Managing Broken URLs in Federated Metadata

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Disclaimer

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LRE and Broken URLs

• Issues and solutions in managing federations of learning object repositories
• LRE Federation
  – Content providers expose metadata
  – LRE provides unified access by compiling a digital catalog
    • Metadata contains URLs where learning objects can be retrieved
  – LRE does not host the objects
  – Outdated metadata exposed to the LRE can lead to broken URLs

Objective

• Effectively detect broken URLs
• Automate communication with content providers
• Allow for greater flexibility for LRE to insure quality user experience
Presentation Roadmap

• Background of problem
• Broken URL handlings system and heuristic algorithm
• Guidelines to support collaboration and communication in a federation
• Outstanding issues and future plans

Background

• Broken URLs can become significant problems
  – User satisfaction impacted by broken URLs
• Other methods of addressing problem
  – User reports of broken links
    • Individualized solution
  – Regular harvesting of metadata
    • Relies on the content providers to update their metadata
  – Systematically check all URLs in catalog
    • Full check of more than 200,000 records taxes system for extended period of time (2 days)
    • Appears as ‘unfriendly’ on content provider systems
Solution: Broken URL Handling System

- Feasibility in detecting broken URLs demonstrated
- Mechanisms to trigger ameliorative actions
- Avoids detection techniques that can appear as denial of service attacks

System Architecture
Broken URL Detection (1)

- Simple check
  - Check all URLs one by one
  - Long time (more than 48 hours)
  - ‘Denial-of-service attack’

Broken URL Detection (2)

- Solving the speed performance by
  - Cloud computing?
  - Better network bandwidth?
  - Heuristic algorithm?
  - What else?
Broken URL Detection (3)

- **Cloud computing**
  - JPPF with 4 machines in a local network
  - More than 24 hours
    - Internal processing takes less than 30 minutes
    - Network communication (between system and learning objects’ network hosts) takes all the rest
    - It took almost same amount of time using only 1 machine
    - Cloud computing is faster mainly because URLs are checked in a random order

Broken URL Detection (4)

- **But why random order made a difference?**
  - Maximum HTTP requests per second
- **Better network bandwidth?**
  - Expensive
  - Might not work well (see Learning Object Location Distribution)
- **Heuristic algorithm**
Our Beliefs

• Probability of a broken URL
  – $url_1, url_2 \in \text{domain}_1$, $url_3 \in \text{domain}_2$
  – $A, B, C$ are events of $url_1$, $url_2$, $url_3$ are broken
  – $\text{Probability}(B | A) \geq \text{Probability}(C | A)$

• Reasons
  – Domain is unavailable
  – Folder on the domain is moved or deleted

Learning Object Domain Distribution

Each domain host more than 1000 LOs
a small number of domains host 96% of all LOs

\[ p_2 = p_1^2 + \frac{N_{\text{rep}}}{N_{\text{rep}} + (p_2^+ - p_2^-)} \]

Sampling Plan

Number of good URLs (%)
Algorithm 1 Heuristic checking algorithm

1: procedure CHECK
2: for all domain ∈ domains do
3:   Re-check all broken URLs on domain
4:   Calculate $p_2$ using equation 2
5:   sampling = true
6: while (sampling and (domain has unchecked URLs)) do
7:   Take a group of URLs for checking
8:   Check this group
9:   Update $p$ using equation 3
10: if $p < p_1$ then
11:   Check all other URLs
12:   sampling = false
13: else
14:   if $p_2 \leq p$ then
15:     sampling = false  // assume that all other URLs are good
16:   end if
17: end if
18: end while
19: end for
20: end procedure

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Experiment (1)

- June 23rd, 2010
  - 45711 / 236763 broken URLs
  - Params: $G = 100, p_1 = 50\%, p_2^- = 90\%, p_2^+ = 95\%$
Procedures to Correct Broken URLs

• Heuristic checking algorithm deployed to test discrete domains
  – This allows for multiple-recheck without taxing systems

• Possible to automate communication with providers using a scheduling sequence
  – Automate initial report of broken URLs found
  – Seven days after report, a re-check is possible
    • If not corrected – initiate attempts to communicate between LRE service managers and repository managers
  – Thirty days after initial discovery of broken URL another re-check
    • Records with broken URL are removed from search
    • Automated notification to repository

### Table 1. Results

<table>
<thead>
<tr>
<th>Run</th>
<th>Selected URLs (in number and in percentage of total number of URLs)</th>
<th>Broken URLs (in number and in percentage of total number of broken URLs)</th>
<th>Rate (number of broken URLs / number of selected URLs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>41102 = 17.36%</td>
<td>33587 = 73.48%</td>
<td>81.72%</td>
</tr>
<tr>
<td>2</td>
<td>105126 = 44.40%</td>
<td>43388 = 94.92%</td>
<td>41.27%</td>
</tr>
<tr>
<td>3</td>
<td>115005 = 48.57%</td>
<td>45101 = 98.67%</td>
<td>39.22%</td>
</tr>
<tr>
<td>Overall</td>
<td>710289 = 36.78%</td>
<td>45101 = 98.67%</td>
<td>54.07%</td>
</tr>
</tbody>
</table>

(in average) (max) (in average)
Related Works

- Broken link detection
  - Based on the relationship between the resources
- Proactive solutions
  - Permanent identifiers (such as PURL)
  - Local copies

Future Works

- Broken URL filter integrated in
  - OAI-PMH harvester
  - SPI service
- Even better Broken URL detection algorithm
  - Based on URL string similarity / distance
    - When a folder is moved, deleted
Broken URL detection using Adaptive Sampling Plan

• Adaptive plan
• URL string similarity
• A result
  – First run with an assumption that all URLs are good.
    • Number of selected URLs = 118442
    • Number of broken URLs = 44925
  – Second run using knowledge from the first run
    • Number of selected URLs = 57077
    • Number of broken URLs = 45053
  – Third run using knowledge from the second run
    • Number of selected URLs = 56107
    • Number of broken URLs = 45094

Thank you