Lua as a script language for industrial process design and optimization with energy integration

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Agenda

• Background history
  – Previous work in Energy Integration and Optimisation

• Context of the work
  – Industrial project
  – Towards holistic “Simulation – Analysis – Optimisation” of Industrial Processes

• Taking advantage of Lua language

• Sharing and collaborating with the community of Lua

• Closing remarks
Background History

• Previous work in “Osmose”

• Transferring from Matlab to Lua
  – Performance problems
  – License problems: public distribution
    • Industries, academic institutions, research collaborations
Background work (1) - Issues

• Industrial process/es or plant
  – Energy efficiency ?
    • Heat recovery
    • Waste valorization
      – Use of waste heat for district heating ?
**Background work (2) - Context**

- Rational use and conversion of energy in industrial energy systems
  - Need for a systematic framework
    - Thermo-environomic optimisation methodology
    - **Systematic approach** to design complex integrated energy conversion systems
      - Computer-aided tool for process integration & optimization
Background work (3) - Methodology

- Osmose (Matlab) - Platform for studying energy conversion systems

\[
\begin{align*}
\min f_{\text{obj}}(x,z) \\
h(x,z) = 0 \\
g(x,z) \leq 0
\end{align*}
\]

Obj1

\[x_i^L \leq x_i \leq x_i^U\]

Obj2

Pareto set

Global problem

Multi-objective optimisation

Physical model

- Model preprocessing
- Model (external software)
- Model post-processing

Energy integration model
(MILP resolution)

Economic model
& LCA model
Background work (4) - Transition

• Re-implementation in Lua
  – Another presentation in Lua Workshop 2014 with more detail

• Extension to additional dimension: Holistic approach including GIS functions, Environmental Impact Analysis, Database functions
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New horizon: current and future work

• Adding more dimensions
  – Capable of covering generic issues in industrial processes (by and large)
  – Supply Chain
  – Geographical notations
  – LCI (Lifecycle Inventory) & LCIA (Lifecycle Impact Analysis) with the new version of Ecoinvent3 databases
**Context of the project**

- PFE3 – Partly funded by the program SEED 2012 from the French National Agency for Research ANR in the frame of the Plate-Form(E)3 project
  - Industrial Project, consortium composed of several French industries and academic institutions
  - Outcome – A tool for Energy Integration and Optimization for generic simulation of industrial use cases
    - Components for Energy System Modeling
    - Focused on territorial use
    - Manufacturing factories
    - Graphic User Interface running with Model libraries
Context of the Work – The role of Osmose-Lua

- Backend system for Simulation – Analysis – Optimisation
- User Frontend in C++ or Java, GIS tools

Data transfer from User commands using XML

Library of Energy Technology Generic Models – Natural Gas Boiler, Biomethanation, Car, Waste Water treatment, Electricity Grid

Customer Data

PFE3 GUI

OLGate

Instantiate

Tag values

get

run

analyse

optimise

Working Output

Runtime output data

OL.Environnement

Description
Input: Tag/Value
Model Elements
Output

Model making

OL.Observer: Pre & Post-run processing(*)

Model execution (simulation)

Analyse of sensitivity (*)

Multi-Objective Optimisation (*)

(*') External API integration

Figure. OsmoseLua Global architecture

(*) External API integration

Figure. OsmoseLua Global architecture

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Lua Workshop – Moscow, September 2014
Osmose-Lua extended architecture

Osmose-Lua Energy Technology Models and Integrated Optimization

LuaSQL (SQLite3)

Variables, Model Parameters, Simulation Results, Optimisation Report

Generic Model: Utilities (Electricity, Gas, Biomass) Industrial Processes (Elec. generation, Heat transfer), Transportations

Corresponding LCI (CO2 Emission, Other elements)

Geographic location (Longitude, Latitude) from GIS ‘Shapefile’

LCIA Metadata for Impact Analysis (Different analysis methods)
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Taking advantage of Lua...

• Adding new sub-systems, such as GIS data handler, LCI dataset integration and LCIA meta tables, to the existing Osmose-Lua
  – Such an API extension: Not always straight forward

• Which happens in general : Existing system was not designed to be extended in an unknown direction
Lua ?! – Object orientation without ‘Class’

• With the help of flexibility in terms of structuring SW architecture
  – Allow us some relaxed ways of restructuring own Object-Oriented Architecture
Lua ?!: Table management flexibility

• The target system – characteristics
  – Must to handle many different types of data (model parameters and simulation variable) and attributes in a flexible way
  – Without using a particular spreadsheet or RDBMS
  – Already Lua allows to model database accessing in a friendly manner
Substantial difficulties

• Lua: language not very well known and not penetrated into our research society
  – Finding students and assistant in development
  – Promoting the project outcome

• Technical difficulties
  – Exploiting the resulting API on different machines / several types of OS
  – Not always successful in providing a set of generally installable & Executable API
What we are doing in parallel

• New course in Doctoral Student Programs
  – Specialized Field : “Energy”
  – Learning Lua and Osmose-Lua,
  – October..November, 2weeks intensive, 4 ETCS

• Technical support to Swiss and French industries
  – Promoting the approach
Sharing and Communicating with the Community of Lua

- Result sharing
- Academic staffs/students exchange
- Creating other industrial projects
Closing remarks

• We are happy to join the Lua community!