NetFlex: A Simulation Framework for Networked Control Systems

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This guide provides a structured workflow to **set up, configure, and run** an NCS simulation using NetFlex. For further theoretical background and implementation details, refer to the **accompanying research papers**.

To define an example and configure an NCS simulation, three key components need to be set up:

1. `main.m` – Defines the system model and simulation parameters.
2. `NcsStructure.m` – Configures the network topology and creates system nodes.
3. `NCS_sim.slx` – Implements the TrueTime-based Simulink simulation.

1 Setting Up the Main Script (`main.m`)

The main script initializes the NCS and defines the simulation setup. It includes:

- **Defining the System Model**: Use `state-space representation` to describe the plant dynamics.
- **Setting Simulation Parameters**: Specify the **sampling time** and **total simulation time**.
- **Defining Network Effects**: Define them in the `main.m` according to the user-defined rule oder load them from pre-defined (e.g. real-world) data.
- **Defining Control and Observer Parameters**: The parameter can be defined for the strategies provided in `cd('framework/strategies')`.

Once defined, the script initializes the **NCS plant model**, creates an **NCS structure**, and starts the **Simulink simulation**.

2 Configuring Network Topology in `NcsStructure.m`

The `NcsStructure` file defines how nodes interact within the NCS simulation.

- **Assign Node Numbers in `function createNodes()`:**
  - Each **network node** receives a **unique, sequential node number**.
  - These **numbers do not reflect** the physical topology but serve as identifiers.
- **Create Nodes in `function createNodes()`:**
  - Call the respective **class constructors** (`SensorNode`, `ControllerNode`, `NetworkBuffer`, etc.).
  - Pass in required parameters such as **network effects and plant properties**. For the details on the input parameter, use `help` (e.g. `help SensorNode`)

This links the Simulink block to the correct node instance.

3 Configuring Simulink (`NCS_sim.slx`)

The **Simulink model** is used to implement **TrueTime-based simulations**.

- **Drag & Drop Nodes**:
  - Load `SimulinkBlocks.slx` and drag required nodes into `NCS_sim.slx`.
  - Available nodes include **sensor, controller, delays, network buffers, and orderers**.
- **Reference Nodes in the respective SImulink Blocks using `nodeMap`:**

```
NCS.nodeMap('NetworkNodeName')
```

4 Running the Simulation

Once the setup is complete:

- **Run the `main.m` Script**:
  - This initializes the **system model**, **network effects**, and **control strategies** and starts the Simulation.

5 Extending NetFlex

To modify or extend the framework:

- Add custom **delay, dropout, or network mechanisms**.
- Extend **control and observer strategies** in the `strategies/` folder.