Services Computing
in Education

By
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Outline

- Overview of Services Computing (SC)
  - ACM/IEEE SC degree program
  - Social context of SC
  - SC in a nutshell
  - SC from IT perspective
  - SC research challenges

- My research focus on SC in education
  - Application questions
    - Context-aware course content adaptation and delivery service
  - Research questions
    - Adaptable data presentation, management, and delivery

- My vision integrating research & teaching in the field of SC
Services Computing Volume

- IEEE/ACM Volume of Curricula Series for Services Computing (SC)
  - Services industry: one of the most significant industries of the new century
  - Potential value that SC can bring to research and engineering community
- Initial targets are its 100,000 members and 500 universities worldwide.
- Global “Services University” program

Services Computing 2007

Curriculum Guidelines for Degree Programs in Services Computing
A Volume of the Computing Curricula Series
June 1, 2007

DRAFT Prepared by the "Services University" Task Force of the IEEE Technical Committee on Services Computing

The Joint Task Force on Computing Curricula
IEEE Computer Society
Association for Computing Machinery
Social Context of Services Computing (SC)

- SC bridges the gap between business and IT
- SC promises to benefit business
  - A new cross discipline aims to enable IT to help perform business services more efficiently & effectively.
  - Global standardization
    - Interactions between existing services
    - Small business go global
  - Software as a Service (SaaS)
- Business initiatives
  - Gartner prediction ($11.5 billion in 2011)
  - Many current implementations
    - e.g., Amazon.com, ual.com, Motorola, etc.
  - Support by major software infrastructure vendors
    - e.g., IBM, SAP, Microsoft, Sun, BEA, etc.
SC in a Nutshell

- SC covers the science and technology of leveraging computing and IT to model, create, operate, and manage business services.
  - Web services as the best enabling technology
  - Service Oriented Architecture (SOA) as the central architectural model

- A Web service is a programmable module with standard interface descriptions that provide universal accessibility through standard communication protocols.

- SOA is an application framework facilitating services operations.
  - Service provider, requestor, registry

- Standard support
  - SOAP, WSDL, UDDI
SC from IT Perspective

- SOA guide service-oriented decomposition/composition

- SOA is a next-generation model for distributed & Internet computing
  - Reusability, extensibility, interoperability, etc.
  - Language & platform independent
  - Machine searchable
  - A new cost-effective way of engineering software to quickly develop and deploy Web applications

- Web services is changing the Internet from a repository of data into a repository of services

- New discipline: SC
SC Landscaping
Technical Challenges

- SC brings technical challenges
  - Standard stack
    - *Ad hoc*, on-going, comprehensive
  - Not advisory
    - Simple, no systematic method
  - Services Engineering
  - Platform, environment, etc.
    - Comply with standards
    - New techniques
  - Domain-specific

- **Result:** Higher education needs to train more SC researchers and practitioners urgently.
Research Challenges

- SC brings significant research challenges from many aspects
  - Services publishing & discovery
    - What to publish
      - Semantic data
    - How to publish
      - Centralized/distributed
    - How to decide
      - Semantic matching
  - Registry data management
    - Classification facility, access control, version control, consistency and integrity, etc.

- Services composition
  - How to capture & formalize domain-specific requirements
    - Machine interpretable
  - Services coexistence
    - Input/output parameters, constraints, relationships
  - Dynamic composition
    - Requirements-driven, locate service candidates, automatic reasoning, negotiation
Research Challenges (cont’d)

- Services testing
  - Solution-level / Service-level QoS
  - Re-inspection of existing techniques
    - Specific features of Web services, e.g., remote hosting, dynamic discovery & invocation
  - Dynamic testing
    - Efficiency, scalability
    - Mobile agents-based testing
- Services delivery (more later)
  - Context-based delivery
    - Context taxonomy, real-time detection
  - Dynamic content adaptation
    - Automatic adaptation, efficiency, rule-based
  - End-to-end delivery
    - QoS requirements
- Services Engineering
  - Engineering process
  - How to model, design, develop services, platform, reference model, etc.
    - Methodology and tooling
  - …
Security Challenges

- Security refers to the protection of assets from unauthorized access, use, alteration, or destruction.
  - Traditional security requirements
    - Confidentiality, integrity, availability, authentication
  - WS-specific requirements
    - Dynamic discovery and invocation, message-centric security, other threats

- Web services security standard stack (WSSS)

- Current challenges
  - WSSS implementation-related issues
    - Extra overhead
    - Responsibility to users
    - Interoperability issue
  - Other open issues
    - Access control
    - Service discovery
    - Service composition
    - Privacy protection
My Research on SC in Education

- My research on using SC to promote education
  - Application project
    - Context-aware course content adaptation and delivery services
  - Research questions
    - Data/metadata presentation & management, context-aware service delivery

- SC for education as a testbed with application scenarios
  - Domain importance to support ubiquitous course delivery
    - Being an academic researcher
  - Vehicle to test research ideas
    - Convenience of testing with available user pool
    - Broader impacts, e.g., data centers

- Basic research strategy
  - Hyperlink-style, loosely coupled data presentation & management technique
  - SC enablement for higher manageability & reusability
Context-aware Course Content Adaptation & Delivery Services

- Application issues & requirements
  - Instructors
    - Prepare once, used everywhere
  - Students
    - Receiving devices (e.g., PDAs, cell phone)
    - Quality requirements (e.g., fee associated)
    - Locations (e.g., social spaces, dorm, café, hallway, library, ubiquity)
    - Status (e.g., in meeting)
    - Special requests (e.g., individuals with disabilities)

- Research issues
  - Services delivery
    - Context-based delivery, dynamic content adaptation, end-to-end delivery

Analysis & Design

1. Ontology Schema
2. Context elicitation
3. Rule maintenance
4. Segment tree construction
5. Semantic segment detection
6. CAPH-MVC model

- Real time rule-based
- Context model
- Persistent temporary
- Service Requestor (OWL-S, CC/PP)
- Form filling Detection Extraction
- Event-driven Change
- Content adaptation
- Service delivery
- User base, contexts
- SaaS

- QoS model
- SLA document-based
- Aggregate effects
- Workflow composition patterns

- Semantic meta model
- Parse, CSS localize, decomposition, Save

- Object Structure Model
- Unit of Information (UOI) detection
- Atomic Semantic

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Context Model

Context Model

service/requestor ontology

Context-based Request Description in RDF

MACHINE:M(X,Y)
ONTOLOGIES:O
DEFAULTS:D
SETS:S,T={a,b}
PROPERTIES:P
VARIABLES:V
INVARIANT:I
ASSERTIONS:A
INITIALIZATION:B
REQUIREMENTS:R

Calendar_profile = {owner, event, time, attendee, location}
owner = {name, id, privacy}
event = {title, description}
time = {begin yyyy:mm dd;hh:mm}, end/yyyy:mm dd;hh:mm
attendee = {name, contact_info}
location = {place, contact_info}

<rdf:RDF>
  <owl:DatatypeProperty rdf:ID="Owner_Privacy">
    <rdfs:domain rdf:resource="#Calendar_Owner"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
  </owl:DatatypeProperty>

  <owl:DatatypeProperty rdf:ID="Default_Value_of_Device">
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
    <owl:DatatypeProperty rdf:ID="#Preferences"/>
  </owl:DatatypeProperty>

  <owl:DatatypeProperty rdf:ID="Network">
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
    <owl:DatatypeProperty rdf:ID="Availability">
      <rdfs:domain rdf:resource="#Non-functional_Constraints"/>
      <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
    </owl:DatatypeProperty>
    <owl:DatatypeProperty rdf:ID="Driving">
      <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
    </owl:DatatypeProperty>
  </owl:DatatypeProperty>
</rdf:RDF>
Context Elicitation

---

The diagram illustrates a JESS enabled context elicitation system. The system includes components such as a Service Requestor, Ontology Editor, Requester Context Detection Service, Service Context Detection Service, Portal Service, UDDI, and Service contexts. The system processes information from Requestor profile, Environment, QoS, and context-aware inference rules to extract static and dynamic information.

---

Table: Query and Adapted Object

<table>
<thead>
<tr>
<th>Rule#</th>
<th>Original Object</th>
<th>Devices</th>
<th>Adapted Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Object(video,original)</td>
<td>Device(NB)</td>
<td>Object(video,original)</td>
</tr>
<tr>
<td>D2</td>
<td>Object(video,original)</td>
<td>Device(PDA)</td>
<td>Object(video,original)</td>
</tr>
<tr>
<td>D3</td>
<td>Object(video,original)</td>
<td>Device(Phone)</td>
<td>Object(video,low_resolution)</td>
</tr>
</tbody>
</table>

---

Queries:

- Q1: What is the conference Steve attends?
- Q2: Where is the conference held?
- Q3: Who else attend this conference?
- Q4: Who are Steve's colleagues and what are they doing during the conference?
Petri Nets-Based Dynamic Rule Maintenance

- Need for maintenance of rule base
  - Incremental construction, constant changes
  - Structural errors
    - Redundant, inconsistent, incomplete, circular

- Petri nets-based rule base management
  - Petri nets
    - Graphical nature, formal modeling, math foundation
  - Rule normalization
    - Horn clauses with at most one conclusion
  - Rule transformation to Petri nets
    - 3 types
  - Generate reachability graph
  - Detect structural errors
    - Redundant: marking unchanged
    - Inconsistency: contradictory places lead to \( \omega \)
    - Incomplete: place not lead to \( \omega \)
    - Circular: edges lead to the same markings
Dynamic Rule Maintenance Example

Initial rule base

- R1 → P1
- R2 → P2
- R3 → P3
- R4 → P4
- R5 \( P_1 \land P_2 \rightarrow P_3 \land P_6 \)
- R6 \( P_2 \rightarrow P_{14} \)
- R7 \( P_0 \land P_{10} \)
- R8 \( P_3 \land P_4 \rightarrow P_7 \)
- R9 \( P_5 \rightarrow \neg P_7 \)
- R10 \( P_{14} \rightarrow P_{10} \)
- R11 \( P_7 \rightarrow P_{10} \land P_{11} \)
- R12 \( P_{11} \rightarrow P_8 \)
- R13 \( P_8 \rightarrow P_7 \)
- R14 \( P_9 \rightarrow \neg P_7 \rightarrow P_{12} \)
- R15 \( P_{10} \rightarrow P_{12} \)
- R16 \( P_{10} \rightarrow P_{13} \)
- R17 \( P_{12} \rightarrow P_1 \)
- R18 \( P_{13} \rightarrow . \)

Rule normalization

- R1 → P1
- R2 → P2
- R3 → P3
- R4 → P4
- R5.1 \( P_1 \land P_2 \rightarrow P_5 \)
- R5.2 \( P_1 \land P_2 \rightarrow P_6 \)
- R6 \( P_2 \rightarrow P_{14} \)
- R7 \( P_5 \rightarrow P_{10} \)
- R8 \( P_3 \land P_4 \rightarrow P_7 \)
- R9 \( P_5 \rightarrow \neg P_7 \)
- R10 \( P_{14} \rightarrow P_{10} \)
- R11 \( P_7 \rightarrow P_{10} \land P_{11} \)
- R12.1 \( P_{11} \rightarrow P_8 \)
- R12.2 \( P_7 \rightarrow P_{11} \)

Generate Petri nets

Reachability graph

Rule verification

- (\( 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 \))
- (\( \omega, \omega, \omega, \omega, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 \))
- (\( \omega, \omega, \omega, \omega, \omega, \omega, 0, 0, 0, 0, 0, 0, \omega, \omega, 0, 0, 0, 0, 0 \))
- (\( \omega, \omega, \omega, \omega, \omega, \omega, \omega, 0, 0, 0, \omega, 0, 0, 0, \omega, 0, 0, 0, 0 \))

Redundant: t_{12}, t_{15}, t_{16}
Inconsistent: t_{13}, t_{11}, t_{18}
Circular: P_7
Content Model

- Object Structure Model (OSM)
- Segment tree construction algorithm
- UOI concept
- UOI detection algorithm
- UOI-based content adaptation

//Annotate object clusters (OC)
public void markOC(Node n) {
    if (n.children != null) {
        for (int i = 0; i <= n.children.length(); i++)
            markOC(n.children[i]);
    }
    if ((n.isTC() || n.isSIC() || n.isVC() || n.isDIC() || n.isFC() || n.isAC()))
        n.type = "OC";
}

//Annotate arranging segment (AS) & containing segment (CS)
public void markASCS(Node n) {
    if (n.children != null) {
        for (int i = 0; i <= n.children.length(); i++)
            markASCS(n.children[i]);
    }
    if ((n.type!="OC")&&(n.numOfOCChildren()>=1))
        n.type = "CS";
    else n.type = "AS";
}

Segment Tree Construction
// Step 3. UOI determination
public int determineUOI (Node n) {
    if (n.children != null) {
        for (int i = 0; i <= n.children.length(); i++)
            determineUOI (n.children[i]);
    }

    //3.0 if all children are UOI candidates
    if (n.children != null) {
        boolean flag = true;
        for (int i = 0; i <= n.child.length(); i++)
            if (n.child[i].type != "uoic") {
                flag = false;
                break;
            }
        if (flag)
            n.type = "uoic";
    }

    //3.1 merge group with UOI candidate child
    if (n.contain_UOIC_child())
        n.type = "uoic";

    //3.2 merge group with adjacent UOI candidate
    if (n.has_uoic_sibling())
        n.type = "uoic";

    //3.3 merge group with adjacent group
    if (n.is_group() &&
        (n.has_uoic_sibling()) &&
        (n.has_group_sibling())){
        n.type = "uoic";
        //assign "uoic" to adjacent group
    }
}

Unit of Information: atomic presentation unit

- 35 websites
- 5 categories
- Average 78.49%
Semantic Segment Detection

\[ \text{functional_object := } \langle a \rangle / \langle label \rangle / \langle select \rangle / \langle form \rangle / \langle marquee \rangle / \langle button \rangle / \langle fieldset \rangle / \langle img \rangle / \langle usemap \rangle / \langle div \rangle / \langle span \rangle \]

\[ \langle blockquote \rangle / \langle code \rangle / \langle pre \rangle / \langle center \rangle / \langle textarea \rangle / \langle address \rangle / \langle cite \rangle / \langle blockquote \rangle / \langle code \rangle / \langle dfn \rangle / \langlekbd \rangle / \langle samp \rangle / \langle var \rangle / \langle sp \rangle \]

\[ \text{Wrapper := } \langle block \rangle / \langle dummy \rangle \]

\[ \text{Container := } \langle element \rangle / \langle object \rangle / \langle block \rangle / \langle dummy \rangle \]

\[ \text{Body := } \langle body \rangle / \langle element \rangle / \langle object \rangle / \langle block \rangle / \langle dummy \rangle \]

\[ \text{Object := } \langle element \rangle / \langle object \rangle / \langle block \rangle / \langle dummy \rangle \]

\[ \text{Element := } \langle text \rangle \]

\[ \text{Text Element := } \text{general white space} \]
Blackboard System Case Study

WSRF Resource

<table>
<thead>
<tr>
<th>Time slot</th>
<th>Before applying CA</th>
<th>After applying CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>07-09 (Before class)</td>
<td>12%</td>
<td>25%</td>
</tr>
<tr>
<td>09-12 (During class)</td>
<td>65%</td>
<td>52%</td>
</tr>
<tr>
<td>12-14 (After class)</td>
<td>3%</td>
<td>14%</td>
</tr>
<tr>
<td>Other</td>
<td>20%</td>
<td>11%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Without CA</th>
<th>With CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>100%</td>
<td>82%</td>
</tr>
<tr>
<td>Outdoor</td>
<td>0%</td>
<td>16%</td>
</tr>
<tr>
<td>On the move</td>
<td>0%</td>
<td>2%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BB area</th>
<th>Without CA</th>
<th>With CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Announcement</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>Course documents</td>
<td>74%</td>
<td>52%</td>
</tr>
<tr>
<td>Communication</td>
<td>0%</td>
<td>20%</td>
</tr>
<tr>
<td>Discussion board</td>
<td>12%</td>
<td>18%</td>
</tr>
<tr>
<td>Others</td>
<td>4%</td>
<td>3%</td>
</tr>
</tbody>
</table>
Supporting Collaborative e-Learning

- Application issues
  - Student isolation problem
  - Different student needs
    - e.g., ethical groups, foreign students, disabilities
  - General students away from the peer group for the first time

- Research issues
  - P2P-based information search
  - Computer-Supported Collaborative Work

- Basic research strategy
  - P2P->Social network-based P2P
Research Angles

- Social Network-Based P2P Smart Grouping
  - Knowledge relationship tie
  - Social relationship tie

- Improving P2P Search Performance
  - Multidimensional Scaling (grouping)
  - Group/social routing
  - Dynamic maintain group by SNA
    - Degree centrality, closeness centrality

- COllabotion Description Language (CODL)
  - Collaboration space with states
  - Coordination specification & verification
  - CODL to CPN translation

- A Web 2.0 Collaborative e-Learning Tool
  - Annotation models
  - Access control
A Web 2.0 Collaborative e-Learning Tool

- Annotation knowledge model
- Annotation knowledge space
- Annotation association model
- Annotation clustering
- Annotation similarity computation
- Annotation metadata model

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Internet-Based Project Management

- Application issues
- Distributed Project Management
- Robert’s Rules of Order (RRO) as communication channel protocols
- Research questions
  - Extension, trade-off, interface, bylaws, QoS, awareness, unanticipated use
  - Benefits, granularity, language, Web 2.0 technology, data management

Intellectual merits
- A distributed interaction strategy based on XRRO; CODL produce real-time minutes for visualization, archival, and guidance.
- DPMS services can be launched automatically and integrated into new business transactions.

Broader impact
- Contributes to SE; Incorporate assurances into the management process; facilitate decision audits; new-generation tools.
My Vision as Integrating Research & Teaching

- Teaching of SC program
  - IEEE/ACM global SC program
  - IEEE/ACM Services University
  - Co-authored SC book, formally recommended
  - Course materials (slides, etc)

- Integrated Web portal
  - Learn by doing
  - Various services for instructors/students
  - Multiple universities
  - Web portal as a testbed
    - Context-aware course delivery
    - Collaborative e-Learning
    - Services-oriented testing techniques
      - Research challenges
      - Mobile agents-based strategy
      - Automatic test case generation
Publications/Conferences Promoting SC

- IEEE Computer Society Technical Committee on Services Computing
- IEEE Transactions on Services Computing (TSC)
- International Journal of Web Services Research (JWSR)
- International Journal of Business Process Integration and Management (IJBPIM)
- International Journal of Grid and Utility Computing (IJGUC)
- IEEE IT Professional Magazine
- IEEE Congress on Services (SERVICES)
- International Conference on Web Services (ICWS) [6 years old]
- International Conference on Services Computing (SCC) [5 years old]
- IEEE European Conference on Web Services (ECOWS) [6 years old]
- IEEE Asia-Pacific Services Computing Conference (APSCC)