Composition of Web Services on Large Service Models

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Outline

Introduction

Service Model

Logic for Composition on Service Models

Experiments

- Large Service models
- Hierachical Service Models

Results and Future Work

Introduction

- Web services – software components, accessible over the web using the machine processable interface descriptions.
- Syntactic web service descriptions: WSDL.
- Semantic web service descriptions: OWL-S, SAWSDL, WSDL-S, WSML.
- Message exchange: RPC, SOAP, REST.

Automated Web Service Composition

- The goal of web service composition is to construct new web services from existing web services.
- Compound web services can also contain control constructs, such as, cycle and condition.

Why is Composition Complicated?

- Domain can be very knowledge intensive – domain expert is needed.
- The set of web services to choose from is large – automation is needed.
- Web service providers use different ontologies.

Current Solutions

- Automated web service mapping into service template.
- Automated workflow generation from a given goal.
- Combined approaches.

Automated Web Service Mapping into Service Template

- Entire workflow has to be created manually.
- Visual tools are ofthen used to create workflows.
- Templates are created for suitable component services to map web services automatically into compound web service workflow.
- If suitable web services do not exist, then service template needs to be redesigned manually.
- Examples: eFlow, METEOR-S framework, Zeng et al., WSMO Studio.

Automated Workflow Generation

- Aim is to fully automate the web service composition.
- Easier with atomic services and sequential workflows.
- Synthesis of control constructs or composition of web services that are themselves compound web services needs a very detailed and complex goal specification language and a very detailed goal from the user.
- Examples: Sword; Rao, Küngas and Matskin; Haav et al.; Kona et al.; ASTRO toolset; QSynth.

Combined Approaches

- JOpera – Visual composition of workflow, data flow creation can be automated by mapping inputs and outputs.
- Web Service Composer – the user starts the composition by selecting the last web service. Web services that provide input are automatically proposed.
- Synthy – automated web service matching into user created workflow. Automated service finding and control flow creation if there are no exact matches.

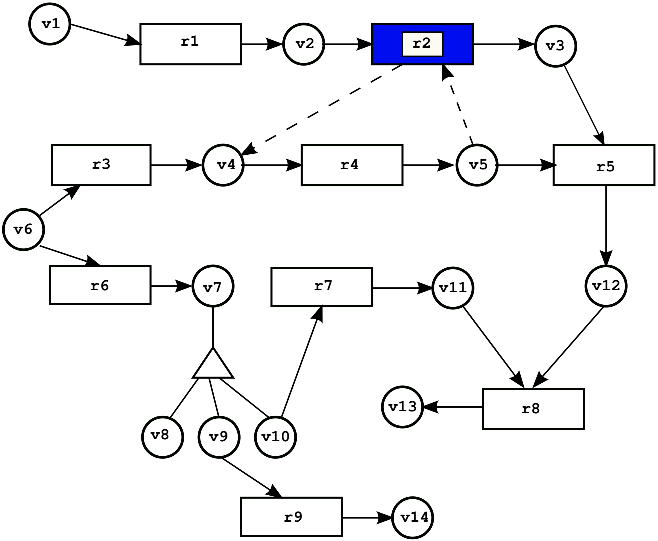
Proposed Solution

- *Service model* – can be used to represent available web services, control constructs and concepts from ontology.
- Service model has a visual representation.
- Service model can be described in logic that allows to automatically synthesise new compound web services.

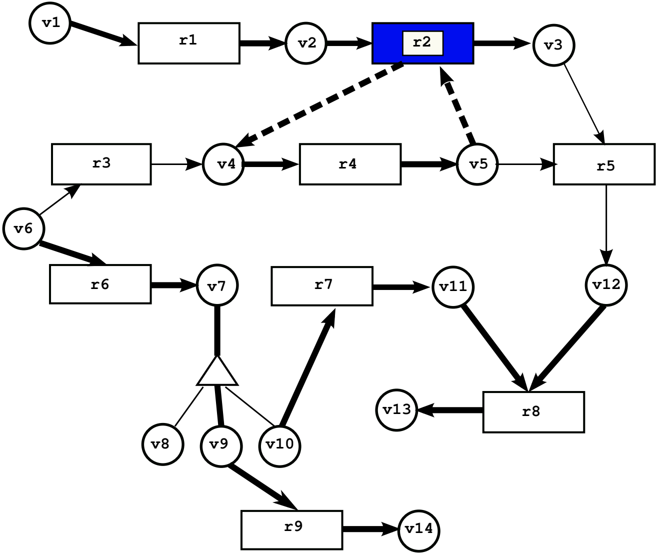
Service Model

- *Service model is a description of a collection of interoperable services that includes information necessary for automatic composition of compound services and uses one ontology.*
- A service model is abstractly represented as a bipartite graph with two sets of nodes R and V. The set R is a set of services and data dependency relations that can also be represented by atomic services. The set V is a set of variables representing data that can be inputs and outputs of services, and logical variables that are pre- and postconditions of services. Elements of V have names from the ontology used.

Example Service Model

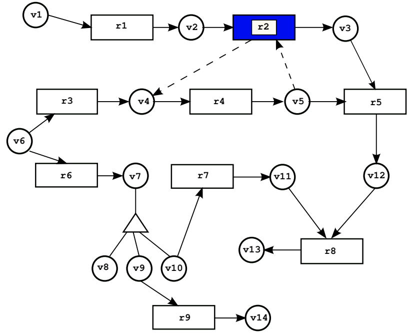


(Higher-Order) Workflows on Service Model



Services included into workflows: r1, r2(r4); r6, r9; r7, r8.

Logic for Representing Service Models



$V1 \supset V2\{r1\};$

$V3 \wedge V5 \supset V12\{r5\};$

$V6 \supset V4\{r3\};$

$V4 \supset V5\{r4\};$

$V6 \supset V7\{r6\};$

$V10 \supset V11\{r7\};$

$V9 \supset V14\{r9\};$

$V11 \wedge V12 \supset V13\{r8\};$

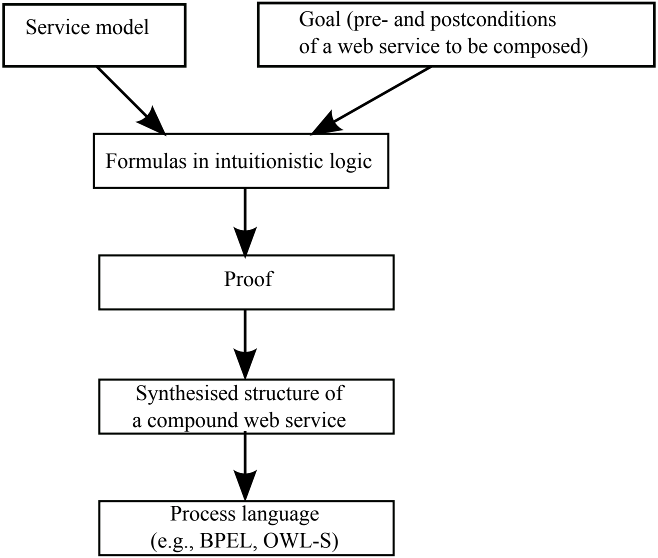
Higher-order component:

$(V4 \supset V5) \wedge V2 \supset V3\{r2\};$

Selector component:

$V7 \supset V8 \wedge V9 \wedge V10\{select\}.$

Synthesis of Compound Services


Service model

Goal (pre- and postconditions of a web service to be composed)

Formulas in intuitionistic logic

Proof

Synthesised structure of a compound web service

Process language (e.g., BPEL, OWL-S)

Composition on Service Models

Rules of structural synthesis on programs:

$$\frac{A \supset B \wedge C\{f\} \quad B \wedge D \supset G\{g\}}{A \wedge D \supset C \wedge G\{f;g\}} \qquad \text{(SEQ)}$$

$$\frac{(A \supset B) \wedge X \supset Z\{f\} \quad A \wedge W \supset B\{g\}}{X \wedge W \supset Z\{f(g)\}} \qquad \text{(HOW)}$$

Composition on Service Models – Example

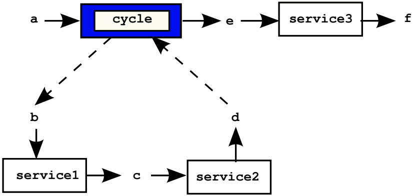
Let us have the following services:

$$B \supset C\{service1\};$$

$$C \supset D\{service2\};$$

$$E \supset F\{service3\};$$

$$A \wedge (B \supset D) \supset E\{cycle(\phi)\};$$



and a goal: $A \supset F$.

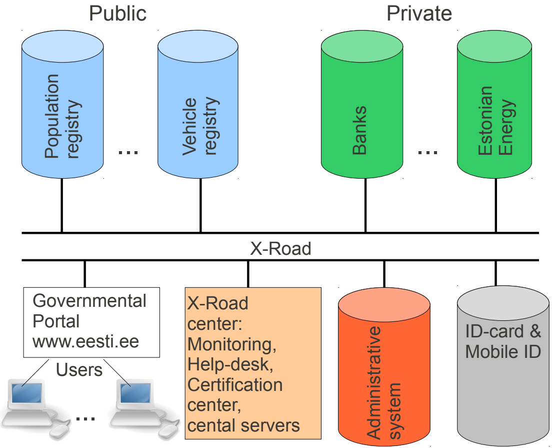
Dervivation of the proof:

$$\dfrac{\dfrac{A \wedge (B \supset D) \supset E\{cycle(\phi)\} \qquad \dfrac{B \supset C\{service1\} \quad C \supset D\{service2\}}{B \supset D\{service1; service2\}}\,SEQ}{A \supset E\{cycle(service1; service2)\}}\,HOW \qquad E \supset F\{service3\}}{A \supset F\{cycle(service1; service2); service3\}}\,SEQ$$

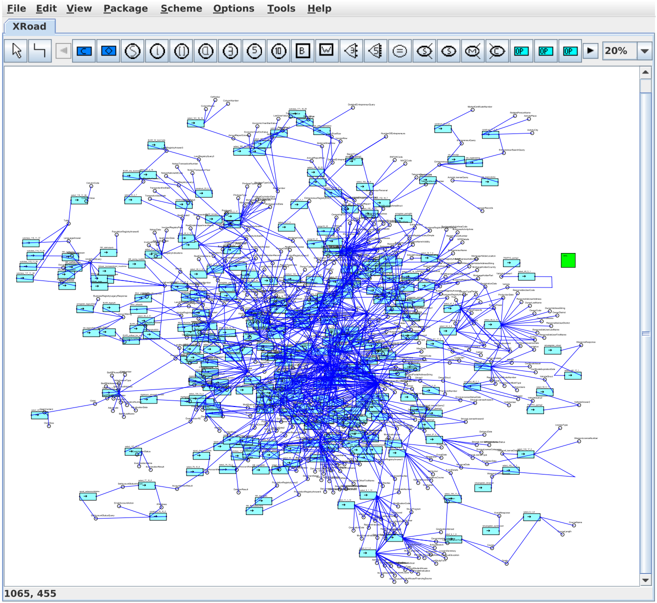
Web Service Composition Tool

- Proof of concept tool has been implemented on CoCoViLa model- based software development platform.
- CoCoViLa supports planning based on structural synthesis of programs and is able to handle specifications in the visual or textual form.

Estonian e-government Web Services (X-Road)



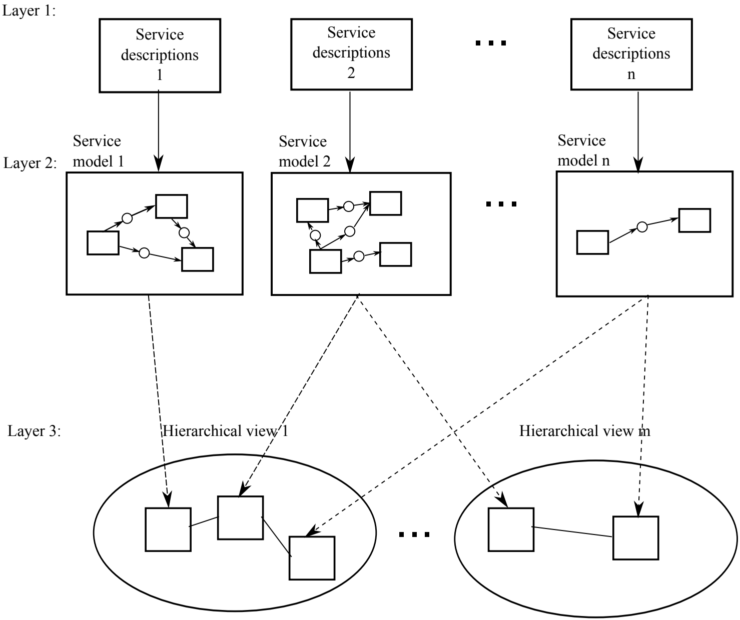
Large X-Road Service Model (1)



Large Service Model (2)

- This model contained about 900 components.
- Originally created by Peep Küngas in 2006.
- Synthesis on this large model showed the feasiblity of the proposed web service composition method.
- The service model was hard to use because of its size.

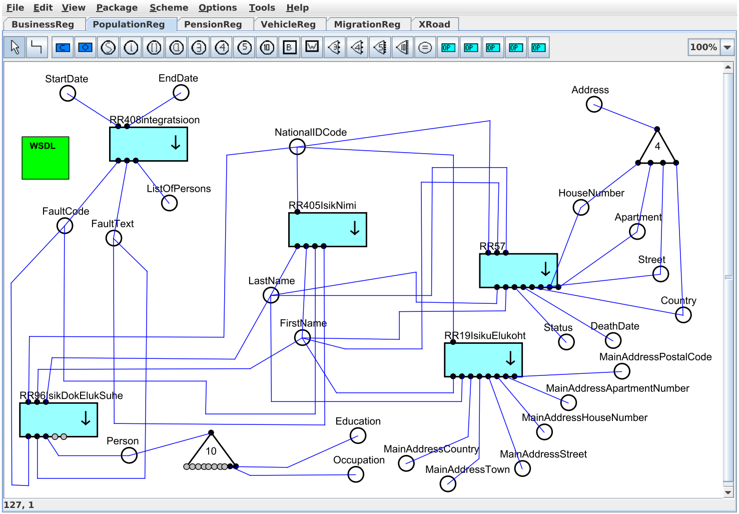
Hierarchical Service Models (1)



Hierarchical Service Models (2)

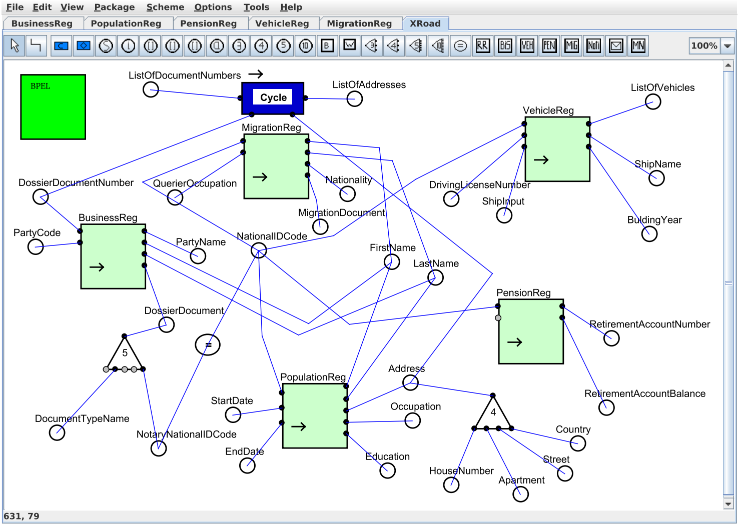
- Generated automatically from the (SAWSDL) descriptions of the X-Road web services.
- Service models are generated for each provider (registry) and saved as components to be used on the hierachical model.
- Different ontologies can be used to represent:
  - submodels
  - upper level model (hierachical view)

Population Registry's Service Model



Hierarchical Service Model

ListOfDocumentNumbers.data->ListOfAddresses.data



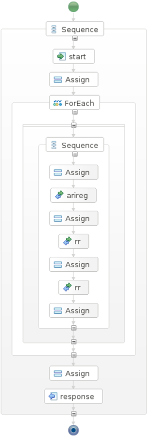
Output

As a result the following three services are cycled trough:

`arireg:toimiku_dokument` (**BusinessReg**)

`rr:RR405IsikNimi` (**PopulationReg**)

`rr:RR57` (**PopulationReg**)



Results

- A logic-based web service composition method suitable for automating web service composition in the knowledge intensive domain with a large number of services was proposed in this work.
- The service model concept was proposed as a way to represent available web services, control constructs and data dependency relations.
- A prototype tool, based on the method proposed, was implemented on the CoCoViLa model-based software development platform and tested on web service desciptions of the Estonian e-government information system.

Future Work

- Futher automation of service model generation:
  - complex data types,
  - higher-order components.
- Extentsions to service model:
  - quality of service information,
  - confidentiality and access rights.

Publications

- Riina Maigre, Enn Tyugu (2011). Composition of Services on Hierarchical Service Models. In: EJC 2011 : 21st European-Japanese Conference on Information Modelling and Knowledge Bases. [in print]
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Thank you!

Euroopa Liit
Euroopa Sotsiaalfond

Eesti tuleviku heaks

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