1

Why?

- Different communities
  - Requirements engineering
  - Service-centric computing
  - Little communication, let alone collaboration
- Shared concepts
  - Requirements monitoring, quality-of-service, service discovery queries
- But missed research and practice opportunities
- The SeCSE project
Mini-Tutorial Agenda

- Services and service-oriented systems
- How each can influence the other
- Some SeCSE solutions: processes and software
  - Publishing services based on provider specifications
  - Discovering services that meet consumer needs
  - Monitoring services for compliance
- Future trends
- Questions

SeCSE

- Project Acronym: SeCSE
- Project Title: Service Centric Systems Engineering
- Project instrument: Integrated Project
- Consortium: 15 organisations from 6 countries
- Thematic area: Open development Platforms for software and services
- Duration: 48 months (important results from every year)
- Budget: 15.2 MEuro (Funding 9.2 MEuro)
- Partners include: Engineering, Fiat, Telecom Italia, Telefonica, ATOS Origin, Microsoft, CA, Politecnico di Milano, City University London, Lancaster University
The shift towards dynamic environments

- **Closed world environments were unrealistic**
  - Dynamic, open environments become the norm
  - Requirements cannot all be discovered upfront
  - Many unforeseen stakeholders emerge

- **Flexible support for change**
  - Incremental, agile and prototype-based approaches
  - Modular, distributed design; changes need recompilation and redeployment
  - Information hiding, encapsulation, interface versus implementation; all need new languages
  - Component-based software

- **Critical in emerging domains**
  - Ambient intelligence, context aware applications, pervasive computing, web 2.0
Autonomic systems

- The system needs to change when the context changes
  - Some of its parts can disappear
  - Some new parts can be found
- Re-organize itself at run-time

The open-world assumption

- One remaining assumption
  - We own the software modules and components
- Services become key actors in open-world systems
  - Resources made available on a network as services with which our software can interact remotely to obtain a goal
  - Loosely coupled
  - Accessed on demand
- Key differences
  - Services are owned by other people and organizations, and not under our jurisdiction
  - Contractual arrangement between service consumer and provider
Services

- Services are self-describing, open components that support rapid, low-cost composition of distributed applications
- Service providers procure the service implementations, supply their service descriptions, and provide related technical and business support
- Since services may be offered by different enterprises and communicate over the Internet, they provide a distributed computing infrastructure for both intra and cross-enterprise application integration and collaboration
- Service descriptions are used to advertise the service capabilities, interface, behavior, and quality

Example of Services in Dynamic Environments

- Fiat’s customer care service centre:
  - Service centre acts as service integrator
  - Composing services for Fiat car owners e.g. navigation, mobile office, remote maintenance (after vehicle breakdown), remote mail service activation, profile customisation
Service-oriented systems

- **Main development task in SoAs**
  - Applications created by combining building blocks provided by services
  - Service compositions may themselves become services
  - Recursive service composition
- **Service composition should**
  - Use functional requirements
  - Be based on quality-of-service parameters
  - Use P2P conversational interactions
  - Exploit multi-party interactions
- **Many composition models are possible and available**
Integrating heterogeneous systems

Is this the whole story?

| Business Domain Specific extensions | Business Domain
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Secure Management</td>
<td>Management</td>
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<tr>
<td>WS/ESB, WS/AM, WS/IM</td>
<td>Security</td>
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<td>Business Processes</td>
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<td>WS/Messaging, WS/Message</td>
<td>Business processes</td>
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<td>WS/Policy</td>
<td>Metadata</td>
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<th>Application Services</th>
<th>Business Domain Specific extensions</th>
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<td>Orchestration</td>
<td>WS/Policy, WS/Message, WS/Security</td>
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<td>Event Notification</td>
<td>WS/Message, WS/Notification</td>
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<td>Multiple Message Sessions</td>
<td>WS/Communication, WS/Transfer</td>
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<td>Reliable Messaging</td>
<td>WS/Security, WS/Message/Reliability</td>
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<td>Reliable Network</td>
<td>WS/Reliability, WS/Reliability</td>
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<td>Message Packaging</td>
<td>WS/Policy, WS/Message/Notification</td>
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<td>WS/Policy</td>
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<td>WS/Message/Security</td>
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<tr>
<th>Secure Service and Message Description</th>
<th>WS/Security</th>
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<td>WS/Security</td>
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<td>WS/Message/Security</td>
<td></td>
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<tr>
<td>WS/Policy</td>
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Service-Oriented Architectures (SoAs) and the ESB stack

Enterprise Service Bus

- Web Services
  - SOAP, WSDL, UDDI
  - XML Processing
- Policy
  - Security Management
  - Audit
  - Configuration
  - Charging
- Adapters
  - Middleware
  - Messaging
  - Mainframe
  - DB
  - ESB
- Data Transformation
  - Format Translation
  - Content Transformation
  - XML, CSV, Fixed, Tagged, Excel...
- Orchestration
  - BPEL Engine
  - Process Monitoring & Control

Services, Service-Oriented Systems and Requirements

Neil Maiden
Publishing Services

- Service providers
  - Explore markets for new services; product lines
  - Design and deliver (families of) services
  - Supply service descriptions to maximize discovery by consumers
  - Provide related technical and business support

- Consequences
  - Publish (yet-to-be implemented) service descriptions to investigate market – requirements exploration and acquisition
  - Batch requirements into services and service releases
  - Requirements to describe service goals, behaviour and qualities

Discovering services at design-time

- Service integrators and consumers
  - Generate service queries
  - Discover and retrieve the best-fit services
  - Select best-fit services using qualities-of-service

- Consequences
  - Service queries incorporate requirements
  - Service discovery algorithms robust enough to overcome requirements problems – incompleteness and ambiguity
  - Common non-functional requirement and quality-of-service ontologies
  - Reasoning about quality-of-service to select best-fit services
Composing services

- **Service integrators**
  - Compose services to deliver functional requirements
  - Compose services to meet quality-of-service constraints
  - Decompose requirements to generate required behaviour and qualities of atomic services in composition

- **Consequences**
  - Represent requirements using process-oriented models
  - Requirements-based application design
  - Develop arguments for requirements satisfaction by a composition

Service-level agreements (SLAs)

- **Service consumers and providers**
  - Negotiate what service should do for consumer
  - Agree SLAs to document results of negotiation
  - Seek to update SLAs as circumstances change

- **Consequences**
  - Negotiations are requirements-based, e.g. Win-Win approach
  - SLAs are developed from requirements used to discover services documented in SLAs
  - Requirements-based change processes
Monitoring services

- Service-centric systems
  - Construct service monitors
  - Loose monitoring of services: runs in parallel with main execution
  - Strict monitoring of services: intertwined with main execution

- Consequences
  - Requirements – functional and quality – inform monitor construction
  - Measurable requirements to enable service monitoring
  - Monitors test services for (requirement) compliance
Publishing focus

Existing service specification formats

- For any service property, there is a choice of notation with which to describe it, e.g.:
  - Service Signature
    - WSDL, UML, WSDL-S, ...
  - Operation Semantics
    - OWL-S, UML/OCL, WSMO, WSDL-S, ...
  - Behavioural Specification
    - UML, OWL-S, OpenModel, BPEL4WS, WSCI, ...
  - QoS
    - UDDIe, SWSQL, WSQL, E QoS, WSLA, WSML, ...
SeCSE’s specification solution

- Specification based on service Facets
  - Primary aim is to organise specifications that address different properties of a service
  - Projections over one or more service properties
  - Provide flexibility for service providers
  - Maintain compatibility with existing standards
  - Present information to support the other techniques developed within SeCSE
  - Support 3rd party specification mechanisms so compatibility with other approaches is maintained.

Example
Facet support for discovery

- Meta-data used to:
  - describe the set of facets that exist for any service
  - The languages used to specify each facet property
- New facets can be added as they become available
- New facet types can be defined and facets can accommodate any new notation that is encodable using XML

SeCSE facets

- A number of facet types exist, e.g.:
  - Signature – operation signatures and bindings (a subset of WSDL)
  - Operational Semantics – dependencies between operation invocations
  - Exception – descriptions of service failure behaviour
  - Commerce – commercial aspects about service usage, including SLAs
  - Description – structured natural language primarily intended to support requirements-based service discovery
  - QoS – assertions of non-functional properties

Our focus here
SeCSE Specification Support Tool

- Facet Management
  - Create, edit and publish specifications

- Specification Management
  - XML-based (including XMI/UML)

- Editor Management
  - Integration with 3rd party editors

- Facet Forms
  - Specification guidance, set structure

- Consistency Mechanisms
  - Consistency across specifications/facets

The Description Facet

- To support service discovery, the description facet uses a simple form permitting the capture of:
  - Service goal
  - Target service consumers
  - Service description
  - Description of operations
  - Service rationale
  - Business assumptions
  - Technical assumptions
  - Pre and post-conditions
  - Miscellaneous
The QoS Facet

- NFRs may be important to a service consumer.
  - E.g. Service availability may be important for on-demand applications
- The QoS facet is designed to allow providers to represent their services’ non-functional properties in a way that supports service discovery.
Service QoS discovery challenges

- Must be machine-readable
  - How to represent non-functional properties in a machine-readable form?
- Typically > 1 metric for any given NFR
  - How to insulate the service consumer from having to express their requirement query using the same metrics and units that the service provider uses in their published service specification?

SeCSE QoS solution

- Exploit facets’ ability to reference an ontology
- Defined an NFR OWL ontology called QoSOnt

- Set of QoS attributes derived from ISO 9126
- Set of appropriate metrics associated with each QoS attribute
- Set of units associated with each metric
The SST uses QoSOnt to guide the service provider when specifying the NF properties of their service.

More significantly, QoSOnt has an associated reasoner web service that will resolve metric and unit mismatches transparently.

Service consumer

QoSOnt Reasoner

Service X Availability = 99.4%

√

Required Availability: >= 99% percentage uptime

Service provider

Service X Availability: MTTF = 7 days MTTR = 1 hr
q. QoSOnt also has a role in SLA negotiation
q. Derived an SLA template based on WS-Agreement
q. Uses QoSOnt to concretise the WS-Agreement guarantee term

```xml
<wsag:GuaranteeTerm Name="AvailabilityGuarantee" Obligated="ServiceProvider">
  <wsag:ServiceScope ServiceName="xTripService"/>
  <wsag:ServiceLevelObjective>
    <wsag:KPITarget>
      <wsag:KPIName OntMetricConcept="http://www.comp.lancs.ac.uk/owl_qos/qosont2.owl#AvailabilityAsPercentageUptime">Availability</wsag:KPIName>
      <wsag:Target OntUnitConcept="http://www.comp.lancs.ac.uk/owl_qos/qosont2.owl#percent">98.9</wsag:Target>
    </wsag:KPITarget>
  </wsag:ServiceLevelObjective>
  <wsag:BusinessValueList/>
</wsag:GuaranteeTerm>
```
The problem

- Two assumptions
  - Service specifications - large numbers of services with multiple versions, expressed in English and WSDL
  - Requirement queries - structured natural language, measurable quality criteria, no ontologies
- Two challenges to discover services when
  1. Semantic, ontological and granularity mismatches exist
  2. Queries are incomplete and ambiguous

Requirements-based discovery process

- Iterative and incremental service discovery process
  - Query refinement in light of relevance feedback [Fischer et al 1991]
Four Key Modules

- Web-based application
  - NET implementation using a three-layer model
- Seamless integration of requirements processes and service discovery

UCaRE requirements component

EDDIE service discovery component

SeCSE service browser component

SeCSE service registry

XQueries

Facets
- Description
- Signature
- Commerce
- Qualities-of-service
- Operational semantics

Use case-based specification of requirements
Ontology-based quantification of requirements

Manipulation of use case specifications
Seamless formulation of service requests

### Setting Service Requests

<table>
<thead>
<tr>
<th>Use Case Attributes</th>
<th>Normal Course</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Use Case Name:</strong></td>
<td>Deliver remote maintenance service</td>
</tr>
<tr>
<td><strong>Actor:</strong></td>
<td>driver, garage, on-board diagnostic system, car, automobile, vehicle, passenger</td>
</tr>
<tr>
<td><strong>Preceding:</strong></td>
<td>A driver is driving his car. The car’s on-board diagnostic system detects an engine problem. The engine is malfunctions. The driver activates FIAT’s remote maintenance service. The service provides the location of the nearest garage to repair the car. The driver follows directions to the garage.</td>
</tr>
<tr>
<td><strong>Problem Statement:</strong></td>
<td>The car engine stalls</td>
</tr>
<tr>
<td><strong>Assumptions:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Preconditions:</strong></td>
<td>The remote-maintenance service is available.</td>
</tr>
<tr>
<td><strong>Successful End State:</strong></td>
<td>The driver arrives the garage.</td>
</tr>
<tr>
<td><strong>Unsuccessful End State:</strong></td>
<td>The service doesn’t locate a garage to repair the car.</td>
</tr>
<tr>
<td><strong>Triggering Event:</strong></td>
<td>The car engine stalls</td>
</tr>
</tbody>
</table>

#### Functional Requirement(s):

- **Description**: The remote maintenance service will provide the driver with directions to the nearest garage.
  - **Source**: FIAT
- **Description**: The remote-maintenance service shall detect faults with the car’s engine.
  - **Source**: FIAT
- **Description**: The remote-maintenance service shall diagnose faults with the car’s engine.
  - **Source**: FIAT

#### Non-Functional Requirement(s):

- **Description**: The remote-maintenance service will provide the driver with reliable directions to the nearest garage.
  - **Source**: FIAT
- **Description**: The remote-maintenance service shall correctly diagnose 60% of faults with the car’s engine.
  - **Source**: FIAT

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**Request**

<table>
<thead>
<tr>
<th>Registry:</th>
<th>SecCSE Service Registry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Home)</td>
</tr>
<tr>
<td><strong>Type of Speech:</strong></td>
<td>Noun</td>
</tr>
<tr>
<td><strong>Expansion Type:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Similar terms (synonym):</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Terms in definition:</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Date:** 13/03/2006

**Author:** Jos

**Preceding:** A driver is driving his car. The car’s on-board diagnostic system detects an engine problem. The engine is malfunctions. The driver activates FIAT’s remote-maintenance service. The service provides the location of the nearest garage to repair the car. The driver follows directions to the garage.

**Other:**

| **Description**: The remote maintenance service will provide the driver with directions to the nearest garage. |
| **Source**: FIAT |
| **Description**: The remote maintenance service will provide the driver with reliable directions to the nearest garage. |
| **Source**: FIAT |
Retrieved services

Filter services using non-functional requirements compliance
EDDiE’s Service Discovery Algorithm

- Disambiguating & expanding natural language terms

- Pre-processed terms
- Sense-tagged terms
- Expanded terms
- Matched terms

- Sense-tagged glossary terms
- Stemmer
- Senses
- Semantic relations

- Service query terms
- Retrieved services
- Matching engine
- SeCSE service query
- WordNet
- Local glossary
- Hyponym
- Synonym
- Term expander
- Matching engine
- SeCSE service registry

Disambiguation Strategies

- Determine correct WordNet sense of each term
  - Essential for effective expansion of query terms
- Seven procedures - increasing cost to apply
  1. Selecting senses from glossary
  2. Selecting sense of term with only 1 possible sense
  3. Selecting senses of synonyms of terms that have already been disambiguated
  4. Context-based selection of senses - based on senses of terms before and after
  5. Car: automobile, motor car, ....
  6. Car: vehicle, transport device, ....
Expansion Strategies

- Expand service queries with more terms
  - Increases likelihood of discovering services not expressed using identical terms
- Cannot rely on problem domain ontologies
  - Nature of requirements, use WordNet as ontology
- Three term expansion procedures
  1. Synset expansion, with terms with similar meaning
  2. Hypernym expansion, with terms with more generic meaning
  3. Gloss expansion, with selected terms from definition of the original term

Driver: operator, vehicle, ....

Query Matching

- Expanded queries expressed as XQueries
  - Uses traditional vector-space model to compute semantic distance between query and service description
  - Terms assigned weights according to originality and frequency of occurrence
  - Computes single measure of semantic distance for each retrieved service description
- Current algorithm is simple
  - Further refinement within industrial evaluation
Does It Work?

- Different evaluations have taken place
  - Experiments of EDDiE algorithm to retrieve services
  - Remote uses of UCaRE, EDDiE and Service Browser tools in requirements processes at CA (Computer Associates), KD Software
  - Facilitated requirements workshops in automotive (Fiat, CA, DaimlerChrysler) and UK policing (NPIA)

- Outcomes
  - EDDIE precision and recall adequate but influenced by selected requirements attributes
  - Retrieved services trigger discovery of more novel requirements not discovered using other techniques, when facilitated
  - Un-facilitated generation of requirements more difficult

Monitoring Services

Neil Maiden (on behalf of Luciano Baresi)
Current approaches

- **Standard technology**
  - BPEL is the de-facto standard for web services composition
  - Many interesting engines are available (for free)
  - Services can be described in many different ways, e.g. WSDL

- **Issues**
  - No defensive programming
  - No intertwining of business and supervision logics
  - Many possible supervision policies for the same business process

- **Possible deviations**
  - Inconsistency with respect to recorded behaviour
  - Inconsistency with respect to expected behaviour
  - Unjustified behaviour

Loose and strict service monitoring

- **Loose monitoring**
  - Runs in parallel with main execution

- **Strict monitoring**
  - Intertwined with main execution
Loose monitoring

- Based on event calculus
  - A first-order formal language for specifying properties of dynamic systems which change over time using predefined predicates, including:

  - Happens(e, t, \( R(t_1,t_2) \)) - occurrence of an event e of instantaneous duration at some time t within the time range \( R(t_1,t_2) \)
  - HoldsAt(f, t) - fluent f holds at time t.
  - Initiates(e, f, t) - fluent f starts to hold after the event e at time t.
  - Terminates(e, f, t) - fluent f ceases to hold after the event e occurs at time t

Strict monitoring

![Diagram of a data analysis process](image)
WSCoL (New Language)

- Mixes JML (lightweight version) and XML technology
- Two main activities
  - Data Collection
    - internal, external, and historical variables
    - Variable aliasing
  - Data Analysis: relationships between data
    - Typical boolean operators (and, or, not, implies, if and only if)
    - Relational operators (<, >, =, <=, >=)
    - Typical mathematical operators (+, -, *, /, %)
    - Quantifiers - forall, exists
    - Data computation - max, min, avg, sum, product
    - Data type specific functions - length, starts-with, etc.

WSReL: Expressing Rules for Recovery Strategies

- Event
  - Monitoring has signaled an error
- Condition
  - Discriminates between different recovery strategies depending, for example, on the extent of the error
  - Uses WSCoL to define the condition
- Action
  - A recovery strategy
  - Made up of different recovery steps
    - Step_A || Step_B || Step_C
  - Each step is made up of a number of atomic recovery actions
    - Action_A & & Action_B
- The rules have instance validity
- They do not have access to the process internals
### Future Trends

#### Future Requirements-Related Trends

- **Requirements-driven service composition**
  - Functional and quality requirements informing construction of SLAs on atomic services in a SoA

- **End-user requirements in dynamic environments**
  - Systems integrators cannot be surrogates for emerging end-user needs

- **Systems development governance**
  - Aligning project governance with service governance
  - Wider engagement with business, legal and social research

- **A wider notion of what is a service**
  - Human services (Amazon Turk) and mixed services as well as software services
SeCSE Sources

- Information about SeCSE is available from
  - www.secse-project.eu
- SeCSE tools can be downloaded from
  - http://sourceforge.net/projects/secse
- An explanatory video about the SST tool is available at
  - http://www.comp.lancs.ac.uk/~walkerdi/FacetedSpec.mp4
- Access an interactive version of UCaRe at
  - http://achernar.soi.city.ac.uk/ESD/UCaRe/
- SeCSE’s development environment is online at
  - http://newton.eng.it/SeCSE
- The QoSont quality-of-service ontology is available at
  - http://www.comp.lancs.ac.uk/owl_qos/qosont2.owl

Questions