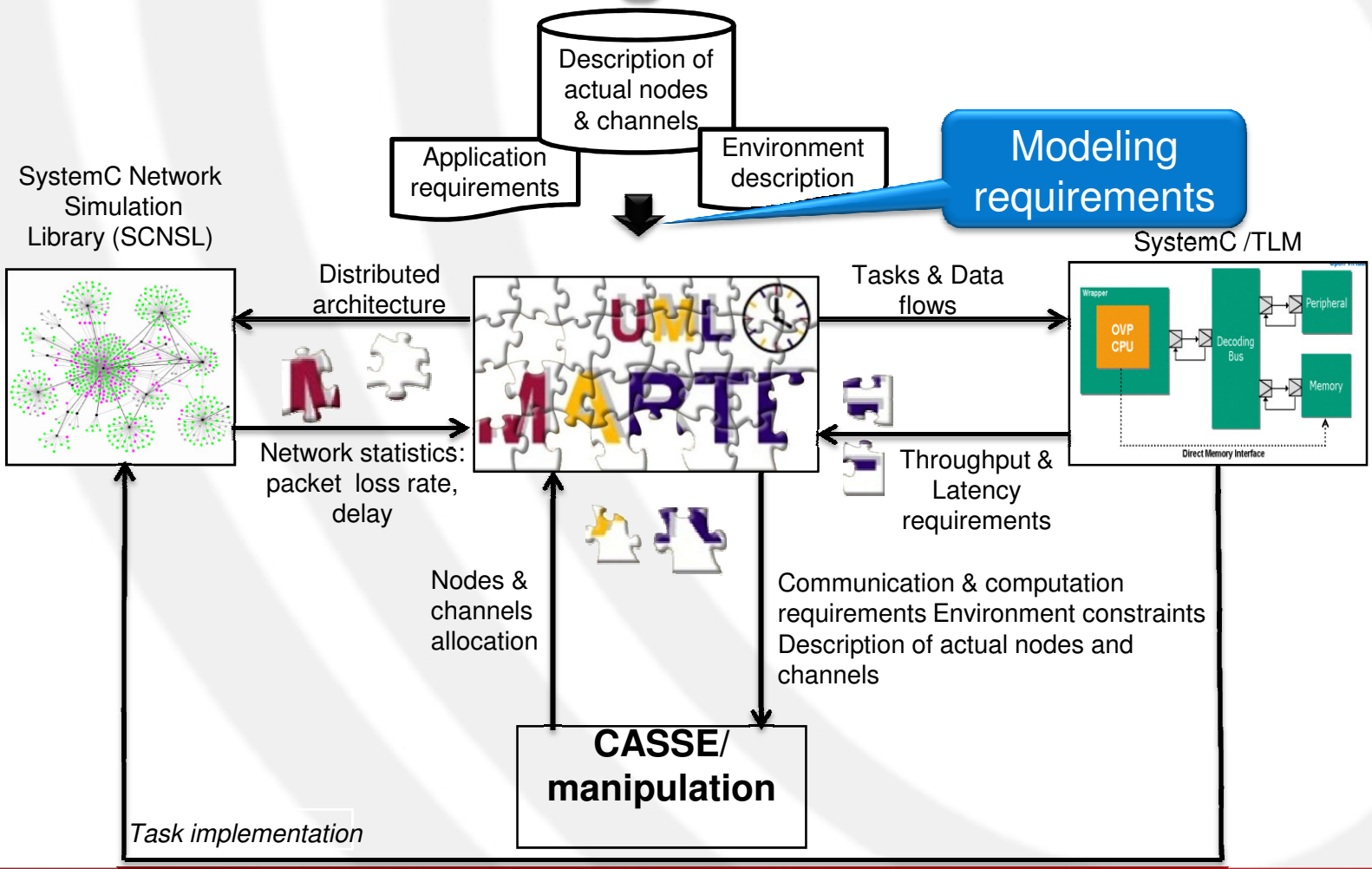
Introduction (2)

Solution:

- **Distributed embedded application** as a single system to be designed
- Start from an abstract Model-Based System Specification



Design flow


Description of actual nodes & channels
Application requirements
Environment description
Modeling requirements
SystemC Network Simulation Library (SCNSL)
Distributed architecture
Tasks & Data flows
SystemC /TLM
UML
MARTE
Wrapper
OVP CPU
Decoding Bus
Peripheral
Memory
Direct Memory Interface
Network statistics: packet loss rate, delay
Throughput & Latency requirements
Nodes & channels allocation
Communication & computation requirements Environment constraints Description of actual nodes and channels
CASSE/ manipulation
Task implementation

Framework requirements

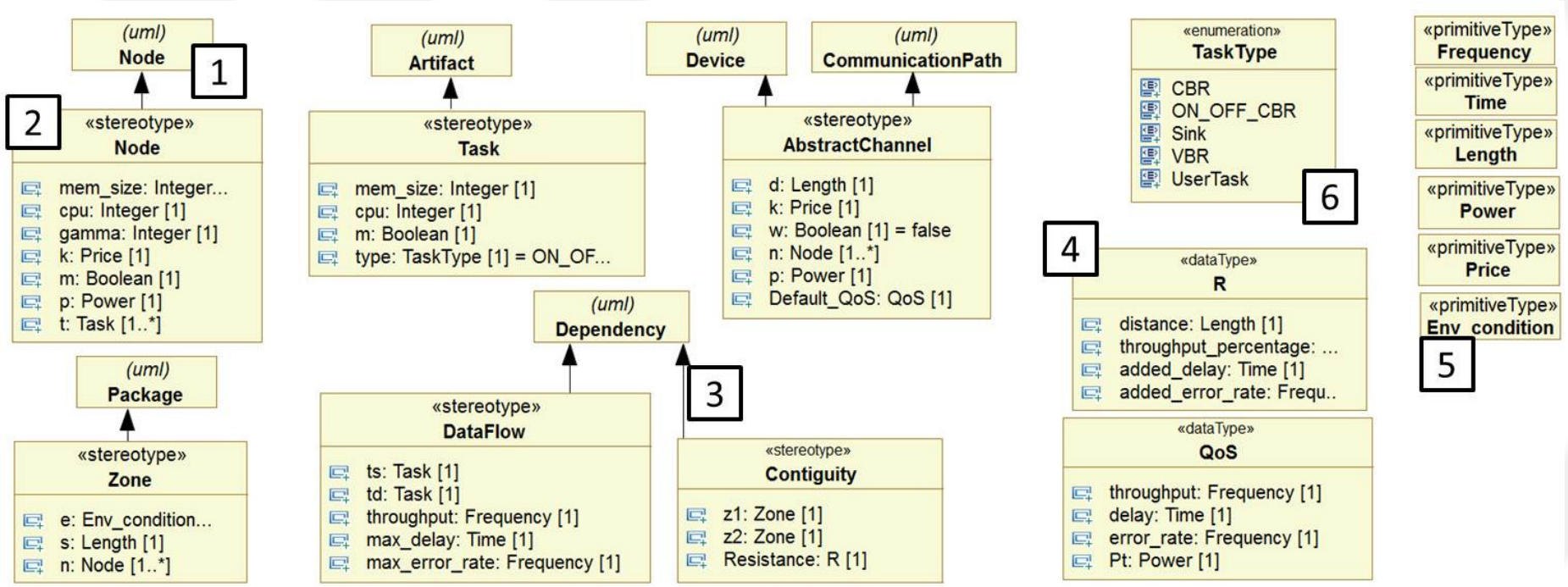
- Intermediate format to represent UML elements
- A set of tools to manipulate and generate executable/simulation code from this format
- Framework for network simulation (e.g. SCNSL)

Modeling requirements

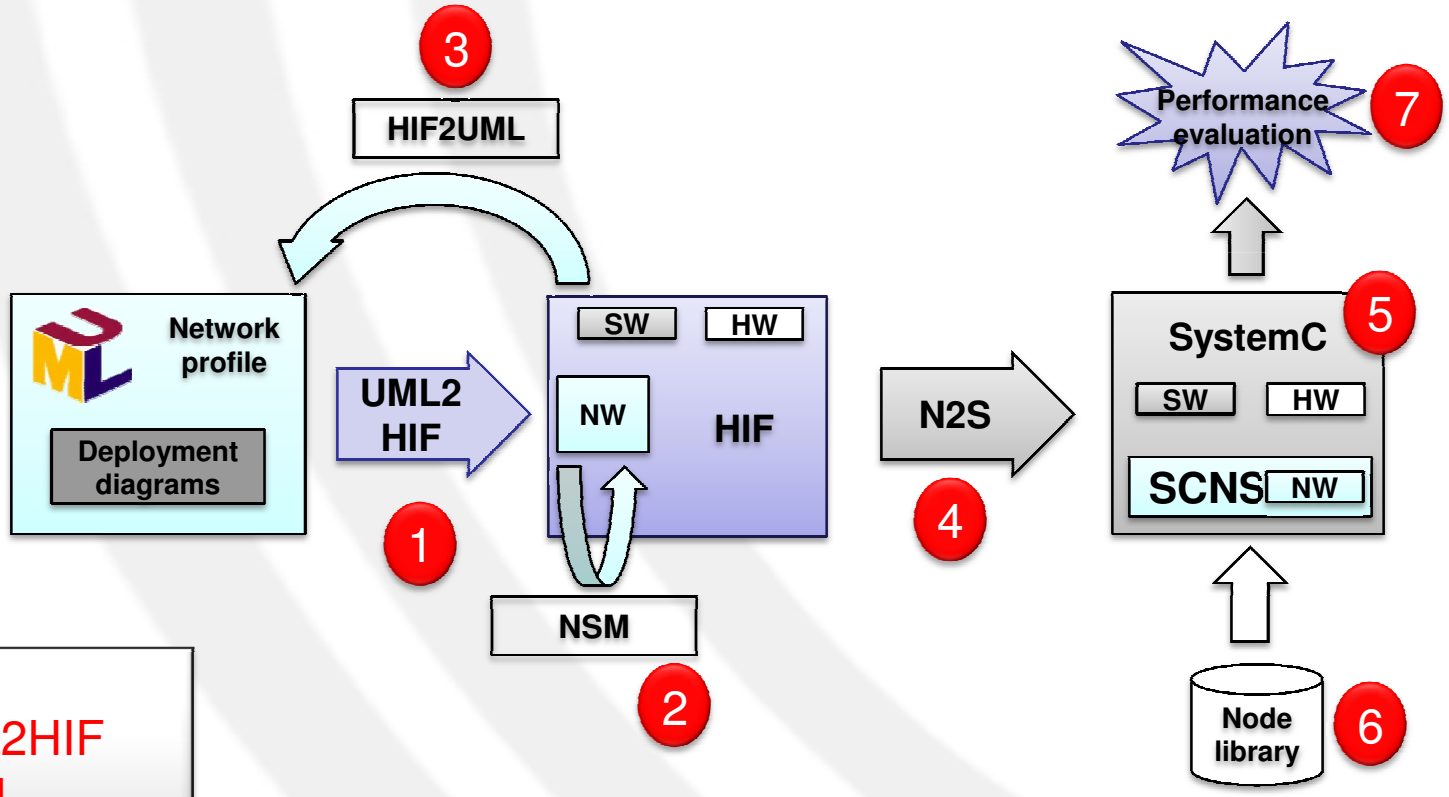
- Graphical modeling language which is closed to user requirements
- New UML profile to add networked embedded systems semantics to this graphical language

UML Network Profile

- Structure of NW profile:



Tools Overview



Tools

1. UML2HIF
2. NSM
3. HIF2UML
4. N2S

HIFSuite

- *HIFSuite* is a set of tools and a library that provide support for modeling and manipulation of **HIF** descriptions
- The Heterogeneous Intermediate Format (HIF) language can be used to build and manipulate descriptions of blocks interconnected together and featuring a finite state machine behavior
- HIF language is currently used to describe HW and SW blocks but it can be used also for the network

UML2HIF

- **UML2HIF** tool is HIF front-end tool for parsing UML diagrams and generating the corresponding HIF description.
- Up to now, the tool generates the complete description of the network from UML/Deployment diagram with NW profile.
- The tool supports wired/wireless communication and the concept of zone

N2S

- **N2S:** (Network to Simulation), is a tool which translates the corresponding HIF description of the NW into a description for the simulation platform
- Currently, the tool generates the SCNSL description from HIF
- In the future, it can support NS-3, OMNET++, etc.

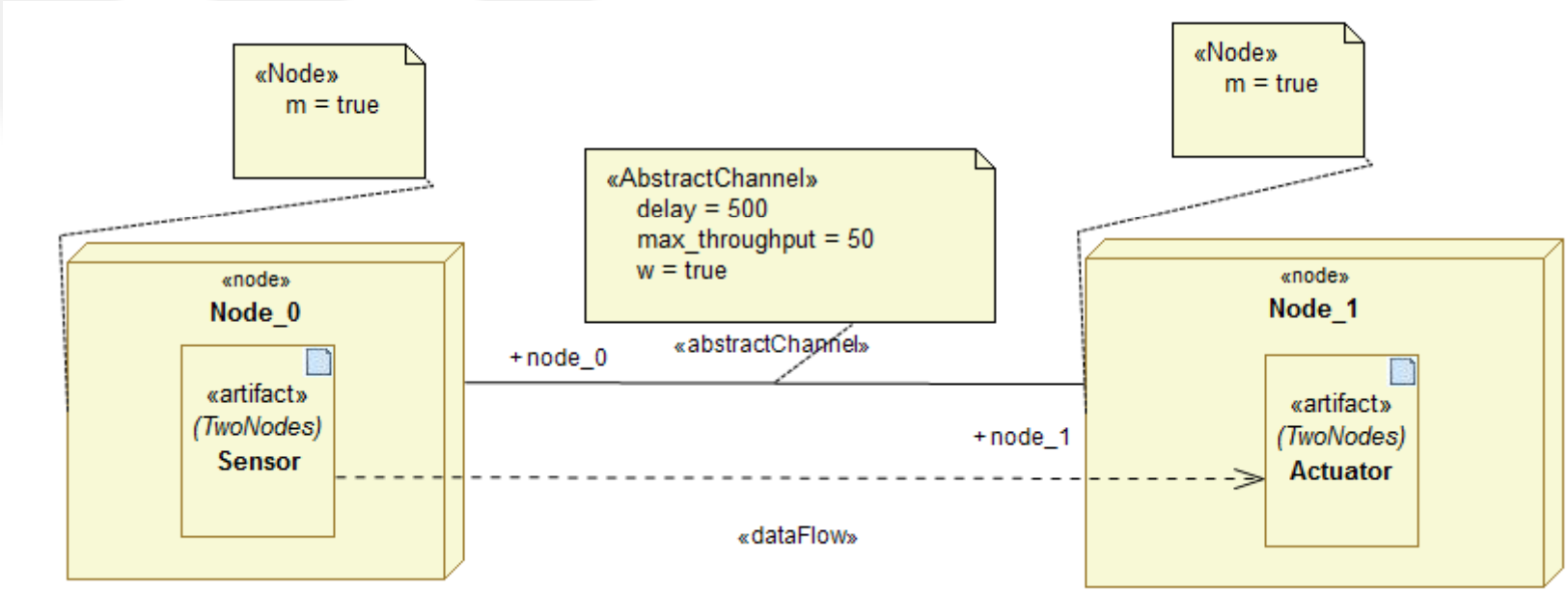
NSM

- **NSM:** (Network Scenario Manipulation), is a tool which manipulate the corresponding HIF description of the NW to generate different network design alternatives
- Currently, the tool supports divide and split channels mechanism

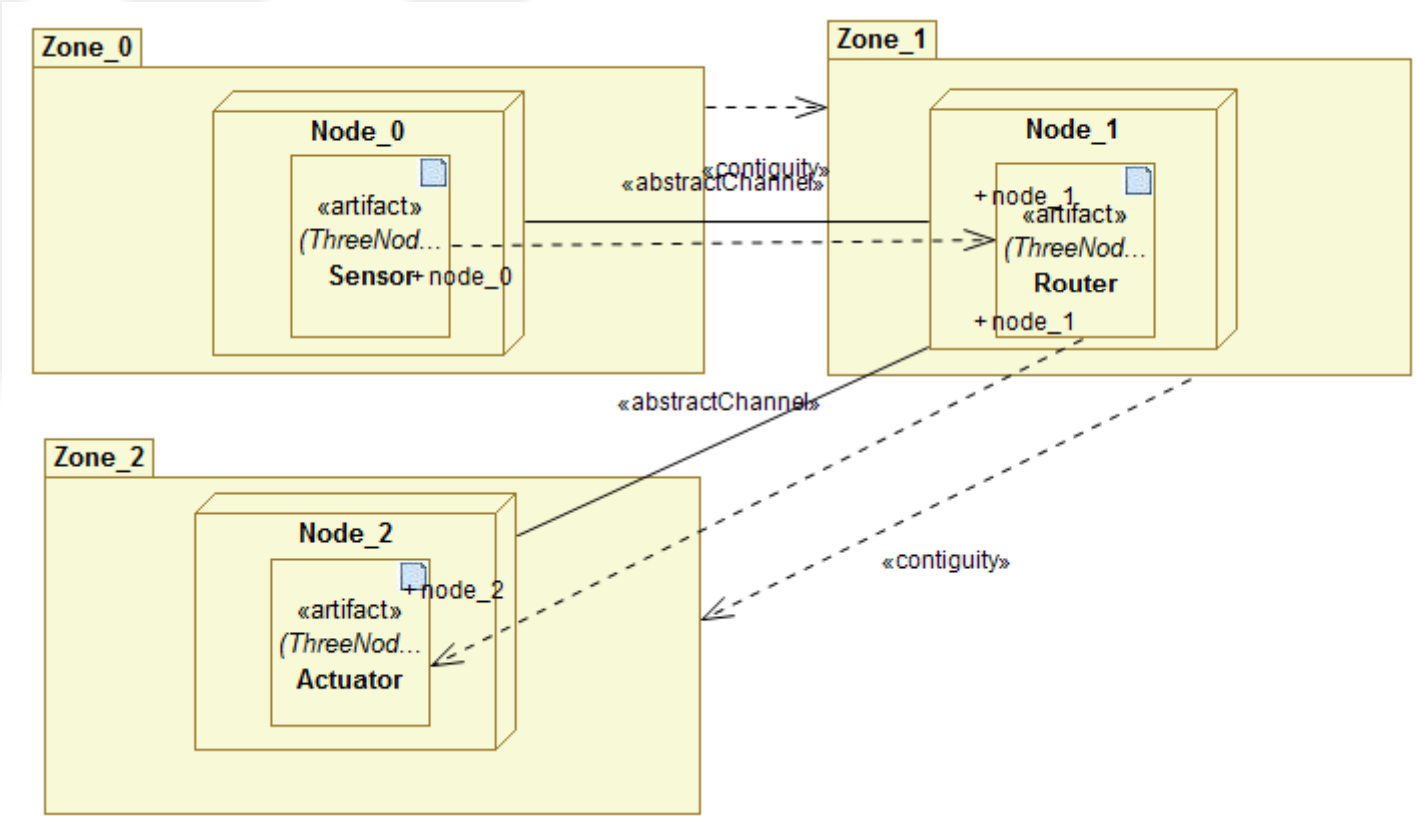
HIF2UML

- **HIF2UML:** it is a tool which redraw the HIF description back into UML level
- The main reason of it is
  - to back annotate UML diagrams
  - to generate UML diagrams from new network alternatives generated through manipulation
- Currently, the tool redraw the HIF descriptions of the network in terms of task, node, channel, data flow and zones in UML deployment diagrams
- In the future, the tool will support profile annotation

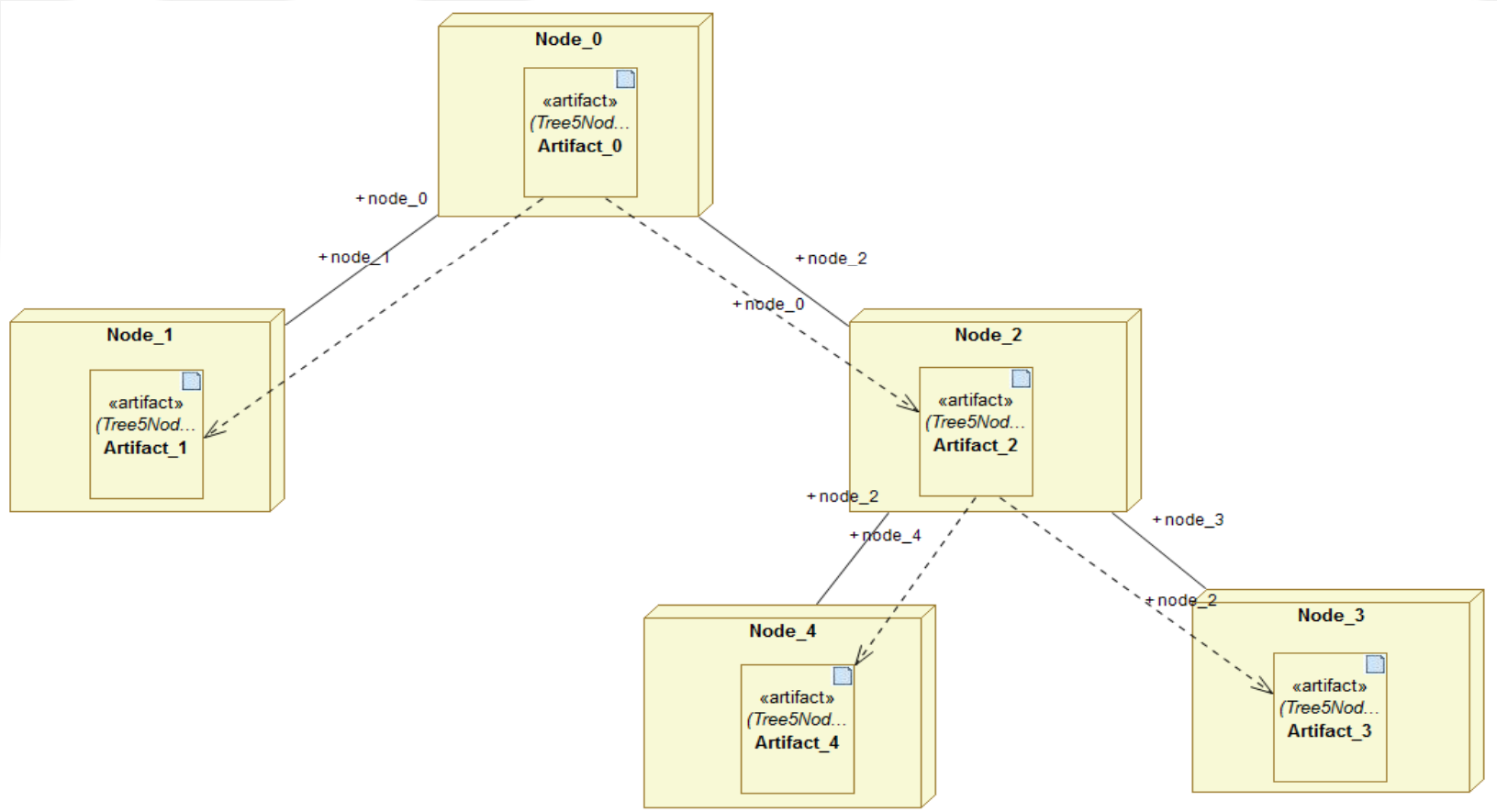
Case : Two Nodes



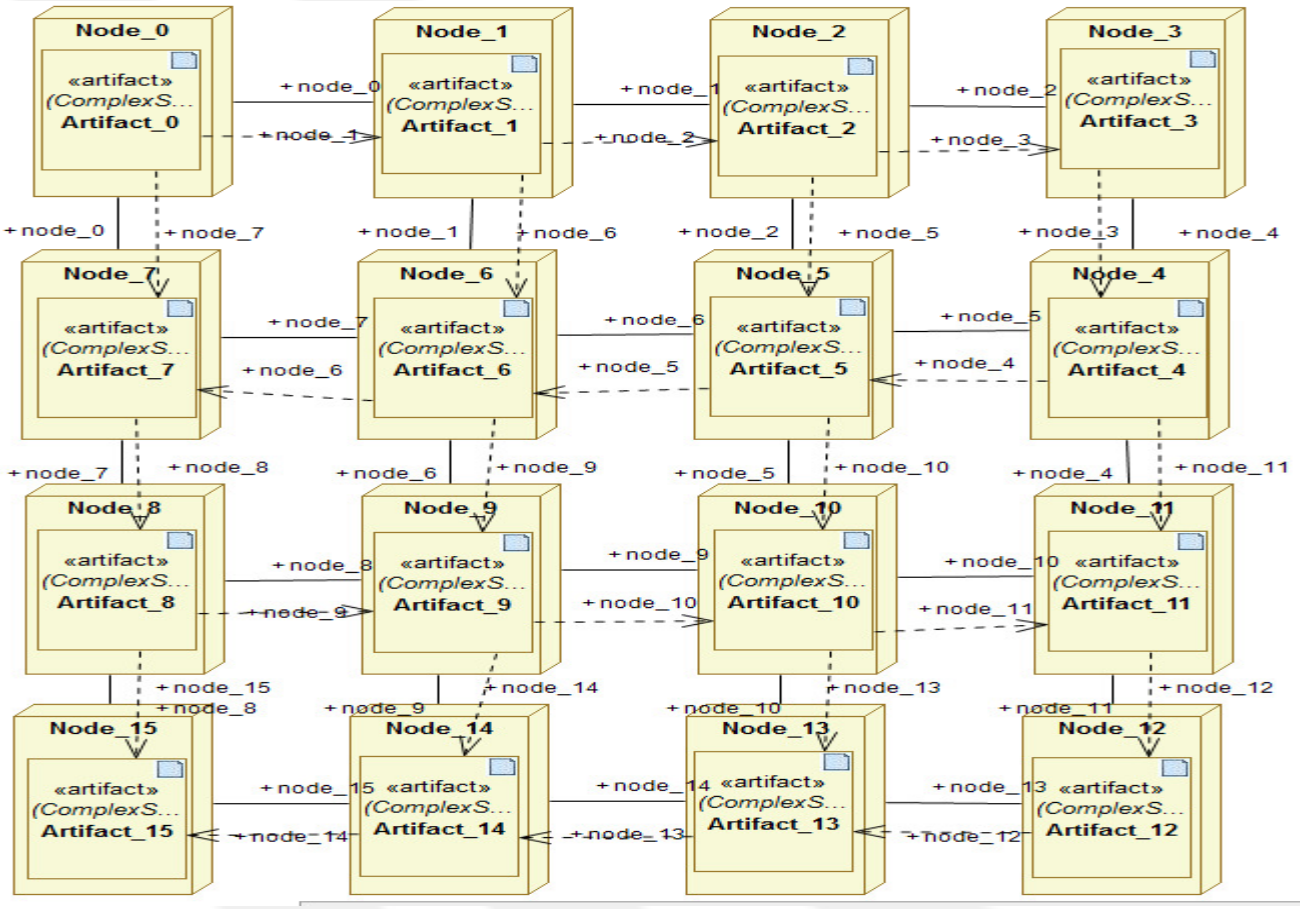
Case : Three Nodes With Zones



Case : Tree topology with 5 Nodes

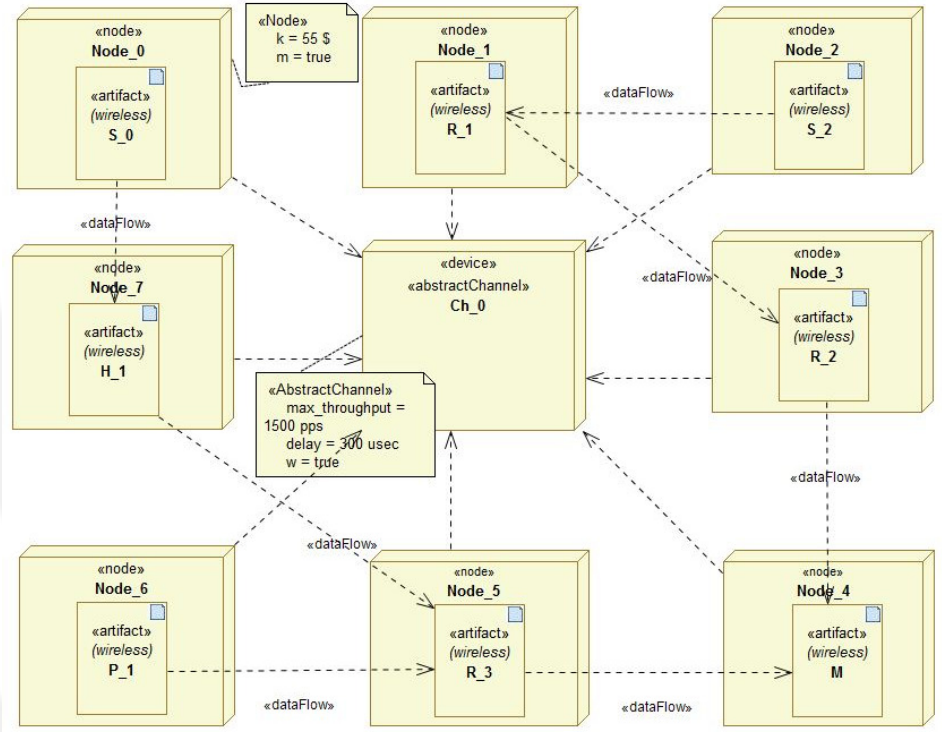


Case : Complex Scenario



Test case

- The building automation application



Test case

```
#include <tlm.h>
#include <exception>
#include <scnsl.hh>
#include "MyTask_t.hh"
using namespace Scnsl::Core;
int sc_main( int argc, char * argv[] )
{
// Node creation
    Node_t * Node_0 = scnsl->createNode();
    Node_t * Node_1 = scnsl->createNode();
    ...
// Task creation
    MyTask_t Controller( "Controller", Node_0 );
    MyTask_t Sensor_1( "Sensor_1", Node_1 );
    ...
// Channel creation
    CoreChannelSetup_t ccs;
    ccs.extensionId = "core";
    ccs.channel_type = CoreChannelSetup_t::UNIDIRECTIONAL;
    ccs.name = "Unidirectional";
    ccs.delay = sc_core::sc_time(400, sc_core::SC_MS );
    ccs.nodes_number = 2;
    Channel_if_t * ch0 = scnsl->createChannel(ccs);
    ...
// Bind setup
    scnsl->bind( Node_0, ch0, bsb0);
    scnsl->bind( Controller, Sensor_1, ch0, bsb0, Mac_0 );
    ...
```