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ZeroMQ remote API

The ZeroMQ remote API is one of several ways an application can connect with CoppeliaSim.

The ZeroMQ remote API allows to control a simulation (or the simulator itself) from an external application or a remote hardware (e.g. real robot, remote computer, etc.). It offers all API functions also available via a CoppeliaSim script: this includes all regular API functions (i.e. sim.* -type functions), but also all API functions provided by plugins (e.g. simOMPL.*, simUI.*, simIK.*, etc.), if enabled.

The ZeroMQ remote API functions are interacting with CoppeliaSim via ZeroMQ and its interface plugin to CoppeliaSim and the ZMQ remote API add-on. All this happens in a hidden fashion to the user. The remote API can let one or several external applications interact with CoppeliaSim in a stepping (i.e. *synchronized* with each simulation step) or non-stepping way (i.e. the normal operation mode), and even remote control of the simulator is supported (e.g. remotely loading a scene, starting, pausing or stopping a simulation for instance).

See programming/zmqRemoteApi folder or its related repository for examples.

Python client

Install client package:

```
$ python3 -m pip install coppeliasim-zmqremoteapi-client
```

(the ZeroMQ and CBOR dependencies will be automatically installed with the above command).

Following is a very simple example ZeroMQ remote API client code, which starts then runs a stepping simulation for 3 seconds:

```
from coppeliasim_zmqremoteapi_client import RemoteAPIClient

client = RemoteAPIClient()
sim = client.require('sim')

sim.setStepping(True)

sim.startSimulation()
while (t := sim.getSimulationTime()) < 3:
    print(f'Simulation time: {t:.2f} [s]')
    sim.step()
sim.stopSimulation()
```

C++ client

Any C++ client requires the jsoncons and cppzmq package: those are automatically downloaded and used when compiling via cmake. The boost and ZMQ libraries need to be installed. For details see *programming/zmqRemoteApi/clients/cpp/*, which contains several examples.

Build them with:

```
$ mkdir build
$ cd build
$ cmake ..
$ cmake --build . --config Release
```

Following is a very simple C++ ZeroMQ remote API client code, which starts then runs a stepping simulation for 3 seconds:

```
#include "RemoteAPIClient.h"

int main(int argc,char* argv[])
{
    RemoteAPIClient client;
    auto sim = client.getObject().sim();

    sim.setStepping(true);

    sim.startSimulation();
    double t = 0.0;
    do
    {
        t = sim.getSimulationTime();
        printf("Simulation time: %.2f [s]\n", t);
        sim.step();
    } while (t < 3.0);
    sim.stopSimulation();
    return(0);
}
```

Java client

Any Java client requires Apache Maven. For details see *programming/zmqRemoteApi/clients/java/src/main/java*, which contains several examples.

Make sure that your folder names do not contain any spaces, and have CoppeliaSim running (API function are fetched from CoppeliaSim). Build with:

```
$ export COPPELIASIM_ROOT_DIR=path/to/CoppeliaSim/exec/folder/or/resources/folder/on/macOS
$ cd zmqRemoteApi/clients/java
$ mvn package -D"GENERATE_INCLUDE_OBJECTS=sim,simIK"
```

In above, only the sim and simIK namespaces are considered, you may add more when needed. Following is a very simple Java ZeroMQ remote API client code, which starts then runs a stepping simulation for 3 seconds:

```
import java.util.Arrays;

import com.coppeliarobotics.remoteapi.zmq.*;

public class Example
{
    public static void main(String[] _args) throws java.io.IOException, co.nstant.in.cbor.CborException
    {
        var client = new RemoteAPIClient();
        var sim = client.getObject().sim();

        sim.setStepping(true);
        sim.startSimulation();

        double simTime = 0.0;
        while((simTime = sim.getSimulationTime()) < 3)
        {
            System.out.printf("Simulation time: %.2f [s]%n", simTime);
            sim.step();
        }
        sim.stopSimulation();
    }
}
```

Matlab & Octave clients

Matlab clients require the bundled JeroMQ, which installs automatically if not yet present.

Octave clients require Octave 6.4+, the octave communications and zeromq packages. Those can be installed with:

```
pkg install -forge communications
pkg install -forge zeromq
```

Following is a very simple Matlab/Octave ZeroMQ remote API client code, which starts then runs a stepping simulation for 3 seconds:

```
client = RemoteAPIClient();
sim = client.require('sim');

sim.setStepping(true);

sim.startSimulation();
while true
    t = sim.getSimulationTime();
    if t >= 3; break; end
    fprintf('Simulation time: %.2f [s]\n', t);
    sim.step();
end
sim.stopSimulation();
```

Lua client

Currently, a Lua client is only supported from within a CoppeliaSim script, e.g. in order to connect 2 or more CoppeliaSim instances.

Following is a very simple Lua ZeroMQ remote API client code, which synchronizes the simulation steps with another CoppeliaSim instance:

```
function sysCall_init()
    remoteApiClient = require('luaZmqRemoteApi')
    remoteApiClient.init('127.0.0.1', 23002)
    simx = remoteApiClient.getObject('sim')

    remoteApiClient.setStepping(true)
    simx.startSimulation()
end

function sysCall_sensing()
    remoteApiClient.step()
end

function sysCall_cleanup()
    simx.stopSimulation()
    remoteApiClient.cleanup()
end
```

Rust client

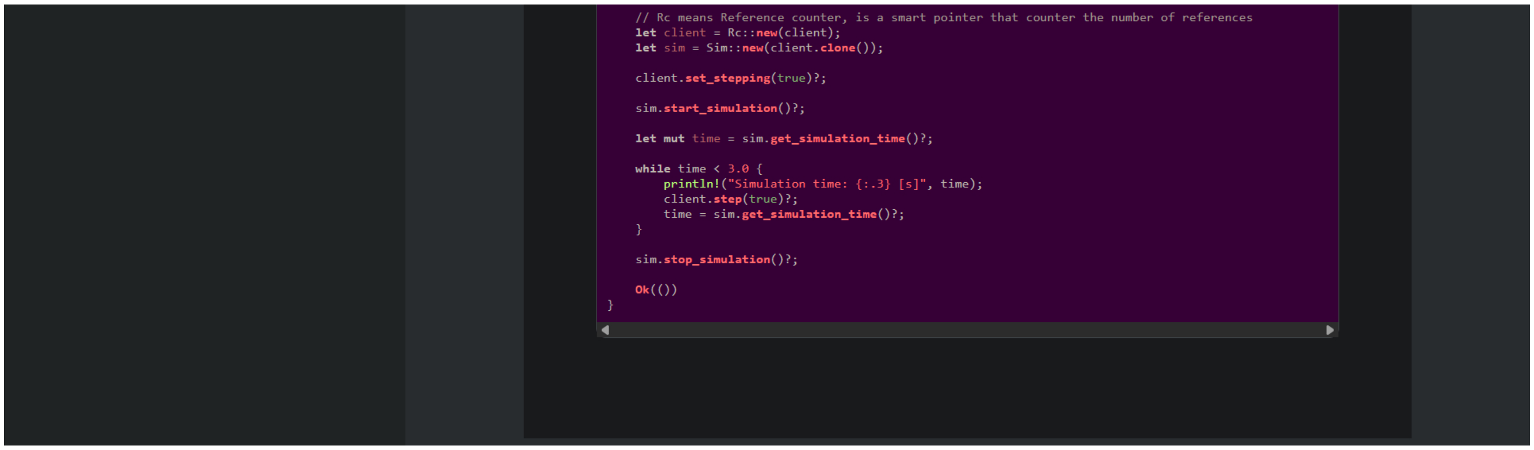
The Rust ZeroMQ remote API is courtesy of Samuel Cavalcanti. Following is a very simple example ZeroMQ remote API client code, which starts then runs a stepping simulation for 3 seconds:

```
use std::rc::Rc;
use zmq_remote_api::{sim::Sim, RemoteAPIError, RemoteApiClientParams};

/*
    Example based on Example.cpp
*/

fn main() -> Result<(), RemoteAPIError> {
    // use the env variable RUST_LOG="trace" or RUST_LOG="debug" to observe the zmq communication
    env_logger::init();

    let client = zmq_remote_api::RemoteApiClient::new(RemoteApiClientParams {
        host: "localhost".to_string(),
        ..RemoteApiClientParams::default()
    })?;
```



```rust
    // Rc means Reference counter, is a smart pointer that counter the number of references
    let client = Rc::new(client);
    let sim = Sim::new(client.clone());

    client.set_stepping(true)?;

    sim.start_simulation()?;

    let mut time = sim.get_simulation_time()?;

    while time < 3.0 {
        println!("Simulation time: {:.3} [s]", time);
        client.step(true)?;
        time = sim.get_simulation_time()?;
    }

    sim.stop_simulation()?;

    Ok(())
}
```