DBGlobe – Current AUEB Involvement

- **Workpackage:** W2 (UoI, CTI)
- **Objective**
  - A simulator of dynamic environments of cooperative mobile entities.
  - Model the distribution, mobility and data of mobile entities
  - Express the interaction among the entities
  - Adhoc creation of dbs, co-ordination, data acquisition
- **Month 18: Deliverable D7**
  - “Simulation Environment”
  - Network Simulation (WLAN)
  - Component Interaction (PMO,CAS)
  - Context Manipulation
Specification of the Simulation Environment

- Space Model
  - Cells
    - Administrative
    - Communication
- PMO
- Cell Administration Server
- Distribution Network
Testbed Environment
Network Simulation

- Network Simulators
  - Develop
  - Test
  - Diagnose
  network protocols_deployments
- Simulation Platform: NCTUns
- Assumptions
  - Equal number of requestors_sources
  - Service request interval 5sec
  - Files exchanged: 100KB (service description)
  - PMO population ranges between 2 and 64
  - Each source serves at most one requestor
  - Simulation duration: 800 sec
NCTUns 1.0 Network Simulator

- Uses real-life TCP/IP Protocol Stack
- Tunnel network interfaces
- Widely used in academic community
- Supports IEEE 802.11 infrastructure mode
## Network - Simulation Results

<table>
<thead>
<tr>
<th>Scenario</th>
<th>PMO #</th>
<th>Avg bandwidth Kbytes/sec</th>
<th>Transfer time (100Kbytes) seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>16</td>
<td>45</td>
<td>2.5</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>32</td>
<td>27</td>
<td>3</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>64</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>Description</td>
<td>Type</td>
<td>Components</td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>------</td>
<td>-----------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>I₁</strong> Service Search</td>
<td>P-2-C</td>
<td>PMO (requestor)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Local CAS</td>
<td></td>
</tr>
<tr>
<td><strong>I₂</strong> Locate Current Cell</td>
<td>P-2-C</td>
<td>PMO (requestor)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Local CAS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Home CAS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Current CAS</td>
<td></td>
</tr>
<tr>
<td><strong>I₃</strong> Find PMO IP</td>
<td>P-2-C</td>
<td>PMO (requestor)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Current CAS</td>
<td></td>
</tr>
<tr>
<td><strong>I₄</strong> Policy related requests</td>
<td>C-2-C</td>
<td>CAS current</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAS Home</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Or</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAS Home</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAS Current</td>
<td></td>
</tr>
</tbody>
</table>
## System Component Interactions II

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Type</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>I₅</td>
<td>PMO request dissemination</td>
<td>C-2-C</td>
<td>Local CAS&lt;br&gt;CAS for all adjacent cells</td>
</tr>
<tr>
<td>I₆</td>
<td>Retrieve Service Grounding Information</td>
<td>P-2-P</td>
<td>PMO requestor&lt;br&gt;PMO source</td>
</tr>
<tr>
<td>I₇</td>
<td>Consume Service</td>
<td>P-2-P</td>
<td>PMO requestor&lt;br&gt;PMO source</td>
</tr>
</tbody>
</table>
Case Study: Service Search

- User submits a query consisting of \( x \) keywords

Components:
- PMO (requestor)
- Local CAS

Modules:
- PMO request definition tool
- CAS request Handler
- CAS Service Manager
- CAS device repository

Input:
- Keyword vector

Output:
- Service ID list, PMO ID list
Assumptions

- Taxonomy tree is balanced
- Taxonomy tree is full
- Nodes of taxonomy contain short category descriptions (few keywords)
- Services belong only to leaf categories
- A service may belong to multiple categories
- Polysemy is defined as number of appearances
- Services are categorized by the owner
Memory requirements

- **Dictionary size:**
  \[ K*(2*s_l + p_f * p_s) \text{ bytes} \]

- \( s_l \): average string length of keywords.
- \( p_f \): average polysemy factor of keywords.
- \( p_s \): pointer size in bytes.
- Unicode char set
Memory requirements

- **Taxonomy Size:**
  
  \[ p_s f (N - f^{h-1}) + \]
  
  \[ 2N s_l k_f + \]
  
  \[ \text{KeySize}_{\text{category}} N^2 + \]
  
  \[ S m_f p_s + \]
  
  \[ (N-1)p_s \]

  (leaf node pointers)

  (node keywords)

  (node keys)

  (pointers to services)

  (pointers to parents)

\( f \): tree fanout

\( k_f \): avg keywords/node

\( N \): Taxonomy nodes

\( m_f \): multicategorization
Memory requirements

- **Service Array Size**

\[(\text{KeySizePMO} + \text{KeySizeservice} + \text{NameSizeservice}) \times S \times 2 \]
\[+ S \times m_f \times p_s \quad \text{(pointers to ontology)}\]
Memory Requirements

- Assume:
  - KeySize = 36 characters (UDDI), $p_s=2$, $p_f = 4$, $f=10$, $s_l=7$, $k_f=2$, $m_f=2.5$

  \[
  \text{Mem} = 22*K + 50*N + 226*S - 4 \text{ bytes}
  \]

  Linear to: no of
  - keywords,
  - taxonomy categories,
  - services

  Small CAS: $O(n)$ – Ontology size
  Large CAS: $O(S)$ – Services population
Memory Requirements

Space Requirements

Megabytes

Services

f=9
h=6
N=66430
Complexity analysis

Service search consists of:

- Dictionary search
- Taxonomy search
- Service retrieval from catalog
- Duplicate service elimination

○ Dictionary Search

\[ \log_2 K \] avg. mem. access (binary)
Complexity - Taxonomy Search I

- 1 keyword with 1 appearance at a hops from the leaves:
  \[
  \frac{(f^a-1)}{(f-1)} + S^* m_f / f^{(h-1)-a}
  \]
- Best Case, Leaf (a=0)
  \[S^*m_f/f^{h-1}\] iterations
- Worst Case, Root (a=h-1):
  \[N + S^* m_f\]
Complexity - Taxonomy Search II

- 1 keyword with m appearances:
  - m times the previous cost

  (we cannot optimize because we do not traverse the whole tree to find appearances: we follow dictionary pointers)
o x keywords with several appearances each
o x: small integer (x>1).
k_1, k_2, ..., k_x
k1: \{a_1, ..., a_i\}, (i appearances)
k2: \{b_1, ..., b_j\}, (j appearances)
...
k_x: \{z_1, ..., z_r\}, (r appearances)
Complexity - Taxonomy Search VI

- \((x-1) \cdot p_f\) comparisons / node traversal
- \(1 \rightarrow h-1\) node traversals / appearance
- \(p_f \cdot x\) appearances / keyword

<table>
<thead>
<tr>
<th></th>
<th>Best Case</th>
<th>Worst Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparisons</td>
<td>All x keywords have 1 appearance each, close to the root</td>
<td>All x keywords have ki appearances, ki &gt;&gt; 1, (p_f = \text{AVG}(k_i))</td>
</tr>
<tr>
<td>Node Traversals</td>
<td>(x \cdot (x-1)) comparisons</td>
<td>((p_f)^2 \cdot x \cdot (x-1) \cdot (h-1)) comparisons</td>
</tr>
<tr>
<td>Keyword</td>
<td>(p_f \cdot x ) node traversals</td>
<td>(p_f \cdot x \cdot (h-1)) node traversals</td>
</tr>
</tbody>
</table>
Service retrieval from catalog

- Appearance paths usually end close to the leaves.
  \[ S^{m_f/f^{h-1}} \text{ services} \]
- Worst case: All keywords describe the root node:
  \[ S^{m_f} \text{ services} \]
Eliminating Duplicates

![Graph showing iterations and hops from the leaf node of the path. The graph has a line indicating iterations with labels 1 to 7 for hops, and a y-axis ranging from 0 to 25,000,000. The line is marked with the condition f=5, h=7, mf=3.](image-url)
Polysemy effect

The Effect of Polysemy and No of keywords

average iterations

No of Keywords

Pf=2
Pf=2.1
Pf=2.2
Taxonomy Size

The Effect of Taxonomy Height and No of keywords

average iterations

No of Keywords

h=10
h=12
h=14
Context awareness - simulation

A context-aware service directory facilitates the process and increase the precision of service discovery

Types of context

- requesting device (device properties, characteristics, capabilities)
- Source PMO (location, time, version, type of returned results)
Context awareness – simulation II

(a) \( k=3, m=4 \)

(b) \( k=3, n=250 \)

Search time (msec)

Pentium IV, 523MB RAM

Number of services (n)

Values per dimension (m)

Pentium II, 128MB RAM
Conclusions

Further Work

- Service discovery enhanced with semantic proximity
- Contribution to the design of the DB-globe prototype
- Integration of network, component interaction and context-matching simulation modules
Dissemination


DBGlobe Simulator Web Page

http://www.db-net.aueb.gr/dbglobe

THANK YOU