Progetto di Simulazione di Sistemi

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A.1 Job

```
//
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//

#ifndef __QUEUEING_JOB_H
#define __QUEUEING_JOB_H

#include <vector>
#include "Job_m.h"

namespace queueing {

class JobList;

/**
 * We extend the generated Job_Base class with support for split-join, as well
 * as the ability to enumerate all jobs in the system.
 *
 * To support split-join, Jobs manage parent-child relationships. A
 * relationship is created with the makeChildOf() or addChild() methods,
 * and lives until the parent or the child Job is destroyed.
 * It can be queried with the getParent() and getNumChildren()/getChild(k)
 * methods.
 *
 * To support enumerating all jobs in the system, each Job automatically
 * registers itself in a JobList module, if one exist in the model.
 * (If there's no JobList module, no registration takes place.) If there
 * are more than one JobList modules, the first one is chosen.
 * JobList can also be explicitly specified in the Job constructor.
 * The default JobList can be obtained with the JobList::getDefaultInstance()
 * method. Then one can query JobList for the set of Jobs currently present.
 */
class QUEUEING_API Job: public Job_Base
{
    friend class JobList;
    protected:
        Job *parent;
        std::vector<Job*> children;
        JobList *jobList;
        virtual void setParent(Job *parent); // only for addChild()
        virtual void parentDeleted();
        virtual void childDeleted(Job *child);
        // progettoss
        simtime_t absoluteDeadline;
    public:
        /**
         * Creates a job with the given name, message kind, and jobList. If
         * jobList==nullptr, the default one (or none if none exist) will be chosen.
         */
        Job(const char *name=nullptr, int kind=0, JobList *table=nullptr);
```

```
        /** Copy constructor */
        Job(const Job& job);

        /** Destructor */
        virtual ~Job();

        /** Duplicates this job */
        virtual Job *dup() const override {return new Job(*this);}

        /** Assignment operator. Does not affect parent, children and jobList. */
        Job& operator=(const Job& job);

        /** @name Parent-child relationships */
        //@{
        /** Returns the parent job. Returns nullptr if there's no parent or it no longer
            exists. */
        virtual Job *getParent();

        /** Returns the number of children. Deleted children are automatically removed
           from this list. */
        virtual int getNumChildren() const;

        /** Returns the kth child. Throws an error if index is out of range. */
        virtual Job *getChild(int k);

        /** Marks the given job as the child of this one. */
        void addChild(Job *child);

        /** Same as addChild(), but has to be invoked on the child job */
        virtual void makeChildOf(Job *parent);
        //@}

        /** Returns the JobList where this job has been registered. */
        JobList *getContainingJobList() {return jobList;}

        // progettoss
        void setAbsoluteDeadline(simtime_t absoluteDeadline);

};

}; // namespace

#endif
```

Listing 1: "Job.h"

```
//
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//
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// 'license' for details on this and other legal matters.
//

#include <algorithm>
#include "Job.h"
#include "JobList.h"
```

```
namespace queueing {

Job::Job(const char *name, int kind, JobList *jobList) : Job_Base(name, kind)
{
    parent = nullptr;
    if (jobList == nullptr && JobList::getDefaultInstance() != nullptr)
        jobList = JobList::getDefaultInstance();
    this->jobList = jobList;
    if (jobList != nullptr)
        jobList->registerJob(this);
}

Job::Job(const Job& job)
{
    setName(job.getName());
    operator=(job);
    parent = nullptr;
    jobList = job.jobList;
    if (jobList != nullptr)
        jobList->registerJob(this);
}

Job::~Job()
{
    if (parent)
        parent->childDeleted(this);
    for (int i = 0; i < (int)children.size(); i++)
        children[i]->parentDeleted();
    if (jobList != nullptr)
        jobList->deregisterJob(this);
}

Job& Job::operator=(const Job& job)
{
    if (this == &job)
        return *this;
    Job_Base::operator=(job);
    // leave parent and jobList untouched
    return *this;
}

Job *Job::getParent()
{
    return parent;
}

void Job::setParent(Job *parent)
{
    this->parent = parent;
}

int Job::getNumChildren() const
{
    return children.size();
}

Job *Job::getChild(int k)
{
```

```
    if (k < 0 || k >= (int)children.size())
        throw cRuntimeError(this, "child index %d out of bounds", k);
    return children[k];
}

void Job::makeChildOf(Job *parent)
{
    parent->addChild(this);
}

void Job::addChild(Job *child)
{
    child->setParent(this);
    ASSERT(std::find(children.begin(), children.end(), child) == children.end());
    children.push_back(child);
}

void Job::parentDeleted()
{
    parent = nullptr;
}

void Job::childDeleted(Job *child)
{
    std::vector<Job *>::iterator it = std::find(children.begin(), children.end(), child)
        ;
    ASSERT(it != children.end());
    children.erase(it);
}

void Job::setAbsoluteDeadline(simtime_t absoluteDeadline)
{
    this->absoluteDeadline = absoluteDeadline;
}

}; // namespace
```

Listing 2: "Job.cc"

A.2 Source

```
//
// This file is part of an OMNeT++/OMNEST simulation example.
//
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// 'license' for details on this and other legal matters.
//

package org.omnetpp.queueing;

//
// A module that generates jobs. One can specify the number of jobs to be generated,
// the starting and ending time, and interval between generating jobs.
// Job generation stops when the number of jobs or the end time has been reached,
// whichever occurs first. The name, type and priority of jobs can be set as well.
// One can specify the job relative deadline.
```

```
//
simple Source
{
    parameters:
        @group(Queueing);
        @signal[created](type="long");
        @statistic[created](title="the number of jobs created";record=last;
            interpolationmode=none);
        @display("i=block/source");
        int numJobs = default(-1);                // number of jobs to be generated (-1
            means no limit)
        volatile double interArrivalTime @unit(s); // time between generated jobs
        string jobName = default("job");          // the base name of the generated job (
            will be the module name if left empty)
        volatile int jobType = default(0);        // the type attribute of the created
            job (used by classifers and other modules)
        volatile int jobPriority = default(0);    // priority of the job
        double startTime @unit(s) = default(interArrivalTime); // when the module sends
            out the first job
        double stopTime @unit(s) = default(-1s); // when the module stops the job
            generation (-1 means no limit)
        // progettoss
        double jobRelativeDeadline @unit(s) = default(0s);     // job relative deadline
    gates:
        output out;
}
```

Listing 3: "Source.ned"

```
//
// This file is part of an OMNeT++/OMNEST simulation example.
//
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// 'license' for details on this and other legal matters.
//

#ifndef __QUEUEING_SOURCE_H
#define __QUEUEING_SOURCE_H

#include "QueueingDefs.h"

namespace queueing {

class Job;

/**
 * Abstract base class for job generator modules
 */
class QUEUEING_API SourceBase : public cSimpleModule
{
    protected:
        int jobCounter;
        std::string jobName;
        simsignal_t createdSignal;
    protected:
        virtual void initialize() override;
        virtual Job *createJob();
```

```
        virtual void finish() override;
};


/**
 * Generates jobs; see NED file for more info.
 */
class QUEUEING_API Source : public SourceBase
{
    private:
        simtime_t startTime;
        simtime_t stopTime;
        int numJobs;

    protected:
        virtual void initialize() override;
        virtual void handleMessage(cMessage *msg) override;
};


/**
 * Generates jobs; see NED file for more info.
 */
class QUEUEING_API SourceOnce : public SourceBase
{
    protected:
        virtual void initialize() override;
        virtual void handleMessage(cMessage *msg) override;
};

}; //namespace

#endif
```

Listing 4: "Source.h"

```
//
// This file is part of an OMNeT++/OMNEST simulation example.
//
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//
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// 'license' for details on this and other legal matters.
//

#include "Source.h"
#include "Job.h"

namespace queueing {

void SourceBase::initialize()
{
    createdSignal = registerSignal("created");
    jobCounter = 0;
    WATCH(jobCounter);
    jobName = par("jobName").stringValue();
    if (jobName == "")
        jobName = getName();
}
```

```
Job *SourceBase::createJob()
{
    char buf[80];
    sprintf(buf, "%.60s-%d", jobName.c_str(), ++jobCounter);
    Job *job = new Job(buf);
    job->setKind(par("jobType"));
    job->setPriority(par("jobPriority"));
    job->setAbsoluteDeadline(simTime() + par("jobRelativeDeadline"));
    return job;
}

void SourceBase::finish()
{
    emit(createdSignal, jobCounter);
}

//---

Define_Module(Source);

void Source::initialize()
{
    SourceBase::initialize();
    startTime = par("startTime");
    stopTime = par("stopTime");
    numJobs = par("numJobs");

    // schedule the first message timer for start time
    scheduleAt(startTime, new cMessage("newJobTimer"));
}

void Source::handleMessage(cMessage *msg)
{
    ASSERT(msg->isSelfMessage());

    if ((numJobs < 0 || numJobs > jobCounter) && (stopTime < 0 || stopTime > simTime()))
        {
        // reschedule the timer for the next message
        scheduleAt(simTime() + par("interArrivalTime").doubleValue(), msg);

        Job *job = createJob();
        send(job, "out");
    }
    else {
        // finished
        delete msg;
    }
}

//---

Define_Module(SourceOnce);

void SourceOnce::initialize()
{
    SourceBase::initialize();
    simtime_t time = par("time");
    scheduleAt(time, new cMessage("newJobTimer"));
```

```
}

void SourceOnce::handleMessage(cMessage *msg)
{
    ASSERT(msg->isSelfMessage());
    delete msg;

    int n = par("numJobs");
    for (int i = 0; i < n; i++) {
        Job *job = createJob();
        send(job, "out");
    }
}

}; //namespace
```

Listing 5: "Source.cc"

A.3 Router

```
//
// This file is part of an OMNeT++/OMNEST simulation example.
//
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// 'license' for details on this and other legal matters.
//

package org.omnetpp.queueing;

//
// Sends the messages to different outputs depending on a set algorithm.
// Sends the messages to first queueNumber-th queues.
//
// @author rhornig, Samuele Evangelisti
// @todo minDelay not implemented
//
simple Router
{
    parameters:
        @group(Queueing);
        @display("i=block/routing");
        string routingAlgorithm @enum("random","roundRobin","shortestQueue","minDelay","
            pssRandom") = default("random");
        volatile int randomGateIndex = default(intuniform(0, sizeof(out)-1));     // the
            destination gate in case of random routing
        // progettoss
        int queueNumber = default(sizeof(out)-1);     // queue number limit
    gates:
        input in[];
        output out[];
}
```

Listing 6: "Router.ned"

```
//
// This file is part of an OMNeT++/OMNEST simulation example.
//
```

```
// Copyright (C) 2006-2015 OpenSim Ltd.
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// 'license' for details on this and other legal matters.
//

#ifndef _QUEUEING_ROUTER_H
#define _QUEUEING_ROUTER_H

#include "QueueingDefs.h"

namespace queueing {

// routing algorithms
enum {
      ALG_RANDOM,
      ALG_ROUND_ROBIN,
      ALG_MIN_QUEUE_LENGTH,
      ALG_MIN_DELAY,
      ALG_MIN_SERVICE_TIME,
      // progettoss
      ALG_PSSRANDOM
};

/**
 * Sends the messages to different outputs depending on a set algorithm.
 * Sends the messages to first queueNumber-th queues.
 */
class QUEUEING_API Router : public cSimpleModule
{
    private:
        int routingAlgorithm;  // the algorithm we are using for routing
        int rrCounter;         // msgCounter for round robin routing
        // progettoss
        int queueNumber;
    protected:
        virtual void initialize() override;
        virtual void handleMessage(cMessage *msg) override;
};

}; //namespace

#endif
```

Listing 7: "Router.h"

```
//
// This file is part of an OMNeT++/OMNEST simulation example.
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// 'license' for details on this and other legal matters.
//

#include "Router.h"

namespace queueing {
```

```
Define_Module(Router);

void Router::initialize()
{
    const char *algName = par("routingAlgorithm");
    if (strcmp(algName, "random") == 0) {
        routingAlgorithm = ALG_RANDOM;
    }
    else if (strcmp(algName, "roundRobin") == 0) {
        routingAlgorithm = ALG_ROUND_ROBIN;
    }
    else if (strcmp(algName, "minQueueLength") == 0) {
        routingAlgorithm = ALG_MIN_QUEUE_LENGTH;
    }
    else if (strcmp(algName, "minDelay") == 0) {
        routingAlgorithm = ALG_MIN_DELAY;
    }
    else if (strcmp(algName, "minServiceTime") == 0) {
        routingAlgorithm = ALG_MIN_SERVICE_TIME;
    }
    else if (strcmp(algName, "pssRandom") == 0) {
        routingAlgorithm = ALG_PSSRANDOM;
    }
    rrCounter = 0;
    int qn = par("queueNumber").intValue() - 1;
    if (qn < 0 || qn > gateSize("out") - 1)
        throw cRuntimeError("Invalid queue number");
    else
        queueNumber = qn;
}

void Router::handleMessage(cMessage *msg)
{
    int outGateIndex = -1;  // by default we drop the message

    switch (routingAlgorithm) {
        case ALG_RANDOM:
            outGateIndex = par("randomGateIndex");
            break;

        case ALG_ROUND_ROBIN:
            outGateIndex = rrCounter;
            rrCounter = (rrCounter + 1) % gateSize("out");
            break;

        case ALG_MIN_QUEUE_LENGTH:
            // TODO implementation missing
            outGateIndex = -1;
            break;

        case ALG_MIN_DELAY:
            // TODO implementation missing
            outGateIndex = -1;
            break;

        case ALG_MIN_SERVICE_TIME:
            // TODO implementation missing
            outGateIndex = -1;
            break;
```

```
        case ALG_PSSRANDOM:
            outGateIndex = intuniform(0, queueNumber);
            break;

        default:
            outGateIndex = -1;
            break;
    }

    // send out if the index is legal
    if (outGateIndex < 0 || outGateIndex >= gateSize("out"))
        throw cRuntimeError("Invalid output gate selected during routing");

    send(msg, "out", outGateIndex);
}

}; //namespace
```

Listing 8: "Router.cc"

A.4 Server e SelectionStrategies

```
//
// This file is part of an OMNeT++/OMNEST simulation example.
//
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// 'license' for details on this and other legal matters.
//

package org.omnetpp.queueing;

//
// Queue server. It serves multiple input queues (PassiveQueue), using a preset
// algorithm. Inputs must be connected to Passive Queues (PassiveQueue)
//
simple Server
{
    parameters:
        @group(Queueing);
        @display("i=block/server");
        @signal[busy](type="bool");
        @statistic[busy](title="server busy state";record=vector?,timeavg;
            interpolationmode=sample-hold);

        string fetchingAlgorithm @enum("priority","random","roundRobin","longestQueue","
            exhaustiveService") = default("priority");
              // how the next job will be choosen from the attached queues
        volatile double serviceTime @unit(s); // service time of a job
    gates:
        input in[];
        output out;
}
```

Listing 9: "Server.ned"

```
//
// This file is part of an OMNeT++/OMNEST simulation example.
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//

#ifndef __QUEUEING_SELECTIONSTRATEGIES_H
#define __QUEUEING_SELECTIONSTRATEGIES_H

#include "QueueingDefs.h"

namespace queueing {

/**
 * Selection strategies used in queue, server and router classes to decide
 * which module to choose for further interaction.
 */
class QUEUEING_API SelectionStrategy : public cObject
{
    protected:
        bool isInputGate;
        int gateSize;         // the size of the gate vector
        cModule *hostModule; // the module using the strategy
    public:
        // on which module's gates should be used for selection
        // if selectOnInGate is true, then we will use "in" gate otherwise "out" is used
        SelectionStrategy(cSimpleModule *module, bool selectOnInGate);
        virtual ~SelectionStrategy();

        static SelectionStrategy * create(const char *algName, cSimpleModule *module,
            bool selectOnInGate);

        // which gate index the selection strategy selected
        virtual int select() = 0;
        // returns the i-th module's gate which connects to our host module
        cGate *selectableGate(int i);
    protected:
        // is this module selectable according to the policy? (queue is selectable if
            not empty, server is selectable if idle)
        virtual bool isSelectable(cModule *module);
};

/**
 * Priority based selection. The first selectable index will be returned.
 */
class QUEUEING_API PrioritySelectionStrategy : public SelectionStrategy
{
    public:
        PrioritySelectionStrategy(cSimpleModule *module, bool selectOnInGate);
        virtual int select() override;
};

/**
 * Random selection from the selectable modules, with uniform distribution.
 */
```

```
class QUEUEING_API RandomSelectionStrategy : public SelectionStrategy
{
    public:
        RandomSelectionStrategy(cSimpleModule *module, bool selectOnInGate);
        virtual int select() override;
};

/**
 * Uses Round Robin selection, but skips any module that is not available currently.
 */
class QUEUEING_API RoundRobinSelectionStrategy : public SelectionStrategy
{
    protected:
        int lastIndex; // the index of the module last time used
    public:
        RoundRobinSelectionStrategy(cSimpleModule *module, bool selectOnInGate);
        virtual int select() override;
};

/**
 * Chooses the shortest queue. If there are more than one
 * with the same length, it chooses by priority among them.
 * This strategy is for output only (i.e. for router module).
 */
class QUEUEING_API ShortestQueueSelectionStrategy : public SelectionStrategy
{
    public:
        ShortestQueueSelectionStrategy(cSimpleModule *module, bool selectOnInGate);
        virtual int select() override;
};

/**
 * Chooses the longest queue (where length>0 of course).
 * Input strategy (for servers).
 */
class QUEUEING_API LongestQueueSelectionStrategy : public SelectionStrategy
{
    public:
        LongestQueueSelectionStrategy(cSimpleModule *module, bool selectOnInGate);
        virtual int select() override;
};

// progettoss
/**
 * End all the tasks in a queue, then chooses cyclically the next one.
 * Input strategy (for servers).
 */
class QUEUEING_API ExhaustiveServiceSelectionStrategy : public SelectionStrategy
{
    private:
        int actualInputGate;    // actual input gate
    public:
        ExhaustiveServiceSelectionStrategy(cSimpleModule *module, bool selectOnInGate);
        virtual int select() override;
};

}; //namespace

#endif
```

Listing 10: "SelectionStrategies.h"

```
//
// This file is part of an OMNeT++/OMNEST simulation example.
//
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// 'license' for details on this and other legal matters.
//

#include "SelectionStrategies.h"
#include "PassiveQueue.h"
#include "Server.h"

namespace queueing {

SelectionStrategy::SelectionStrategy(cSimpleModule *module, bool selectOnInGate)
{
    hostModule = module;
    isInputGate = selectOnInGate;
    gateSize = isInputGate ? hostModule->gateSize("in") : hostModule->gateSize("out");
}

SelectionStrategy::~SelectionStrategy()
{
}

SelectionStrategy *SelectionStrategy::create(const char *algName, cSimpleModule *module,
    bool selectOnInGate)
{
    SelectionStrategy *strategy = nullptr;

    if (strcmp(algName, "priority") == 0) {
        strategy = new PrioritySelectionStrategy(module, selectOnInGate);
    }
    else if (strcmp(algName, "random") == 0) {
        strategy = new RandomSelectionStrategy(module, selectOnInGate);
    }
    else if (strcmp(algName, "roundRobin") == 0) {
        strategy = new RoundRobinSelectionStrategy(module, selectOnInGate);
    }
    else if (strcmp(algName, "shortestQueue") == 0) {
        strategy = new ShortestQueueSelectionStrategy(module, selectOnInGate);
    }
    else if (strcmp(algName, "longestQueue") == 0) {
        strategy = new LongestQueueSelectionStrategy(module, selectOnInGate);
    }
    else if (strcmp(algName, "exhaustiveService") == 0) {
        strategy = new ExhaustiveServiceSelectionStrategy(module, selectOnInGate);
    }

    return strategy;
}

cGate *SelectionStrategy::selectableGate(int i)
{
    if (isInputGate)
```

```
        return hostModule->gate("in", i)->getPreviousGate();
    else
        return hostModule->gate("out", i)->getNextGate();
}

bool SelectionStrategy::isSelectable(cModule *module)
{
    if (isInputGate) {
        IPassiveQueue *pqueue = dynamic_cast<IPassiveQueue *>(module);
        if (pqueue != nullptr)
            return pqueue->length() > 0;
    }
    else {
        IServer *server = dynamic_cast<IServer *>(module);
        if (server != nullptr)
            return server->isIdle();
    }

    throw cRuntimeError("Only IPassiveQueue (as input) and IServer (as output) is
        supported by this Strategy");
}

//
    ---------------------------------------------------------------------------


PrioritySelectionStrategy::PrioritySelectionStrategy(cSimpleModule *module, bool
    selectOnInGate) :
    SelectionStrategy(module, selectOnInGate)
{
}

int PrioritySelectionStrategy::select()
{
    // return the smallest selectable index
    for (int i = 0; i < gateSize; i++)
        if (isSelectable(selectableGate(i)->getOwnerModule()))
            return i;

    // if none of them is selectable return an invalid no.
    return -1;
}

//
    ---------------------------------------------------------------------------


RandomSelectionStrategy::RandomSelectionStrategy(cSimpleModule *module, bool
    selectOnInGate) :
    SelectionStrategy(module, selectOnInGate)
{
}

int RandomSelectionStrategy::select()
{
    // return the smallest selectable index
    int noOfSelectables = 0;
    for (int i = 0; i < gateSize; i++)
        if (isSelectable(selectableGate(i)->getOwnerModule()))
```

```
            noOfSelectables++;

    int rnd = hostModule->intuniform(1, noOfSelectables);

    for (int i = 0; i < gateSize; i++)
        if (isSelectable(selectableGate(i)->getOwnerModule()) && (--rnd == 0))
            return i;

    return -1;
}

//
    ----------------------------------------------------------------------------


RoundRobinSelectionStrategy::RoundRobinSelectionStrategy(cSimpleModule *module, bool
    selectOnInGate) :
    SelectionStrategy(module, selectOnInGate)
{
    lastIndex = -1;
}

int RoundRobinSelectionStrategy::select()
{
    // return the smallest selectable index
    for (int i = 0; i < gateSize; ++i) {
        lastIndex = (lastIndex+1) % gateSize;
        if (isSelectable(selectableGate(lastIndex)->getOwnerModule()))
            return lastIndex;
    }

    // if none of them is selectable return an invalid no.
    return -1;
}

//
    ----------------------------------------------------------------------------


ShortestQueueSelectionStrategy::ShortestQueueSelectionStrategy(cSimpleModule *module,
    bool selectOnInGate) :
    SelectionStrategy(module, selectOnInGate)
{
}

int ShortestQueueSelectionStrategy::select()
{
    // return the smallest selectable index
    int result = -1;  // by default none of them is selectable
    int sizeMin = INT_MAX;
    for (int i = 0; i < gateSize; ++i) {
        cModule *module = selectableGate(i)->getOwnerModule();
        int length = (check_and_cast<IPassiveQueue *>(module))->length();
        if (isSelectable(module) && (length < sizeMin)) {
            sizeMin = length;
            result = i;
        }
    }
    return result;
```

```
}

//
-------------------------------------------------------------------------------


LongestQueueSelectionStrategy::LongestQueueSelectionStrategy(cSimpleModule *module, bool
    selectOnInGate) :
    SelectionStrategy(module, selectOnInGate)
{
}

int LongestQueueSelectionStrategy::select()
{
    // return the longest selectable queue
    int result = -1;  // by default none of them is selectable
    int sizeMax = -1;
    for (int i = 0; i < gateSize; ++i) {
        cModule *module = selectableGate(i)->getOwnerModule();
        int length = (check_and_cast<IPassiveQueue *>(module))->length();
        if (isSelectable(module) && length > sizeMax) {
            sizeMax = length;
            result = i;
        }
    }
    return result;
}

//
-------------------------------------------------------------------------------


ExhaustiveServiceSelectionStrategy::ExhaustiveServiceSelectionStrategy(cSimpleModule *
    module, bool selectOnInGate) :
    SelectionStrategy(module, selectOnInGate)
{
    actualInputGate = 0;
}

int ExhaustiveServiceSelectionStrategy::select()
{
    // previously selected queue is not empty
    if (isSelectable(selectableGate(actualInputGate)->getOwnerModule()))
        return actualInputGate;
    // scan cyclically the next non empty queue
    else {
        for (int i = 1; i < gateSize; i++) {
            int gn = (actualInputGate + i) % gateSize;
            if (isSelectable(selectableGate(gn)->getOwnerModule())) {
                actualInputGate = gn;
                return gn;
            }
        }
    }

    // if none of them is selectable return an invalid no.
    return -1;
}
```

```
}; //namespace
```

Listing 11: "SelectionStrategies.cc"