S-Cube

Addressing Multi-disciplinary Research Challenges for Software Services

Andreas Metzger

Software Systems Engineering
Institute for Computer Science and Business Information Systems (ICB)
University of Duisburg-Essen, Germany
www.sse.uni-due.de
Agenda

- The Future of Software Services
  Some trends

- Service-oriented Architecture
  “State of the Art” & Need for Integration of Research

- S-Cube
  The Software Service and Systems Network

- The S-Cube Research Framework
  Addressing Cross-Disciplinary Research Challenges
The Future of Software Services
Some Trends

- YouTube accounts for 27 Petabytes of Internet traffic in 2006.
- This is about as much traffic as the whole Internet traffic in 2000.

User generated content:
Year 2006: 160 Exabyte
  (= 12 book stacks from earth to sun)
Year 2010: 990 Exabyte

Recorded outputs of every human language since world began:
  5 Exabyte

Social Networking websites (e.g., facebook or myspace.com)
1 Billion people registered
3 Billion minutes spent every day
8 Billion pages accessed every day

Source: Presentation by Joao Da Silva (European Commission Director Converged Networks and Services) at the NESSI General Assembly
The Future of Software Services
Some Trends

Software is at the core of the Information Society

1 Million specialists in the EU
76 B€ software market

Today: every EU industry sector depends on Software

Tomorrow every EU industry sector will succeed only when mastering software and services complexity

Source: Presentation by Joao Da Silva (European Commission Director Converged Networks and Services) at the NESSI General Assembly
Future Software Services and Systems

... will serve **fixed, mobile and “nomadic” users**
... will be **ubiquitous**
... will **change their functionality and quality dynamically** (\& **proactively**) depending on the **context** (incl. physical usage environment)
... can be easily assembled by laypersons to **create innovative applications** (“user-generated services”)
... will exploit high-speed networks and **virtualization of the infrastructure**

Source: Report on longer term research challenges in Software & Services; Mike Papazoglou Klaus Pohl (Eds.); http://cordis.europa.eu/fp7/ict/ssai/
Agenda

- The Future of Software Services
  Some trends

- Service-oriented Architecture
  “State of the Art” & Need for Integration of Research

- S-Cube
  The Software Service and Systems Network

- The S-Cube Research Framework
  Addressing Cross-Disciplinary Research Challenges
State of the Art
SOA Functional Layers

- describing, publishing and discovering services
  - facilities for service description (e.g., WSDL)
  - capabilities for service discovery (e.g., UDDI)
- run-time environment for execution of service-based systems (computing nodes)
  - primitives for service communication (e.g., SOAP)
State of the Art
SOA Functional Layers

- (hierarchical) aggregation of multiple (individual) services into service compositions
- specifying (e.g., using BPEL), controlling and coordinating the execution of aggregated services
- managing data flow & control flow between aggregated services
State of the Art
SOA Functional Layers

- end-to-end visibility and control of business processes
  - spanning multiple organizations; involving human actors
- mechanisms for expressing, understanding, representing and managing an organization in terms of a collection of business processes
State of the Art
Observations

- Focusing on the functional layers is not sufficient to build future software services and systems

  - Existing isolated / local solutions (in the individual layers) are not enough to address cross-cutting issues
    - How to handle conflicting adaptations in different layers?
    - How to manage quality of service across all layers?

  - Huge body of knowledge of many communities (e.g., Software Engineering; Human Computer Interaction), which is often not exploited by other communities
    - How to realize context-aware systems (e.g., different user types)?
State of the Art
Cross-cutting Issues

- Analysis, Design, & Development
- Quality Definition, Negotiation & Assurance
- Runtime Adaptation

Business Process Management Layer
Service Composition & Coordination Layer
Service Infrastructure Layer

Context
State of the Art
Contributions of Disciplines

Analysis, Design, & Development
Quality Definition, Negotiation & Assurance
Runtime Adaptation

Business Process Management Layer
Service Composition & Coordination Layer
Service Infrastructure Layer

SE
Softw. Eng.

AP
Auto. Planning

BPM

SOC

HCI

IR
Inform Retrieval

Grid „Cloud“

Context
Agenda

- The Future of Software Services
  Some trends

- Service-oriented Architecture
  “State of the Art” & Need for Integration of Research

- S-Cube
  The Software Service and Systems Network

- The S-Cube Research Framework
  Addressing Cross-Disciplinary Research Challenges
S-Cube Overview

- **Software Services and Systems Network**

- **FP 7 Network of Excellence**

- **Project coordination**
  - Prof. Dr. Klaus Pohl (Project Coordinator), University of Duisburg-Essen, Germany
  - Prof. Dr. Mike Papazoglou (Scientific Director), Tilburg University, The Netherlands

- **Duration:** 01.03.2008 – 29.02.2012

- **Total cost:** approx. 11 Mio. EUR

www.s-cube-network.eu
S-Cube Partners

<table>
<thead>
<tr>
<th>City University London</th>
<th>Tilburg University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lero</td>
<td>NoEs...</td>
</tr>
<tr>
<td>INRIA</td>
<td>FP6</td>
</tr>
<tr>
<td>Université Claude Bernard Lyon</td>
<td>Large (40+ partners)</td>
</tr>
<tr>
<td>Universidad Politécnica de Madrid</td>
<td>Funding of Integration Activities</td>
</tr>
<tr>
<td>Politecnico di Milano</td>
<td>FP7</td>
</tr>
<tr>
<td>Consiglio Nazionale delle Ricerche (CNR)</td>
<td>Smaller (10-15 partners)</td>
</tr>
<tr>
<td>Center for Scientific and Technol. Research (FBK)</td>
<td>Funding of Integration &amp; Research Activities</td>
</tr>
<tr>
<td>University of Stuttgart</td>
<td></td>
</tr>
<tr>
<td>Vienna University of Technology</td>
<td></td>
</tr>
<tr>
<td>MTA SZTAKI</td>
<td></td>
</tr>
<tr>
<td>University of Crete</td>
<td></td>
</tr>
</tbody>
</table>
S-Cube Objectives

- Establish a **unified, multidisciplinary, vibrant research community**

- Invent the next wave of **service technologies**

- Establish **agile & holistic service engineering & adaptation** principles, techniques & methods **to foster innovation**

- Inaugurate a **Europe-wide education and training programme** for researchers and industry

- Establish a **trust relationship with industry** (via NESSI)
Agenda

- The Future of Software Services
  Some trends

- Service-oriented Architecture
  “State of the Art” & Need for Integration of Research

- S-Cube
  The Software Service and Systems Network

- The S-Cube Research Framework
  Addressing Cross-Disciplinary Research Challenges
S-Cube’s Research Framework Overview

- **Goals:**
  - Handling complexity
  - Making knowledge of different disciplines explicit in order to avoid overlaps (exploit synergies) and to identify gaps

- **Means to achieve Goal:**
  - **Clear separation** of concerns:
    - **Local** mechanisms / technologies
    - **Local** principles, techniques and methods
    - **Global** principles, techniques and methods
  - **Precise interfaces** between the separate concerns
S-Cube’s Research Framework Overview

Adaptation & Monitoring

Capabilities
Specifications
Status
Adaptation Specifications

Business Process Management

Capabilities
Design Specifications
Status
Design Specifications

Service Composition

Capabilities
Design Specifications
Status
Adaptation Specifications

Service Infrastructure

Capabilities
Design Specifications
Status
Adaptation Specifications

Engineering & Design
S-Cube’s Research Framework

Overview

Service Engineering

Quality & SLA

Service Technologies

Adaptation & Monitoring

Engineering & Design

Specifications & Capabilities
Challenge: Cross-Layer Monitoring
Challenges for Monitoring

- Situation:

  *Measurements of KPIs (e.g., customer satisfaction)*

  *Run time SLA Conformance Check (e.g., service availability)*

  *Infrastructure Monitoring (e.g., server availability)*
Challenges for Monitoring

Example: Business Process Management

**Challenge:** How are QoS and SLA conformance related to KPIs?

- **SLA1:** Availability = 90%
- **SLA2:** Response Time = 80%
- **SLA3:** Availability = 99%
- **SLA4:** = 70%
- **SLA5:** = 99%

**KPI:** Satisfaction = 80%
Challenges for Monitoring

- “Solution”:

- **Adaptation & Monitoring**
  - Models & Reasoning on QoS and SLAs

- **KPI**
  - Business Process Management

- **SLA**
  - Service Composition
  - Adaptation Specifications

- **QoS**
  - Service Infrastructure
  - Adaptation Specifications

- **重要意义**
Challenge:

Cross-Layer Adaptation
Challenges for Adaptation

- Situation:

  - Adaptation of Business Process (e.g., alternative workflows)
  - Adaptation of Composition (e.g., bind different Services)
  - Adaptation of Infrastructure (e.g., reconfigure nodes)
Challenges for Adaptation

- Example:

  Challenge:
  How to coordinate adaptations across layers?

  Adaptations can be conflicting.

  Event
  
  Challenge:
  How to coordinate adaptations across layers?

  Service Infrastructure
  
  Service Composition
  
  Service

  Business Process Management

  Activity
Challenges for Adaptation

“Solution”:

Adaptation

Adaptation Analysis

Monitoring Events

Adaptation Spec.

Monitoring Events

Adaptation Spec.

Monitoring Events

Adaptation Spec.

Business Process Management

Service Composition

Service Infrastructure
Challenge:

Proactive Adaptation
Challenges for Adaptation

- Situation:

Adaptation currently is based on monitoring events ➔ reactive
Challenges for Adaptation

- Drawbacks of “reactive” approach:
  - Executing faulty services can lead to:
    - loss of money
    - unsatisfied users
  - Execution of adaptation activities increases execution time
    → reduction of system performance
  - It might take time before problems in the system lead to monitoring events
    → monitoring events might arrive so late that adaptation of the system is not possible anymore
Challenges for Adaptation

“Solution”:

- Anticipating Need for Adaptation(*)
- Adaptation Specifications
- Monitoring

(*) e.g. by means of:
- online testing
- context-observation
- log analysis and prediction
Challenge:
Service Testing
Challenges for Quality

- Situation:

Test conditions cannot be completely enforced (no ownership and control over external services)

- Business Process Management
- Service Composition
- Service Infrastructure
Challenges for Quality

- Example: Performance Test

Service Composition (To be Tested)

Challenge:
How to assess information about services required during testing?
(e.g. context conditions like platform load etc.)

Service Infrastructure

FAIL
(response time too long)

High load!
Challenges for Quality

- “Solution”:

- Business Process Management
- Service Composition
- Service Infrastructure
- Engineering & Design
- Enriched Service Interfaces
- Additional Information from Infrastructure
- Additional Information from Composition
- Design Specifications
- Capabilities
Challenge:

Engineering Innovative Service-Based Systems
Challenges for Engineering

- Situation:
Challenges for Engineering

- Example: Traditional Top-Down design of service-based systems

Top-Down design of service-based systems might oversee new services that can foster innovation.
Challenges for Engineering

- Example: Bottom-Up / Exploratory Design

Requirements for SBS

Elicitation of Requirements

Analysis of Service Capabilities

Exploration of Services

Services
Challenges for Engineering

- Example:

  Situation-dependent fusion of top-down and bottom-up approaches?

Requirements for SBS

Definition and Refinement of Requirements

Analysis of Service Capabilities

Search

Services
Challenges for Engineering

- “Solution”: 

- BPM Capabilities
- Service Composition Capabilities
- Service Discovery Capabilities
Mastering the challenges requires cross-disciplinary research!

S-Cube provides the “platform”

... AND ...

you can be part of it

Join S-Cube as an Associate Partner

(details can be found on the S-Cube Web Portal)