SAFE: Simulation Automation Framework for Experiments

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Related Work

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Architecture

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Timeline

• First year: major push on XML languages, execution manager and architecture of data collection framework.

• Second year: major push on public release of data collection framework, implementation of web based interfaces, and implementation of steady-state and run length detection.
Experiment Description Language

- **Big picture:** An XML-based language used to define a set of factors and their associated possible levels as lists. These data are used by the framework to construct the experiment design space.

- Provides (so far) two special ways to “prune” uninteresting/irrelevant design points.
Specifying lists of levels

- A “member-of” element defines an external list and specifies that a certain factor must take on values only from that list.
- A “sequence” element defines a mathematical expression used to create a sequence of level values for a certain factor.
Example: The **member-of** element

```xml
<member-of>
  <factor>DATARATE</factor>
  <listid>dataRateValues</listid>
</member-of>

<member-of>
  <factor>PACKETSIZE</factor>
  <listid>externalFile.xml</listid>
</member-of>
```
Example: The **sequence** element

```
<sequence>
    <factor>DATARATE</factor>
    <test>EQUALS</test>
    <lconst>3000000</lconst>
    <op>MULT</op>
    <rvar>i</rvar>
    <where>
        <range var="i" lo="0" hi="10" delta="1"/>
    </where>
</sequence>
```
Pruning design points

- A “linking-restriction” element specifies the factors whose level values must appear in a one-to-one correspondence (e.g., as consecutive pairs).
- An “exclusion-restriction” element specifies complete or partial design points which should not be part of the design space.
Pruning with linking- and exclusion-restriction

```xml
<linking-restriction>
  <factor>ONTIME</factor>
  <factor>OFFTIME</factor>
</linking-restriction>

<exclusion-restriction>
  <setting factor="ONTIME" level="0.0"/>
</exclusion-restriction>
```
Data Flow

- All *experiment description* documents are validated against a general XML Schema.
- We follow a modular design which specifies APIs between separate tools for validation, parsing, design point generation. This will enable flexibility for further improvements.
- Experiment description documents are parsed by a module which passes to a design point generator the mapping of factors to lists of levels. The design points are used by an *experiment execution manager*. 
Experiment Validation

![Image of validation output]

```
INFO: Found factor 'ONTIME'
INFO: Found factor 'OFFTIME'
INFO: Found factor 'DATARATE'
INFO: Found factor 'PACKETSIZE'
INFO: Validating <memberof> element where...
INFO: <factor> = ONTIME
INFO: <listid> = valueList.xml
INFO: <listid> matches an internal <levellist> 'id' attribute: True
INFO: <listid> matches external filename: False
INFO: Validating <memberof> element where...
INFO: <factor> = OFFTIME
INFO: <listid> = internalList
INFO: <listid> matches an internal <levellist> 'id' attribute: True
INFO: <listid> matches external filename: False
ERROR: Factor 'NOTAFACTOR' in <memberof> element does not appear in the <factorlist>.
INFO: Validating <memberof> element where...
INFO: <factor> = DATARATE
INFO: <listid> = anotherlist
INFO: <listid> matches an internal <levellist> 'id' attribute: False
INFO: <listid> matches external filename: False
CRITICAL: list identifier 'anotherlist' does not match the 'id' attribute of any any internal <levellist> element, nor does it match an external filename in this directory.
INFO: Validating <memberof> element where...
INFO: <factor> = PACKETSIZE
INFO: <listid> = internalList
INFO: <listid> matches an internal <levellist> 'id' attribute: True
INFO: <listid> matches external filename: False
INFO: Validating <sequence> element where...
INFO: <factor> = OFFTIME
INFO: <test> = EUQasdFALS
CRITICAL: Sequence test 'EUQasdFALS' is not a valid test. Must one of ['EQUALS', 'LT', 'GT']
```
Experiment Execution Manager

Client/Server structure written in Python, based on the Twisted network programming framework.

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Experiment Execution Manager

• The server processes experiment descriptions and generate design points, which are dispatched to clients.

• Clients run ns-3 simulations for design points, which use a **data collection framework** to generate samples of metrics. Results are sent to external processes for steady-state and run length detection, then back to server for storage in SQL database.

• API for accessing the results is in the works.
Simulation Client

- Requests a design point to run from the EEM.
- Executes the simulator with that design point.
- Listens for samples from the simulator via a pipe.
- Reports samples to the EEM.
- Listens for further instructions from the EEM to decide when to terminate the simulator (via a signal).
Data Collection Framework

Goals:

• Record ‘samples’ of variables (attributes and non-attributes) every time there’s a change in their value.

• Tag data with timestamp and an identifier of the source (context).

• Compute basic statistics on samples.
New Classes Defined

- **DataCollection**: Base class for all elements of the data collection framework.
- **Probe**: Mechanism for detecting changes to a variable.
- **Collector**: Contains and processes samples generated by a probe.
- **Aggregator**: Sends samples to chosen output according to a pre-defined format.
Data Collection Framework Classes

DataCollection

- Probe
  - Probelnt
  - ProbeDouble
- Collector
  - CollectorSample
- Aggregator
  - AggregatorSQLite
  - AggregatorFile
  - AggregatorSafe
  - AggregatorFileTab
  - AggregatorFileCSV
  - CollectorHistogram

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DataCollection

class DataCollection : public Object {

public:

    static TypeId GetTypeId ();
    DataCollection ();
    virtual ~DataCollection ();
    virtual bool GetStatus () const;
    virtual void SetStatus (bool s);

private:

    bool m_enabled;
    typedef std::map<std::string, Ptr<DataCollection>> DataCollectionMap;
    DataCollectionMap m_inputs;
    DataCollectionMap m_outputs;
Usage Example

ns-3 simulation script

probe  collector  aggregator

Simulation Client

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Context / Identification

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Points to Notice

• ns-3 defines the TracedValue template class - when a variable changes, a pre-determined function is called. Some ns-3 classes use TracedValue to define trace sources, which can be connected to trace sinks via Config::Connect (one identifies the source using a path to the right object and the callback to serve as sink).

• The value monitored by a probe is not an attribute; it can be “just a variable” in the scope of some method (main use case).
Control Requirements

**Global disable**: No samples; negligible run time cost.

**Global enable**: All probes report samples during a window of simulation time specified by a start and an end value. Outside this window, no samples are reported.

**Local enable**: Only individually selected probes report samples during a window of simulation time.
Data Type Requirements

• **Integer:** A standard integer data type (64 bit?)
• **Double:** A standard double data type.

• **Scalar:** The probe generates scalar data types.
• **Non-scalar:** The probe generates a data type that can be seen as a collection of scalar values (e.g. a vector of values).
Milestones

- April: data collection framework, execution manager, and language tools out for review.
- May/June: development of interface components, analysis and graphing tools, modules for steady-state and run length detection.
Project Web Resources

- Current project site:
  http://redmine.eg.bucknell.edu/perrone/projects/framework

- Upcoming revamped project site (summer 2011):
  http://redmine.eg.bucknell.edu/safe

- Data Collection Framework code review (under refactoring):
  http://github.com/lfperrone
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