Building Interoperable Digital Libraries:
A Practical Guide to creating Open Archives

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1. Introduction

- What is the OAI?
- Motivation
- General System Strategy
- History
- Case study: NDLTD
1.1. What is the OAI?

What is the Open Archives Initiative (OAI)?
- Organization dedicated to solving problems of digital library interoperability by defining simple protocols, most recently for the exchange of metadata.

What is the Metadata Harvesting Protocol?
- Protocol to transfer metadata from a source archive to a destination archive
1.2. Motivation

- Existence of some established but independent archives
- Need for cross-archive services (like search engines)
- Lack of low-cost interoperability technology
- Experience from past projects such as Dienst
1.3. General System Strategy

- Services
- Metadata Harvesting
- Document Model
1.4. History

- Santa Fe Meeting – October 1999
  - Santa Fe Convention, January 2000
- Workshops (ACM-DL 2000, ECDL 2000)
- Structuring of the OAI
  - Steering Committee
  - Technical Committee
- Open Days – US/Europe
  - Metadata Harvesting Protocol, January 2001
1.5. Case Study: NDLTD

Networked Digital Library of Theses and Dissertations

Multiple independent university-based collections of electronic documents

Virginia Tech
Rhodes U.
U. Waterloo

OAI Metadata Harvesting Protocol

International ETD Library

JCDL 2001
2. Definitions / Concepts

- Basic Principles
  - What is an Open Archive?
  - Harvesting vs. Federation
  - Metadata vs. Data
  - Data and Service Providers

- Underlying Technology
  - HTTP and XML
  - XML, XML Namespaces and Schema

- Protocol Policies
  - Uniqueness and Persistence
  - What is a record?
  - Multiplicity of Metadata
  - Sets
  - Datestamp, Harvesting and Flow Control

*JCDL 2001*
2.1. What is an Open Archive?

- Any WWW-based system that can be accessed through the well-defined interface of the Open Archives Protocol for Metadata Harvesting
- … aka OAI-Compliant Repository
- No implications for:
  - Physical storage of data
  - Cost of data
  - Metadata and data formats
  - Access control to server
2.2. Harvesting vs Federation

- Competing approaches to interoperability
  - Federation is when services are run remotely on remote data (e.g. Federated searching)
  - Harvesting is when data/metadata is transferred from the remote source to the destination where the services are located (e.g. Union catalogues)
- Federation requires more effort at each remote source but is easier for the local system and vice versa for harvesting
- OAI currently focuses on harvesting
2.3. Metadata vs Data

- Data refers to digital objects or digital representations of objects
- Metadata is information about the objects (e.g. title, author, etc.)
- OAI focuses on metadata, with the implicit understanding that metadata usually contains useful links to the source digital objects
2.4. Data and Service Providers

Data Providers refer to entities who possess data/metadata and are willing to share this with others (internally or externally) via well-defined OAI protocols (e.g. database servers)

Service Providers are entities who harvest data from Data Providers in order to provide higher-level services to users (e.g. search engines)

OAI uses these denotations for its client/server model (data=server, service=client)
2.5. HTTP and XML

- Metadata Harvesting Protocol is an almost stateless request/response protocol
- Requests and responses are sent via the HTTP protocol
- Requests are encoded as GET/POST operations
- Responses are well-formed XML documents
2.6. XML Namespaces and Schema

_consistency and data quality is ensured by using XML Schema descriptions for each possible response_

*XML Namespaces are used where necessary to clearly define which parts of the responses are actual metadata and which support the Metadata Harvesting Protocol*
2.7. Uniqueness and Persistence

- Each record must be uniquely addressable by a distinct identifier.
- Each metadata entity must be persistent to guarantee that service providers can always refer back to the source.
2.8. What is a record?

* A record refers to an independent XML structure that may be associated with digital or physical objects.
* Records are usually associated with metadata, not data.
* OAI advocates harvesting of records, which contain metadata and additional fields to support the harvesting operation.
2.9. Sample OAI Record

<record>
  <header>
    <identifier>oai:jcdl:tut3</identifier>
    <datestamp>2001-02-03</datestamp>
  </header>
  <metadata>
    <dc>
      <title>OAI Tutorial at JCDL</title>
      <creator>Hussein Suleman</creator>
      <language>English</language>
    </dc>
  </metadata>
  <about>
    <metadataID>oai:jcdl:tut3md</metadataID>
  </about>
</record>
2.10. Multiplicity of Metadata

- Multiple formats of metadata allowed
- Dublin Core is mandatory
- Any other format allowed as long as it has an XML encoding
- E.g. MARC (Libraries), IMS (Education), ETDMS (Theses/Dissertations), RFC1807 (Bibliographies)
2.11. Sets

- Protocol mechanism to allow for harvesting of sub-collections
- No well-defined semantics – depends completely on local data providers
- May be defined by arrangement between data providers and service providers
- E.g. Subject areas, years, author names, search queries
2.12. Datestamps & Harvesting

❖ Each record needs a datestamp that indicates its date of creation or modification

❖ Dates are used to allow for harvesting by date range, thus allowing incremental and continuous transfer of metadata from a data provider to a service provider
2.13. Flow Control

- HTTP “retry-after” mechanism can be leveraged to support server-side delaying of a client’s request
- Resumption Tokens can be used to return partial results – the client is issued with a token which may be presented to the server to receive more results
3. Requirements to be a Data Provider

- Source of metadata
- Server technology
- Datestamps
- Deletions
- Unique identifiers
- Metadata mappings
3.1. Source of Metadata

- Database in proprietary format
- Collection of metadata records in well-defined format/s
  - Files on disk
- Metadata may be dynamically or statically extracted from data
- Synthetic collection
3.2. Server Technology

- WWW Server
- Protocol may be implemented in many forms
  - CGI Script (Perl, C++, Java)
  - Java Servlet
  - PHP
- Metadata (e.g. database) access mechanism required
- See [www.openarchives.org](http://www.openarchives.org) for list of publicly available software templates
- See [www.dlib.vt.edu](http://www.dlib.vt.edu) for VT experimental software
3.3. Datestamps

- Needed for every record to support incremental harvesting
- Must be updated for every addition/modification/deletion to ensure changes are correctly propagated
- Different from dates within the metadata – this date is used only for harvesting
3.4. Unique Identifiers

- Each record must have a unique identifier
- Identifiers must be valid URIs
- Example:
  
  oai:&lt;archiveId&gt;:&lt;recordId&gt;

- Each identifier must resolve to a single record and always to the same record (for a given metadata format)
3.5. Deletions

- Archives must keep track of deleted records, by identifier and datestamp
- All protocol result sets can indicate deleted records
- Deletions must be stored indefinitely so as to correctly propagate to service providers with varying harvesting schedules
3.6. Metadata Mappings

- Data provider must map its metadata to the formats it chooses to provide through its OAI interface
- Unqualified Dublin Core required
  - Best practice is to include a link to a human-readable page in the <identifier> tag
- Native formats recommended
- Community-based formats recommended
4. Metadata Harvesting Protocol

- Service Requests
  - Identify
  - ListMetadataFormats
  - ListSets
  - GetRecord
  - ListIdentifiers
  - ListRecords

- Metadata Multiplicity
- Date Ranges
- Resumption Tokens
4.1. Identify

❖ Purpose
❖ Return general information about the archive and its policies

❖ Parameters
❖ None

❖ Sample URL
❖ http://www.anarchive.org/cgi-bin/OAI?verb=Identify
4.2. Identify - Response

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<Identify xmlns="http://www.openarchives.org/OAI/1.0/OAI_Identify"
    xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
    xsi:schemaLocation="http://www.openarchives.org/OAI/1.0/OAI_Identify http://www.openarchives.org/OAI/1.0/OAI_Identify.xsd">
    <responseDate>2001-06-14T15:09:40-05:00</responseDate>
    <requestURL>http://oai.dlib.vt.edu:80/~hussein/cgi-bin/NDLTD/VTED.pl?
        verb=Identify</requestURL>
    <repositoryName>Virginia Tech Electronic Thesis and Dissertation</repositoryName>
    <baseURL>http://oai.dlib.vt.edu:80/~hussein/cgi-bin/NDLTD/VTED.pl</baseURL>
    <protocolVersion>1.0</protocolVersion>
    <adminEmail>mailto:hussein@vt.edu</adminEmail>
    <description>
        <oai-identifier xmlns="http://www.openarchives.org/OAI/oai-identifier"
            <scheme>oai</scheme>
            <repositoryIdentifier>VTED</repositoryIdentifier>
            <delimiter>:</delimiter>
            <sampleIdentifier>oai:VTED:etd-171110282975860</sampleIdentifier>
        </oai-identifier>
    </description>
    <description>
        <eprints xmlns="http://www.openarchives.org/OAI/eprints"
        </eprints>
    </description>
</Identify>
```
4.3. ListMetadataFormats

**Purpose**
- List metadata formats supported by the archive as well as their schema locations and namespaces

**Parameters**
- identifier – for a specific record (O)

**Sample URL**
4.4. ListMetadataFormats - Response

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<ListMetadataFormats>
  <metadataFormat>
    <metadataPrefix>oai_rfc1807</metadataPrefix>
    <schema>http://www.openarchives.org/OAI/1.0/OAI_ListMetadataFormats.xsd</schema>
    <metadataNamespace>http://www.openarchives.org/OAI/1.0/OAI_ListMetadataFormats.xsd</metadataNamespace>
  </metadataFormat>
  <metadataFormat>
    <metadataPrefix>oai_dc</metadataPrefix>
    <schema>http://www.openarchives.org/OAI/1.0/OAI_ListMetadataFormats.xsd</schema>
    <metadataNamespace>http://www.openarchives.org/OAI/1.0/OAI_ListMetadataFormats.xsd</metadataNamespace>
  </metadataFormat>
  <metadataFormat>
    <metadataPrefix>purl.org/dc/elements/1.1/</metadataPrefix>
    <schema>http://www.openarchives.org/OAI/1.0/OAI_ListMetadataFormats.xsd</schema>
    <metadataNamespace>http://www.openarchives.org/OAI/1.0/OAI_ListMetadataFormats.xsd</metadataNamespace>
  </metadataFormat>
</ListMetadataFormats>
```
4.5. ListSets

Purpose

- Provide a hierarchical listing of sets in which records may be organized

Parameters

- None

Sample URL

- http://www.anarchive.org/cgi-bin/OAI?verb=ListSets
4.6. ListSets – Response

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<ListSets xmlns="http://www.openarchives.org/OAI/1.0/OAI_ListSets"
     xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
     xsi:schemaLocation="http://www.openarchives.org/OAI/1.0/OAI_ListSets http://www.openarchives.org/OAI/1.0/OAI_ListSets.xsd">
  <responseDate>2001-06-14T15:14:30-05:00</responseDate>
  <requestURL>http://oai.dlib.vt.edu:80/~hussein/cgi-bin/NDLTD/VTED.pl?verb=ListSets</requestURL>
  <set>
    <setSpec>All</setSpec>
    <setName>All theses and dissertations</setName>
  </set>
</ListSets>
```
4.7. GetRecord

Purpose
- Returns the metadata for a single identifier in the form of an OAI record

Parameters
- identifier – unique id for record (R)
- metadataPrefix – metadata format (R)

Sample URL
4.8. GetRecord - Response

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<GetRecord xmlns="http://www.openarchives.org/OAI/1.0/OAI_GetRecord"
  xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
  xsi:schemaLocation="http://www.openarchives.org/OAI/1.0/OAI_GetRecord.xsd">
  <responseDate>2001-06-14T15:16:09-05:00</responseDate>
  <requestURL>http://oai.dlib.vt.edu:80/~hussein/cgi-bin/NDLTD/VTED.pl?
    verb=GetRecord&identifier=oai:VTED:etd-
    3123162539751141&metadataPrefix=oai_dc</requestURL>
  <record>
    <header>
      <identifier)oai:VTED:etd-3123162539751141</identifier>
      <timestamp>1997-04-22</timestamp>
    </header>
    <metadata>
      <dc xmlns="http://purl.org/dc/elements/1.1/"
        xsi:schemaLocation="http://purl.org/dc/elements/1.1/
          http://www.openarchives.org/OAI/dc.xsd">
        <title>SMA-Induced Deformations In general Unsymmetric Laminates</title>
        <creator>Dano, Marie-Laure</creator>
        <subject>Engineering Science and Mechanics</subject>
        <description>General unsymmetric laminates exhibit large natural curvatures at room temperature. Additionally, inherent to most unsymmetric laminates is the presence of two stable configurations. Multiple configurations and stability issues arise because of the geometric nonlinearities associated with the large curvatures. The laminate can be changed from one stable configuration to the other by</description>
      </dc>
    </metadata>
  </record>
</GetRecord>
```
4.9. ListIdentifiers

Purpose
- List all unique identifiers corresponding to records in the repository

Parameters
- from – start date (O)
- until – end date (O)
- set – set to harvest from (O)
- resumptionToken – flow control mechanism (X)

Sample URL
- http://www.anarchive.org/cgi-bin/OAI?verb=ListIdentifiers&set=All
4.10. ListIdentifiers - Response

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<ListIdentifiers xmlns="http://www.openarchives.org/OAI/1.0/OAI_ListIdentifiers"
    xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
    xsi:schemaLocation="http://www.openarchives.org/OAI/1.0/OAI_ListIdentifiers http://www.openarchives.org/OAI/1.0/OAI_ListIdentifiers.xsd">
    <responseDate>2001-06-14T15:17:32-05:00</responseDate>
    <requestURL>http://oai.dlib.vt.edu:80/~hussein/cgi-bin/NDLTD/VTED.pl?
        verb=ListIdentifiers</requestURL>
    <identifier>oai:VTETD:etd-3345131939761081</identifier>
    <identifier>oai:VTETD:etd-171110282975860</identifier>
    <identifier>oai:VTETD:etd-05012000-14030054</identifier>
    <identifier>oai:VTETD:etd-3621112139711101</identifier>
    <identifier>oai:VTETD:etd-133422039701091</identifier>
    <identifier>oai:VTETD:etd-23281533974920</identifier>
    <identifier>oai:VTETD:etd-12332282975860</identifier>
    <identifier>oai:VTETD:etd-255314202974780</identifier>
    <identifier>oai:VTETD:etd-335713312971890</identifier>
    <identifier>oai:VTETD:etd-10472396931841</identifier>
    <identifier>oai:VTETD:etd-831102339731121</identifier>
    <identifier>oai:VTETD:etd-454016449701231</identifier>
    <identifier>oai:VTETD:etd-3034112939721181</identifier>
    <identifier>oai:VTETD:etd-522014509642101</identifier>
    <identifier>oai:VTETD:etd-274210359611541</identifier>
    <identifier>oai:VTETD:etd-3210192049721391</identifier>
    <identifier>oai:VTETD:etd-0521318109613220</identifier>
    <identifier>oai:VTETD:etd-3101141259631631</identifier>
    <identifier>oai:VTETD:etd-12164379662151</identifier>
</ListIdentifiers>
```
4.11. ListRecords

Purpose

- Retrieves metadata for multiple records

Parameters

- from – start date (O)
- until – end date (O)
- set – set to harvest from (O)
- resumptionToken – flow control mechanism (X)
- metadataPrefix – metadata format (R)

Sample URL

4.12. ListRecords - Response

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<ListRecords xmlns="http://www.openarchives.org/OAI/1.0/OAI_ListRecords"
    xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
    xsi:schemaLocation="http://www.openarchives.org/OAI/1.0/OAI_ListRecords http://www.openarchives.org/OAI/1.0/OAI_ListRecords.xsd">
    <responseDate>2001-06-14T15:19:19-05:00</responseDate>
    <requestURL>http://oai.dlib.vt.edu:80/~hussein/cgi-bin/NDLTD/YTED.pl?
        verb=ListRecords&metadataPrefix=oai_dc</requestURL>
    + <record>
    + <record>
    - <record>
        - <header>
            <identifier>oai:YTED.etd-05012000-14030054</identifier>
            <datestamp>2000-05-01</datestamp>
        </header>
    - <metadata>
        - <dc xmlns="http://purl.org/dc/elements/1.1/"
            xsi:schemaLocation="http://purl.org/dc/elements/1.1/
                http://www.openarchives.org/OAI/dc.xsd">
            <title>An Examination of Race and Recurrent Substance Problems in the United States</title>
            <creator>Bell, Tannisha D.</creator>
            <subject>Sociology</subject>
            <description>Several studies show that African-Americans are less likely than whites to use alcohol or drugs. However, if African-Americans use drugs then they are more likely to become heavy and persistent users. African-Americans are also more likely to have a current substance abuse disorder. There is not much in the literature to explain this</description>
        </dc>
    </metadata>
</ListRecords>
```
4.13. Metadata Multiplicity

<?xml version="1.0" encoding="UTF-8" ?>
<GetRecord xmlns="http://www.openarchives.org/OAI/1.0/OAI_GetRecord"
xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
xsi:schemaLocation="http://www.openarchives.org/OAI/1.0/OAI_GetRecord
http://www.openarchives.org/OAI/1.0/OAI_GetRecord.xsd">
  <responseDate>2001-06-14T15:20:41-05:00</responseDate>
  <requestURL>http://oai.dlib.vt.edu:80/~hussein/cgi-bin/ndltd/vtetd.pl?
verb=GetRecord&identifier=oai:VTETD:etd-3123162539751141&metadataPrefix=oai_rfc1807</requestURL>
  <record>
    <header>
      <identifier oai:VTETD:etd-3123162539751141</identifier>
      <datestamp>1997-04-22</datestamp>
    </header>
    <metadata>
      <rdf1807 xmlns="http://info.internet.isi.edu:80/in-
notes/rfc/files/rfc1807.txt"
xsi:schemaLocation="http://info.internet.isi.edu:80/in-
notes/rfc/files/rfc1807.txt
http://www.openarchives.org/OAI/rfc1807.xsd">
        <bib-version>1</bib-version>
        <id>etd-3123162539751141</id>
        <entry>1997-04-22</entry>
        <organization>Virginia Polytechnic Institute and State
University</organization>
        <title>SMA-Induced Deformations In general Unsymmetric
Laminates</title>
        <tvne>Thesis/Dissertation</tvne>
      </rdf1807>
    </metadata>
  </record>
</GetRecord>
4.14. Date Ranges
4.15. Resumption Token
5. Implementation Details

- Tools Required
- Basic program layout
- Object-oriented approaches
- Extensible metadata generation
- Data cleaning
- Caching of results
- Error handling
- Denial-of-service prevention
- Constructing resumption tokens
5.1. Tools Required

- Code templates if available (currently available for many languages)
- Basic programming environment
- XML generators (for non-trivial encoding)
- Database access libraries/drivers (e.g. DBI, ODBC, JDBC)
5.2. Basic program layout

parse WWW request to extract parameters
if (verb='Identify')
    ProcessIdentify;
else if (verb='ListMetadataFormats')
    ProcessListMetadataFormats;
else if (verb='ListSets')
    ProcessListSets;
else if (verb='GetRecord')
    ProcessGetRecord;
else if (verb='ListIdentifiers')
    ProcessListIdentifiers;
else if (verb='ListRecords')
    ProcessListRecords;
else
    Error (400, 'Unknown verb');
5.3. Object-Oriented Approaches

 Cleaner separation of protocol, database access and metadata generation

 Example approaches

 - Each service request is handled by a object
  - Simpler incremental development
 - Protocol, Database and Metadata are objects
  - Greater portability of code
5.4. Metadata Generation

**Approaches**

- Map from source to each metadata format
- Use crosswalks to generate additional formats

\[
\begin{align*}
\text{source} & \quad = \quad \text{dc} \quad = \quad \text{rfc1807} \\
\text{name} & \quad = \quad \text{title} \quad = \quad \text{title} \\
\text{author} & \quad = \quad \text{creator} \quad = \quad \text{author}
\end{align*}
\]
5.5. Data Cleaning

- Escape special XML characters
- Convert to UTF-8 version of Unicode
- Convert entity references
- Remove extraneous whitespace
- Convert CR/LF for paragraphs
- URLs
  - `/?#=&;:+` must be encoded as escape sequences
5.6. Result Caching

- For multiple requests from many clients or to handle partial result sets
- Keep temporary tables/files
- Expire temporary data when no longer needed
- Is this necessary to handle date-range requests where new items are added to the result set while harvesting is in progress?
5.7. Error Handling

🌟 400

🔹 Illegal verb value
🔹 Illegal parameter values, combinations

🌟 404

🔹 Archive errors – cannot return a legal response

🌟 In general, everything else returns a legal but empty response!
5.8. Denial-of-Service Prevention

- Return only partial results and issue a resumption token for more
- Use 503 retry-after HTTP errors to have clients try again after a specified back-off time
- Use access control lists to limit who may access the archive
- Invoke an explicit delay before sending back results
5.9. Using resumptionTokens

🌟 Combine from/until/metadataPrefix/set and a record number indicator with delimiters into a sequential token
For example:
- from!until!metadataPrefix!set!recordnumber
- 2000-01-01!2001-01-01!!All!100

🌟 Use a session manager with automatic expiry
For example:
- vtetd123456789
6. Common Problems

⋆ No unique identifiers!
⋆ No datestamps!
⋆ Incomplete information in database
⋆ New metadata format
⋆ XML responses not validating
⋆ Do I return an HTTP error or not?
6.1. No unique identifiers

- Create an independent identifier mapping
- Use row numbers for a database
- Use filenames for data in files
- Use a hash from other fields
  - E.g. author+year+first word in title
6.2. No datestamps

✧ Ignore the datestamp parameters and stamp all records with the current date

✧ Create a date table with the current date for all old entries and update dates for new entries

✧ Most Important: Any harvesting algorithm that is interoperably stable for an archive with real dates should be stable for an archive with synthesized dates
6.3. Incomplete information

✔ Synthesize metadata fields based on a priori knowledge of the data
  ◆ Example: publisher and language may be hard-coded for many archives

✔ Omit fields that cannot be filled in correctly – better to have less information than incorrect information!
6.4. New metadata format

- Find the description, namespace and formal name of the standard
- Find an XML Schema description of the data format
  - If none exists, write one (consult other OAI people for assistance)
- Create the mapping and test that it passes XML schema validation
- Register the new format with the OAI **
6.5. XML not validating

- Check namespaces and schema
- Use Repository Explorer in non-validating mode to check structure of XML, without looking at namespaces or schemata
- Validate schema by itself if it is non-standard
- Look at XML produced by other repositories
- Watch out for character encoding issues
6.6. HTTP Error?

Unless the archive is temporarily non-functional or the parameters are intrinsically wrong, do not return an HTTP error.

- If no metadata exists in a particular format, return a record with no metadata field.
- If the set name does not exist, return an empty list.
- If the identifier does not exist, return an empty response.
7. Tools for Testing

❖ Repository Explorer
  ◆ Interactive Browsing
  ◆ Testing of parameters
  ◆ Multiple views of data
  ◆ Multilingual support
  ◆ Automatic test suite

❖ OAI Registry

❖ XML Schema Validator
Open Archives Initiative - Repository Explorer

This site presents an interface to interactively test archives for compliance with the OAI Protocol for Metadata Harvesting [Click here for details]

JavaScript is required and Netscape Navigator is recommended

Note: To avoid HTTP errors, please wait for each page to finish loading before clicking on any link.

Please enter the URL to the OAI interface (everything before the ?) or choose a predefined archive from the table:

- American Memory [LoC]
- Digital Cultural Heritage Community [UIUC]
- Perseus [Open Language Archives]
- RDN [Resource Discovery Network]

[View Archive Website] [Test and Add an archive to this list]
# 7.2. RE Parameter Testing

<table>
<thead>
<tr>
<th>Verbs</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify</td>
<td>from (YYYY-MM-DD) : [ ]</td>
</tr>
<tr>
<td>List Metadata Formats</td>
<td>until (YYYY-MM-DD) : [ ]</td>
</tr>
<tr>
<td>List Sets</td>
<td>metadataPrefix : [ ]</td>
</tr>
<tr>
<td>List Identifiers</td>
<td>identifier : [ ]</td>
</tr>
<tr>
<td>List Records</td>
<td>set : [ ]</td>
</tr>
<tr>
<td>Get Record</td>
<td>resumptionToken : [ ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Language</th>
<th>Display</th>
<th>Schema Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>Parsed</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Raw XML</td>
<td>Local mirror of schemata</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>Online schemata</td>
</tr>
</tbody>
</table>

**Send all comments to** [hussein@vt.edu](mailto:hussein@vt.edu) --- **Digital Libraries Research Laboratory@Virginia Tech**
7.3. RE Browsing

<table>
<thead>
<tr>
<th>Repository Name</th>
<th>Virginia Tech Electronic Thesis and Dissertation Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base URL</td>
<td><a href="http://scholar.lib.vt.edu:80/theses/OAI/cgi-bin/VTED.pl">http://scholar.lib.vt.edu:80/theses/OAI/cgi-bin/VTED.pl</a></td>
</tr>
<tr>
<td>Protocol Version</td>
<td>1.0</td>
</tr>
<tr>
<td>Admin Email</td>
<td><a href="mailto:webmaster@scholar.lib.vt.edu">mailto:webmaster@scholar.lib.vt.edu</a></td>
</tr>
</tbody>
</table>

Other Information:

```plaintext
description:
  oai-identifier:
    scheme: oai
    repositoryIdentifier: VTED
    delimiter: :
    sampleIdentifier: oai:VTED:etd-171110282975860

description:
  eprints:
    content:
      text: Theses and Dissertations produced by students at Virginia
      metadataPolicy:
      text: Metadata may be used by commercial and non-commercial users
      dataPolicy:
      text: Full texts are individually tagged and the rights statement
```
7.4. RE Browsing

Open Archives Initiative - Repository Explorer

http://scholar.lib.vt.edu/theses/OAI/cgi-bin/VTED.pl?verb=ListSets

**List of Sets**

*Click on the link to list the contents*

**All theses and dissertations**

**Request URL**: http://scholar.lib.vt.edu:80/theses/OAI/cgi-bin/VTED.pl?verb=ListSets

**Response Date**: 2001-06-14T20:27:00-05:00

<table>
<thead>
<tr>
<th>Verbs</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>from (YYYY-MM-DD) :</td>
<td></td>
</tr>
</tbody>
</table>
7.5. RE Browsing

Open Archives Initiative - Repository Explorer

http://scholar.lib.vt.edu/theses/OAI/cgi-bin/VTETD.pl?verb=ListIdentifiers&set=All

List of Record Identifiers

Select a link to view more information

oai:VTED:etd-3345131939761081 [display record in Dublin Core] [display metadata format]
oai:VTED:etd-171110282975860 [display record in Dublin Core] [display metadata format]
oai:VTED:etd-05012000-14030054 [display record in Dublin Core] [display metadata format]
oai:VTED:etd-362112139711101 [display record in Dublin Core] [display metadata format]
oai:VTED:etd-133422039701091 [display record in Dublin Core] [display metadata format]
oai:VTED:etd-2326153974920 [display record in Dublin Core] [display metadata format]
oai:VTED:etd-123322282975860 [display record in Dublin Core] [display metadata format]
oai:VTED:etd-255314202974780 [display record in Dublin Core] [display metadata format]
oai:VTED:etd-335713312971890 [display record in Dublin Core] [display metadata format]
oai:VTED:etd-104722359631841 [display record in Dublin Core] [display metadata format]
7.6. RE Browsing

Open Archives Initiative - Repository Explorer

explorer version - 1.1 : protocol version - 1.0 : April 2001

http://scholar.lib.vt.edu/theses/OAI/cgi-bin/VTETD.pl?verb=ListMetadataFormats&identifier=oai:VTED

List of Metadata Formats

Click on the link to view schema

Prefix=[oai_rfc1807]
Schema=[http://oai.dlib.vt.edu/OAI/rfc1807.xsd]

[display record]

Prefix=[oai_marc]
Namespace=[http://www.openarchives.org/OAI/oai_marc]
Schema=[http://oai.dlib.vt.edu/OAI/oai_marc.xsd]
7.7. RE Browsing

List of Fields

header:
  identifier: oai:VTED:etd-3345131939761081
  dategstamp: 1997-03-31

metadata:
  thesis:
    title: Conceptual Development and Empirical Testing of an Outdoor Recreation Experience Preference Scale
    creator: Walker, Gordon James
    publisher: Virginia Polytechnic Institute and State University
    subject: outdoor recreation
    subject: recreation experience preference scales
    subject: recreation experience matrix
    subject: recreation opportunity spectrum
    description: This dissertation examines four issues, including: (a) whether outdoor recreation experience preference scales exist; (b) whether these experiences can be used with a framework called the Recreation Experience Matrix (REM); (c) how well the Recreation Opportunity Spectrum (ROS) variables of activity, setting, and expertise explain the types of experiences outdoor recreationists receive; and (d) how well two new variables—primary mode and mode dependence—affect the types of experiences outdoor recreationists receive. In order to address these issues, a questionnaire was distributed at Mount Rogers National Recreation Area in Virginia during October and November of 1996. A total of 410 people completed this questionnaire. Of these, 336 provided useable data...
7.8. RE Multiple views of data

Raw XML Output

```xml
<?xml version="1.0" encoding="UTF-8"?>
<ListSets xmlns="http://www.openarchives.org/OAI/1.0/OAI_ListSets" xmlns:aws="http://www.openarchives.org/OAI/1.0/OAI_ListSets"
  xmlns:oai="http://www.openarchives.org/OAI/1.0/OAI_ListSets"
  xmlns:oai-obj="http://www.openarchives.org/OAI/1.0/OAI_ListSets"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.openarchives.org/OAI/1.0/OAI_ListSets"/>

<responseDate>2001-06-14T20:32:33-05:00</responseDate>
:requestURL>http://scholar.lib.vt.edu:80/theses/OAI/cgi-bin/VTED.pl?verb=ListSets&metadataPrefix=tesd&identifier=OAI-SetSpec&amp;SetSpec=All</requestURL>

<set>
  <setSpec>All</setSpec>
  <setName>All theses and dissertations</setName>
</set>

</ListSets>
```
7.9. RE Multilingual Support

Open Archives Initiative - 揣繖咑搀

 проблему - 1.1 : ?? 噴掛 - 1.0 : 2001塚 価域

排掇與崎拾跳蹦詑觀杀譯Harvesting 嘀咖OAI ??紫偶腔譯酸 [ 剃猬載剝漢満 噴僻鰨墩 ]

剔獰保廰JavaScript 據熱徬掀Netscape 噴擬

詑破: 穴続轅 HTTP 潦蝨， 脹善滅坪啞進瑣掀軒軒詑僻蝙誼

懷 善OAI議譯腔URL(?, 嘔蝨 ) 、韓醜謬譯譯議韓蘇譯特柯隅倉腔紫偶

American Memory [LoC]
Digital Cultural Heritage Community [UIUC]
Perseus [Open Language Archives]
RDN [Resource Discovery Network]

[ 脹胞紫偶讌俘 ][ 脢銃甜撚 嘀騷紫偶善掉毬篠 ]
7.10. RE Automatic Test Suite

Open Archives Initiative - Repository Explorer

explorer version 1.1 : protocol version 1.0 : April 2001

Open Archives Initiative :: Metadata Harvesting Protocol v1.0
Protocol Tester v1.1 :: Virginia Tech DLRL :: April 2001

Testing : Identify
URL : http://oai.dlib.vt.edu/~hussein/cgi-bin/NLTD/VTETD.pl?verb=Identify
Test Result : OK
---- [ Repository Name = Virginia Tech Electronic Thesis and Dissertation Collection ]
---- [ Protocol Version = 1.0 ]
---- [ Base URL = http://oai.dlib.vt.edu:80/~hussein/cgi-bin/NLTD/VTETD.pl ]
---- [ Admin Email = mailto:hussein@vt.edu ]

Testing : ListMetadataFormats
URL : http://oai.dlib.vt.edu/~hussein/cgi-bin/NLTD/VTETD.pl?verb=ListMetadataFormats
Test Result : OK
---- [ Sample Metadata Format = oai_rfc1807 ]

Testing : ListSets
URL : http://oai.dlib.vt.edu/~hussein/cgi-bin/NLTD/VTETD.pl?verb=ListSets
Test Result : OK
---- [ Sample Set Name = ill ]
# 7.11. RE Error in Response

## Archive Self-Description

<table>
<thead>
<tr>
<th>Repository Name</th>
<th>Virginia Tech Electronic Thesis and Dissertation Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base URL</td>
<td><a href="http://oai.dlib.vt.edu:80/~hussein/cgi-bin/NDLTDErr1/VTETD.pl">http://oai.dlib.vt.edu:80/~hussein/cgi-bin/NDLTDErr1/VTETD.pl</a></td>
</tr>
<tr>
<td>Protocol Version</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Error: Missing field: `<Identify/>/<adminEmail>`

```
otherInformation

description:
  oai-identifier:
  scheme: oai
  repositoryIdentifier: VTETD
  delimiter: :
  sampleIdentifier: oai:VTETD:etd-17110282975860

description:
  eprints:
    content:
      text: Theses and Dissertations produced by students at Virginia
metadataPolicy:
      text: Metadata may be used by commercial and non-commercial users
dataPolicy:
      text: Full texts are individually tagged and the rights statements
```

*JCDL 2001*
7.12. RE Error in XML

XSD Schema/Instance Validation Error!

Errors in XML instance

```xml
<?xml version='1.0'?>
  <xsi:schemaLocation>
    <xsi:schemaLocation>
      <xsi:schemaLocation>
        <xsi:schemaLocation>
          <xsi:schemaLocation>
            <xsi:schemaLocation>
              <xsi:schemaLocation>
                <xsi:schemaLocation>
                  <xsi:schemaLocation>
                    <xsi:schemaLocation>
                      <xsi:schemaLocation>
                        <xsi:schemaLocation>
                          <xsi:schemaLocation>
                            <xsi:schemaLocation>
                              <xsi:schemaLocation>
                                <xsi:schemaLocation>
                                  <xsi:schemaLocation>
                                    <xsi:schemaLocation>
                                      <xsi:schemaLocation>
                                        <xsi:schemaLocation>
                                          <xsi:schemaLocation>
                                            <xsi:schemaLocation>
                                              <xsi:schemaLocation>
                                                <xsi:schemaLocation>
                                                  <xsi:schemaLocation>
                                                    <xsi:schemaLocation>
                                                      <xsi:schemaLocation>
                                                        <xsi:schemaLocation>
                                                          <xsi:schemaLocation>
                                                            <xsi:schemaLocation>
                                                              <xsi:schemaLocation>
                                                                <xsi:schemaLocation>
                                                                  <xsi:schemaLocation>
                                                                    <xsi:schemaLocation>
                                                                      <xsi:schemaLocation>
                                                                        <xsi:schemaLocation>
                                                                          <xsi:schemaLocation>
                                                                            <xsi:schemaLocation>
                                                                              <xsi:schemaLocation>
                                                                                <xsi:schemaLocation>
                                                                                  <xsi:schemaLocation>
                                                                                    <xsi:schemaLocation>
 effortless transforms.

JCDL 2001
```
7.13. OAI Registry

The Open Archives Initiative

Registering as a Data Provider

Data providers who support the OAI protocol may choose to list their repository in the OAI registry. The goals of the registry are:

- Provide a publicly accessible list of OAI conformant repositories, making it easy for service providers to discover repositories from which metadata can be harvested.
- Provide a mechanism for data providers to ensure their conformance with the OAI protocol specification.
- Provide a means for the OAI to monitor use of the protocol and plan future activities and strategies.

This page allows you to register your repository by entering your BASE-URL in the text box at the bottom of this page. Before doing that, please read all of this instruction page so you understand what registration means and the choices you have.

Consequences of Registration
Protocol Testing
Conformance Testing

JCDL 2001
7.14. OAI Registry

The Open Archives Initiative

List of Registered, OAI-Conformant Repositories

This application allows you to browse the current list of OAI conforming repositories. Currently there are 29 such repositories. The table may be sorted either by the OAI Repository Identifier or by the Repository Name.

You may retrieve information about an OAI repository by selecting one of the rows in the following table. You may view the registration record from the database; alternatively, if your browser can render XML, you may issue the Identify request to the selected repository and receive the current XML response.

<table>
<thead>
<tr>
<th>OAI Repository Identifier</th>
<th>Repository Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>celebration</td>
<td>A Celebration of Women Writers</td>
</tr>
<tr>
<td>arlc</td>
<td>Alaska Native Language Center</td>
</tr>
<tr>
<td>arXiv</td>
<td>arXiv</td>
</tr>
<tr>
<td>CDLCIAS</td>
<td>California International and Area Studies Digital Repository</td>
</tr>
<tr>
<td>Japan GSDR</td>
<td>Japan GSDR</td>
</tr>
</tbody>
</table>

Sort repositories by:
- Repository Name
- OAI identifier

- view registration record
- issue Identify request

JCDL 2001
7.15. XSV Schema Validator

Validator for XML Schema 20000922 version, XML Output

XSV version: XSV 1.176/1.87 of 2001/02/16 16:38:43

NOTICE: This is an ALPHA TEST of a service for a work-in-progress specification. This version is for schema documents with the namespace URI http://www.w3.org/2000/10/XMLSchema and is being actively developed: see XSV for XML Schema 200004007 version for the no longer maintained previous version, for schema documents with the namespace URI http://www.w3.org/1999/XMLSchema.

Use this form for checking a schema which is accessible via the Web, and/or schema-validating an instance with a schema of your own.

Address(es):

Submit

JCDL 2001
8. Service Providers

How to Harvest
Policies
Intermediate systems
Tools
Case Study: ARC
Case Study: NDLTD
8.1. How To Harvest

- Identify to get basic information
- ListIdentifiers, followed by ListMetadataFormats for each record and then GetRecord for each id/metadata combination
  - No. of short HTTP requests = 1+n+n x m
    n=no. of identifiers, m=no. of metadata formats
- ListRecords for each metadata format required
  - No. of long HTTP requests = m
    m=no. of metadata formats
8.2. Policies

- Use schedule for harvesting regularly
- Store date when last harvested (before you start)
- Use a two day overlap (or one day if you work with the timezone of the source)
  - New items may be added for the current day
  - Timezones create up to a day of lag if you ignore them
- Each time a record is encountered, erase previous instances
8.3. Intermediate Systems

- Both a data provider and service provider
- All harvested data must have the datestamps updated to the date on which the harvesting was done
- Identifiers retain their original values
- Note: Consistency in the source archive propagates, but so does inconsistency!
8.4. Tools

- Check OAI website for sample code
- XML parsers – depending on platform – check W3C
- XML Schema validators
  - Very few available – the reference version works but may not be easy to install
  - Ignore validation if you can trust the source
- Sample data providers – check the OAI website for a list of conformant public archives
8.5. Case Study: ARC

Cross Archive Searching Service

This is page 1, hits (1–10) of total 66 hits.

SEARCH RESULTS

Title: Chemical Encoding for Information Visualization: Using Icon Color, Shape, and Size to Convey Nominal and Quantitative Data

Creators: Nowell, Lucille Terry

Description: Nowell/H3/center/ABSTRACT/Center/BpIn producing a user interface design to visualize search results for a digital library called En

Archive: ND0TD

8.6. Case Study: NDLTD

Search/Browse Engines
- VTLS Virtua
- MARIAN

Other Services
- Recommender
- Cross-Ref.

NDLTD ETD Union Catalog

- Virginia Tech
- Humboldt U.
- U. Oldenberg

...
9. OAI Communities

- Shared Metadata Formats
- Shared semantics
- Layering over OAI
- Closed OAI networks
- OAI within the DL
9.1. Shared Metadata Formats

Use metadata formats accepted within a community to convey more specific information

Examples

- E-Print format (under development)
- ETD-MS for theses and dissertations
- VRA Core for multimedia
- IMS Metadata for educational material
9.2. Shared Semantics

- Develop a shared understanding for the meanings of fields

- Examples
  - Developing controlled vocabularies for fields
  - Using specific fields for external links (OAI recommends using identifier in DC for this)
  - Choosing from among existing standards (like language names)
9.3. Layering over OAI

- Convert OAI records into more standard formats like MARC communications format
- Collapse multiple requests into one to make harvesting easier
- Name authority system (developed at OCLC) piggybacks name resolution over the OAI protocol
9.4. Closed OAI networks

- Data providers need not go public!
- Within an organization, OAI can be used for data transfer among heterogeneous systems
- More control over use, making global optimizations possible (like harvesting schedules and choice of metadata formats)
9.5. OAI within the DL

 bson the OAI protocol as the basis for components to communicate

 Examples

 - Search Engines could use dynamic sets to correspond to search results
 - Browsing can be directed by sets
 - Reviews and Annotations can each be independent OAI data providers
10. Now What?

- 1-2-3 Recipe
- Future of Metadata Harvesting Protocol
- Future of OAI
- Links
10.1. 1-2-3 Recipe

✶ DO I REALLY WANT TO DO THIS?
✶ Do I have an accessible metadata source?
✶ Do I have a server to host the OAI script/program?
✶ Can I satisfy the requirements to be a data provider?
✶ Can I write the code or modify a template or hire a programmer to do either?
10.2. Future of Protocol

✦ Version 1.1
  ✦ Soon – minor upgrade to cater for updates to schema language by W3C

✦ Evaluation
  ✦ Within a year – does this protocol make sense?
10.3. Future of OAI

- Advocacy for easier access to information
- New protocols/tools to support this mission
- Research projects to test theory underlying current architecture e.g. Cyclades
10.4. Links

- Open Archives Initiative
  - http://www.openarchives.org

- OAI Metadata Harvesting Protocol
  - http://www.openarchives.org/OAI/openarchivesprotocol.htm

- Virginia Tech DLRL OAI Projects
  - http://www.dlib.vt.edu/projects/OAI/

- Repository Explorer
  - http://purl.org/net/oai_explorer

- NDLTD
  - http://www.ndltd.org

JCDL 2001
10.5. More Links

🌟 ARC Cross-Archive Search Service
   🌟 http://arc.cs.odu.edu/

🌟 XML Schema Validator
   🌟 http://www.w3.org/2001/03/webdata/xsv

🌟 Dublin Core Metadata Initiative
   🌟 http://www.dublincore.org

🌟 E-Prints DL-in-a-box
   🌟 http://www.eprints.org

🌟 XML Tools at W3C
   🌟 http://www.w3.org/XML/#software
That’s All Folks!