WP1 @ M20
Progresses and Plan

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Outline

WP1 at a glance – from the DoW

Task T1.1 (M1-M24) – Component and interaction model

- Computational model for eco-laws and interaction of components
- A blueprint for design of infrastructure

Task T1.2 (M1-M24) – Semantic Representation

- LSA model, and connection with work on semantic reasoning
- Implication to simulation and verification of properties

Task T1.3 (M13-M36) – Methodology

- Complete methodology for SAPERE (guidelines, manuals, tools)
- Simulation and analysis tools for “what if” analysis

Activities carried on Y2

Task T1.1 (M1-M24, 8.5 PM left) – Component and interaction model

- Polished abstract/operational model, eco-law set
- Development of Alchemist (cross-cutting T1.1 and T1.3)

Task T1.2 (M1-M24, 14 PM left) – Semantic Representation

- Developing a prototype LSA-space with built-in semantic representation
- New formulation of "semantic" (Web tech-based) LSAs and eco-laws

Task T1.3 (M13-M36, 24 PM left) – Methodology

- Analysis: Alchemist + Survey on analysis + Early stabilisation results
- Methodology: Survey and initial framing of SAPERE methodology

Deliverables in this period

D1.2 (M20) – Complete operational model

- Completion of operational model
- Extended LSA framework

D1.3 (M24) – Final operational and semantic model

- Final revision of abstract computational model
- Final revision of live semantic annotation framework

D1.4 (M24) – Early report on methodology

- Early analysis of methodological guidelines
- Early analysis of solutions for analysis tools

UNIBO papers in Y2

WP1-related

- Submission at JOS journal (Alchemist, T1.3)
- Submission at WOA 2012 (Approximate Model-checking, T1.3)
- Submission at MONET journal 2012 (SOS Patterns in WP1, T1.1/WP2)
- In press at an IGI-Global book on WS (Web-tech, T1.2)
- Published ACM SAC 2012 [3] (WP1 model and crowd steering, T1.1)
- Published COORDINATION 2012 [2] (Spatial structures, WP1/WP4)
- Published SCW 2012 [4] (WP1 model and spatial structures, T1.1/WP2)

Mostly about other WPs

- In press at SCP journal (self-composition, WP2)
- Submission at SASO 2012 (Anticipative gradient, WP1/WP2/WP3)
- Submission at WOA 2012 (Self-composition, WP2)

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2 Complete Operational Model
- 2.1 Abstract Model
- 2.2 Operational Model
- 2.3 Eco-law set

3 Semantic Framework
- 3.1 LSAs and eco-laws
- 3.2 Translation into RDF/SPARQL

4 Analysis and Prediction
- 4.1 Survey of techniques
- 4.2 On stabilisation of LSA fields
- 4.3 Alchemist simulator

2.1 Abstract Model

A calculus of reaction/diffusion structured rewrites

- Much simpler then previous one in D1.1
- We enabled broadcasts, and focus on reaction/diffusion
- Neglecting at this level many details: structure of LSAs and eco-law

Operational semantics

$$\frac{\theta E = (F_l \overset{r}{\mapsto} F_r) \quad F_l \triangleright S_0 = S_0}{C|E|[S_0 \otimes S]_\sigma \xrightarrow{r} C|E|[(F_r \triangleright S_0) \otimes S]_\sigma} \quad \text{[REA]}$$

$$\frac{(\sigma \rightsquigarrow \overline{\sigma}) \in C \qquad loc(L) = \sigma_i}{C|[L \otimes S]_\sigma|[S']_{\sigma_i} \rightarrow C|[S]_\sigma|[L \otimes S']_{\sigma_i}} \quad \text{[DIFF]}$$

$$\frac{(\sigma \rightsquigarrow \overline{\sigma}) \in C \qquad loc(L) = *}{C|[L \otimes S]_\sigma|\prod_{\sigma_i}[S_i]_{\sigma_i} \rightarrow C|[S]_\sigma|\prod_{\sigma_i}[L@\sigma_i \otimes S_i]_{\sigma_i}} \quad \text{[BRO]}$$

2.2 Operational Model

A fully executable incarnation with handy syntax

- LSAs as multi-valued set of properties
- LSA pattern as a minimal pre/post condition on LSAs
- LSA patterns are LSA with variables and +,-,= polarity symbols

Example eco-law (aggregation)

$$A\langle \mathtt{src} = S; \mathtt{val} = V\rangle + B\langle \mathtt{src} = S; \mathtt{val} = W\rangle$$
$$\mapsto$$
$$A\langle \mathtt{src} = S; \mathtt{val} = \mathtt{aggr}_A(V, W)\rangle$$

Example eco-law (bond "*")

$$A\langle P = D[Q\ \mathtt{"*"}]\rangle + B^{matches(B,D)}\langle\rangle$$
$$\mapsto$$
$$A\langle \mathtt{bond}\ \ + B\rangle + B\langle\rangle$$

2.3 Eco-law set

Discussing the whole eco-law set stuff

- General motivations
- Decision about a subset of eco-laws
- Implementation in the executable model
- Discussion on expressiveness and examples

This part might deserve a better treatment

- Either quickly draft for M20
- Skip at M20 and discuss in M24, as a result of WP4 outcomes

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3.1 LSAs and eco-laws

This is whole about T1.3 – Semantic Representation

- Identifying a LSA/eco-law language based on RDF and SPARQL
- It is key to develop a true semantic framework (by M24!)
- Core ideas at M20: N3 notation and SPARQL-oriented eco-laws

Example LSA

```
:grad-123 :src :source-1230;
          :poi-desc [...];
          :type :grad;
          :val [:dist "0";
                :diff "true"];
          :diff "one-step-inc";
          :aggr "min-dist";
          :decp "creation-time";
          :decf "standard-delay" .
```

Example eco-law

```
?A :src ?S; :val ?V; :aggr ?F +
?B :src ?S; :val ?W
--->
?A :val ?X
BIND (:exec(?F,?V,?W) AS ?X)
```

3.2 Translation to RDF/SPARQL

LSA translation to RDF

- Naive, for the LSA in that form is already RDF
- Note sub-descriptions are handled through *bnodes*

Eco-law translation to SPARQL

- More involved in the part that needs to handle trees recursively
- Simpler for we here plan to have no variables over lists

Example eco-law

```
?A :src ?S; :val ?V; :aggr ?F +
?B :src ?S; :val ?W
--->
?A :val ?X
BIND (:exec(?F,?V,?W) AS ?X)
```

SPARQL translation

```
SELECT DISTINCT * WHERE {
  ?A :src ?S; :val ?V; :aggr ?F .
  ?B :src ?S; :val ?W .
}
INSERT { ?A :val ?X .} WHERE {
  BIND (:exec(?F,?V,?W) AS ?X) .
}
```

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4 Analysis and Prediction

A setting for what-if analysis

- A set of eco-laws
- An hypothesis about how agents/people behave
- An hypothesis on the network topology (structure and changes)

General questions

- How the population of LSAs evolve? Is it bound? Does it stabilise?
- Will human be steered as expected?
- Will an agent receive the requested service promptly?
- Which (middleware) cost for guaranteeing a given level of QoS?

4.1 Survey of techniques

Simulation

- Pointwise – We developed ALCHEMIST (see TR.WP1.2012.3)
- Approximate MC – Planned incorporation in ALCHEMIST by M24
- With Optimisation – Planned incorporation in ALCHEMIST by M36

Exhaustive state-space exploration (Model-checking)

- Classical – Not very practical: only for systems with $\sim$ 20 variables
- Parameterised – Promising, but not in the short term
- Fluid flow analysis – Promising, perhaps even in the short term (Y3)

By-hand Proofs by ad-hoc techniques (see TR.WP1.2012.2)

- Identified a proof methodology for fields stabilisation/boundedness:

$\Rightarrow$ Based on a simple yet expressive reaction/diffusion system

$\Rightarrow$ Extensible to more expressive systems and for quantitative analysis

4.2 Stabilisation and Boundedness

System considered

- Any static topology
- Two eco-laws: $x + y \rightarrow \alpha(x, y) \qquad x \rightarrow x + \sigma(x)^{\rightsquigarrow}$
- A transient phase of any LSA injection by agents

Monotonic systems

- Take any partial order $\leq_D$ over LSA descriptions
- Set $\alpha(x, y) = max_{\leq_D}$, and $\sigma(x) \leq_D x$

Results

1. System evolution necessarily stabilises (to a state depending on σ)
2. If $\forall x_0$, $\sigma(\sigma(\ldots(\sigma(x_0))\ldots))$ is undefined, then there is boundedness
3. Stabil./bound. preserved even with proper juxtapositions of fields

4.2 Stabilisation and Boundedness

Proof details

- Basically proved by induction on the distance from an injected LSA
- Three stages, from simple topologies to the most general case
  - Directed chain → spanning tree → any graph

Application

To middle-level self-organisation patterns:

- Gossiping, up/down gradient, path, partition
- No support for congestion-sensitive steering yet [3]

Will be developed towards M24, and later on

- Dynamic topologies, ctx eco-law, mobile agents
- Possibly with external collaborations
- Need more carefully checking existing literature

4.3 Alchemist Simulation

Alchemist – A pillar of T1.3

- Already presented at Frankfurt
- There are new features and a release
- Will be extended by M24, in particular with...

Approximate Stochastic Model-Checking as in PRISM (see [1])

- Perform a partial exploration of the search-space by N simulations
- The result is searched with given approximation ϵ and confidence δ
- The idea comes from probability theory: just set $N \geq 4log(\frac{2}{\delta})/\epsilon^2$

$\Rightarrow$ E.g. $\epsilon = 10^{-2}$ and $\delta = 10^{-3}$ require $N \approx 130'000$ (also in parallel)

- Early results: can model-check (e.g. gradient) up to ≈ 200 nodes

Let's see what's new in Alchemist at this stage

Danilo's talk

Commented TOC

Comment on backup material (to be shrinked to fit 20 pages)

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Wrap up on D2.1 status – anything to move to M24?

Complete Operational Model (Almost ready)

- Decided polished version of abstract and operational model
- Formalisation of operational model almost done
- Discuss on eco-law set might be put in minimal version or skipped

Semantic Framework (Somewhat incomplete, though many PM are left)

- Admittedly sacrificed, for consortium decision and reviewers focus
- No semantic matching or precise connection with ontologies yet
- Translation to SPARQL has to be reworked (to deal with LSA-trees)
- We are developing a semantic LSA-space for future experiments

Analysis and Prediction (Fully ready)

- Ready to be ported in D1.2

Some decision to be taken

"Refinement" approach

- Go ahead and conclude all by June 30th (maybe keep fixing things later in July)
- And in M24 provide a refinement where needed (Final Model)

"Incremental" approach

- (Justified by extra-effort on prediction)
- Drop eco-law set and detailed SPARQL translation at M20
- Just provide them at M24, with better inter-team collaboration

Outline

On reviewers' comments: Issue 1

Issue 1: Prediction/control of complexity

- What happens when a system is left evolving?
- How to predict/control complex behaviours to avoid undesired effects
- Investing effort in modelling ecological behaviours (extinction..)
- Investing effort in prediction (analytical and by simulation)

Our work

- Alchemist + Approx MC + Stabilisation proofs are significant steps
- Ecological behaviours not done, perhaps part of T2.3 by M24?

On reviewers' comments: Issue 2

Issue 2: Usability of programming model

- How high is programming / testing effort?
- Is testing in a closed system possible?
- Impact of usability to wide-spread deployment of SAPERE concepts

A proposal for a reply at M24

⇒ Eco-law set & middleware guarantee robust self-org patterns

⇒ Developers have to focus on what to use, and hence on LSA structure

⇒ Give evidence by showing the code of interesting applications

⇒ Comparison with SOA (as Franco proposed)

Outline

Answering the prediction/control issue

M20

- Survey of techniques
- Alchemist first release
- Proof methodology for stabilisation

M24

- Alchemist full GUI support
- Alchemist support for approximate MC
- Providing extended results using the proof methodology

Y3

- Making alchemist a full-fledged environment
- Alchemist support for optimisation of system behaviour

Outline

What performance metrics have been identified?

"Qualitative performance"

- Is the proposed model (of eco-laws, LSAs, agents) good enough in expressing service ecosystems?

⇒ A gathering section written with all teams in D1.3 at M24?

Performance impact on other WPs

- Are there WP1 choices that negatively/positively impact performance of middleware/algorithms?

⇒ Not sure this is reasonable to discuss

Performance of WP1 analysis tools

⇒ Performance is key and has been considered since the beginning

⇒ We already have good results for Alchemist (to appear at M24)

⇒ Will have to be studied more comprehensively at M36

Outline

Key open issues

Some research tasks that need some stimulus

- Semantic representation
- Use of Alchemist by other teams
- Usability of programming model

References I

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