LOCKSS Documentation Portal

LOCKSS Program

2024-03-26
# LOCKSS System

## 1 Releases

<table>
<thead>
<tr>
<th>Version</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>LOCKSS 2.0-alpha7</td>
<td>5</td>
</tr>
<tr>
<td>1.2</td>
<td>LOCKSS 1.77</td>
<td>5</td>
</tr>
<tr>
<td>1.3</td>
<td>Archived 2.x Releases</td>
<td>5</td>
</tr>
<tr>
<td>1.4</td>
<td>Archived 1.x Releases</td>
<td>6</td>
</tr>
</tbody>
</table>

## 2 Security

<table>
<thead>
<tr>
<th>CVE ID</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>CVE-2022-39135</td>
<td>9</td>
</tr>
<tr>
<td>2.2</td>
<td>CVE-2021-45105 and CVE-2021-44832</td>
<td>10</td>
</tr>
<tr>
<td>2.3</td>
<td>CVE-2021-44228, CVE-2021-45046 and CVE-2021-4104</td>
<td>11</td>
</tr>
</tbody>
</table>

## 3 Acknowledgments

<table>
<thead>
<tr>
<th>Acknowledgment</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13</td>
</tr>
</tbody>
</table>

# II LOCKSS Guides

## 4 LOCKSS Software Developer Guide

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Classic LOCKSS Development</td>
<td>17</td>
</tr>
<tr>
<td>4.2 License Templates</td>
<td>30</td>
</tr>
<tr>
<td>4.3 REST APIs</td>
<td>34</td>
</tr>
</tbody>
</table>

## 5 LOCKSS Plugin Developer Guide

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Introduction</td>
<td>35</td>
</tr>
<tr>
<td>5.2 Identification</td>
<td>44</td>
</tr>
<tr>
<td>5.3 Crawl Control</td>
<td>63</td>
</tr>
<tr>
<td>5.4 Crawl Validation</td>
<td>73</td>
</tr>
<tr>
<td>5.5 Poll Control</td>
<td>76</td>
</tr>
<tr>
<td>5.6 Hash Filtering</td>
<td>78</td>
</tr>
<tr>
<td>5.7 Metadata Extraction</td>
<td>81</td>
</tr>
<tr>
<td>5.8 Web Replay</td>
<td>89</td>
</tr>
<tr>
<td>5.9 Inheritance</td>
<td>90</td>
</tr>
<tr>
<td>5.10 Appendix</td>
<td>91</td>
</tr>
</tbody>
</table>

## 6 LOCKSS Network Administrator Guide

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>95</td>
</tr>
</tbody>
</table>

Index

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>97</td>
</tr>
</tbody>
</table>
Part I

LOCKSS System
1.1 LOCKSS 2.0-alpha7

development
  • LOCKSS 2.0.72-alpha7 (2023-09-02) latest
  • LOCKSS 2.0.71-alpha7 (2023-08-29)

1.2 LOCKSS 1.77

stable
  • LOCKSS 1.77.6 (2023-10-18) latest
  • LOCKSS 1.77.3 (2023-08-22)

1.3 Archived 2.x Releases

1.3.1 LOCKSS 2.0-alpha6
  • LOCKSS 2.0.61-alpha6 (2023-01-23)

1.3.2 LOCKSS 2.0-alpha5
  • LOCKSS 2.0.55-alpha5 (2022-07-06)
  • LOCKSS 2.0.54-alpha5 (2022-01-27)
  • LOCKSS 2.0.53-alpha5 (2022-01-24)
  • LOCKSS 2.0.52-alpha5 (2022-01-02)
  • LOCKSS 2.0.51-alpha5 (2021-12-17)
1.3.3 LOCKSS 2.0-alpha4

- LOCKSS 2.0.43-alpha4 (2021-12-15)
- LOCKSS 2.0.42-alpha4 (2021-12-13)
- LOCKSS 2.0.41-alpha4 (2021-06-28)

1.3.4 LOCKSS 2.0-alpha3

- LOCKSS 2.0.34-alpha3 (2021-06-04)
- LOCKSS 2.0.33-alpha3 (2021-01-29)
- LOCKSS 2.0.32-alpha3 (2020-11-09)
- LOCKSS 2.0.31-alpha3 (2020-10-29)

1.3.5 LOCKSS 2.0-alpha2

- LOCKSS 2.0.26-alpha2 (2020-02-26)
- LOCKSS 2.0.25-alpha2 (2020-02-25)
- LOCKSS 2.0.24-alpha2 (2020-02-25)
- LOCKSS 2.0.23-alpha2 (2020-02-16)
- LOCKSS 2.0.22-alpha2 (2020-02-10)
- LOCKSS 2.0.21-alpha2 (2020-02-06)

1.3.6 LOCKSS 2.0-alpha1

- LOCKSS 2.0.11-alpha1 (2019-05-13)

1.3.7 LOCKSS 2.0-alpha0

- LOCKSS 2.0-alpha technology preview (2019-04-05)

1.4 Archived 1.x Releases

1.4.1 LOCKSS 1.76

- LOCKSS 1.76.5 (2023-01-23)
1.4.2 LOCKSS 1.75

- LOCKSS 1.75.9 (2022-01-10)
- LOCKSS 1.75.8 (2021-12-06)
- LOCKSS 1.75.7 (2021-06-03)
- LOCKSS 1.75.5 (2021-02-10)

1.4.3 LOCKSS 1.74

- LOCKSS 1.74.10 (2020-06-29)
- LOCKSS 1.74.7 (2019-02-06)
- LOCKSS 1.74.3 (2018-11-06)
- LOCKSS 1.74.2 (2018-07-23)

1.4.4 Older Releases

- LOCKSS from 1.54.x to 1.74.3
- LOCKSS from 1.37.x to 1.53.x
- LOCKSS from 1.3.x to 1.36.x
Chapter Two

Security

This section discusses security issues related to the LOCKSS system.

<table>
<thead>
<tr>
<th>Date</th>
<th>Reference</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>2023-09-08</td>
<td>CVE-2022-39135</td>
<td>Does not affect LOCKSS 2.x to date</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="#">Read more...</a></td>
</tr>
<tr>
<td>2022-01-02</td>
<td>CVE-2021-45105 CVE-2021-44832</td>
<td>Affects LOCKSS 2.x up to and including 2.0.51-alpha5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resolved in LOCKSS 2.0.52-alpha5</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="#">Read more...</a></td>
</tr>
<tr>
<td>2021-12-13</td>
<td>CVE-2021-44228 CVE-2021-45046 CVE-2021-4104</td>
<td>Affects LOCKSS 2.x up to and including 2.0.42-alpha4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resolved in LOCKSS 2.0.43-alpha4</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="#">Read more...</a></td>
</tr>
</tbody>
</table>

### 2.1 CVE-2022-39135

*First published: 2023-09-08*

**Tip:** LOCKSS 2.x to date (2.0.72-alpha7 as of this writing), when used with its embedded Apache Solr container, is not affected by CVE-2022-39135.

The successive embedded Apache Solr containers used by default in LOCKSS 2.x up to and including version 2.0.72-alpha7, namely versions 6.6.5, 7.2.1, and 8.11.2 of Solr, are not used in the vulnerable manner described in CVE-2022-39135. No action is required if using LOCKSS 2.0.72-alpha7 or earlier with embedded Solr (the default mode).
2.2 CVE-2021-45105 and CVE-2021-44832

First published: 2022-01-02

Attention: The LOCKSS 2.x system up to and including 2.0.51-alpha5, and the custom Solr and OpenWayback containers it includes, are affected by CVE-2021-45105 and CVE-2021-44832.

Description

Following the early December 2021\(^1\) discovery of well-publicized critical remote code execution vulnerabilities in Apache Log4j 2.x, a ubiquitous Java library for recording information to software logs, additional Log4j 2.x vulnerabilities of moderate severity have been discovered, tracked as CVE-2021-45105 and CVE-2021-44832.

These vulnerabilities affect the LOCKSS system 2.x up to and including 2.0.51-alpha5 (originally released 2021-12-17), and the custom Solr and OpenWayback containers it includes, requiring an upgrade to fix.

Note that the LOCKSS 1.x system is not affected by these vulnerabilities, requiring no action at this time.

Remediation

Attention: The recommended remediation is to upgrade LOCKSS 2.0.51-alpha5 and earlier to LOCKSS 2.0.52-alpha5 or later.

To upgrade from LOCKSS 2.0.51-alpha5 to 2.0.52-alpha5:

1. Log in to the host system as the lockss user and navigate to the lockss-installer directory.
2. Stop the LOCKSS system with this command:
   ```bash
   scripts/stop-lockss
   ```
3. Upgrade the LOCKSS Installer to 2.0.52-alpha5 with this command:
   ```bash
   curl -sSfL https://www.lockss.org/downloader | sh -s --git-tag=version-2.0.52-alpha5
   ```
   or:
   ```bash
   wget -qO- https://www.lockss.org/downloader | sh -s --git-tag=version-2.0.52-alpha5
   ```
4. Restart the LOCKSS system with this command:

\(^{1}\) See CVE-2021-44228, CVE-2021-45046 and CVE-2021-4104.
To upgrade from LOCKSS 2.0-alpha4 (all variants) to LOCKSS 2.0.52-alpha5, see Upgrading From LOCKSS 2.0-alpha4 in the LOCKSS 2.0-alpha5 System Manual.

To upgrade from LOCKSS 2.x version 2.0-alpha3 or earlier (all variants) to LOCKSS 2.0.52-alpha5, you will need to upgrade incrementally; see Upgrading From LOCKSS 2.0-alpha1, Upgrading From LOCKSS 2.0-alpha2, Upgrading From LOCKSS 2.0-alpha3, and Upgrading From LOCKSS 2.0-alpha4.

Important: If you use the LOCKSS 2.x system with an external Solr database or external OpenWayback replay engine, talk to your system administrator about ensuring these external systems, which can also be affected by these vulnerabilities, are up to date.

References

- https://nvd.nist.gov/vuln/detail/CVE-2021-45105
- https://nvd.nist.gov/vuln/detail/CVE-2021-44832
- https://logging.apache.org/log4j/2.x/security.html

## 2.3 CVE-2021-44228, CVE-2021-45046 and CVE-2021-4104

First published: 2021-12-13
Last updated: 2022-01-02

Attention: The LOCKSS 2.x system up to and including version 2.0.42-alpha4, and the custom Solr and OpenWayback containers it includes, are affected by CVE-2021-44228 ("Log4Shell"), CVE-2021-45046 and CVE-2021-4104.

Description

A critical remote code execution vulnerability has been identified in Apache Log4j 2.x, a ubiquitous Java library for recording information to software logs. Tracked as CVE-2021-44228 and also nicknamed "Log4Shell" or "LogJam", this vulnerability led to the discovery of another critical remote code execution vulnerability severe in Log4j 2.x (CVE-2021-45046) and a related vulnerability in Log4j 1.x (CVE-2021-4104).

These vulnerabilities affect the LOCKSS system 2.x up to and including version 2.0.42-alpha4b, and the custom Solr and OpenWayback containers it includes, requiring an upgrade to fix.

Note that the LOCKSS 1.x system is not affected by these vulnerabilities, requiring no action at this time.
Remediation

**Attention:** Because additional vulnerabilities in Log4j 2.x have been discovered, the recommended remediation is to upgrade to LOCKSS version 2.0.42-alpha4 and earlier to LOCKSS 2.0.52-alpha5 immediately.

If you cannot upgrade LOCKSS 2.0.42-alpha4 and earlier to LOCKSS 2.0.52-alpha5 in a timely manner, we recommend at least shutting it down by logging in as the `lockss` user, navigating to the `lockss-installer` directory, and running the command `scripts/stop-lockss`, until such time as you are able to perform an upgrade.

- To upgrade from LOCKSS 2.0-alpha4 (all variants) to LOCKSS 2.0.52-alpha5, see Upgrading From LOCKSS 2.0-alpha4 in the LOCKSS 2.0-alpha5 System Manual.
- To upgrade from LOCKSS 2.0-alpha3 and earlier (all variants), you will need to upgrade incrementally; see Upgrading From LOCKSS 2.0-alpha1, Upgrading From LOCKSS 2.0-alpha2, Upgrading From LOCKSS 2.0-alpha3, and Upgrading From LOCKSS 2.0-alpha4.

**Important:** If you use the LOCKSS 2.x system with an external Solr database or external OpenWayback replay engine, talk to your system administrator about ensuring these external systems, which can also be affected by these vulnerabilities, are up to date.

**References**

- https://nvd.nist.gov/vuln/detail/CVE-2021-44228
- https://nvd.nist.gov/vuln/detail/CVE-2021-45046
- https://nvd.nist.gov/vuln/detail/CVE-2021-4104
- https://logging.apache.org/log4j/2.x/security.html
The LOCKSS Program is grateful to the many open source software projects on which LOCKSS software relies. We use the JProfiler Java profiler by ej-technologies GmbH.
Part II

LOCKSS Guides
4.1 Classic LOCKSS Development

The code base of the Classic LOCKSS system (version 1.x) is contained in a single Git repository, https://github.com/lockss/lockss-daemon.

4.1.1 Prerequisites

To do development work with the Classic LOCKSS system (version 1.x), you will need:

- Git
- Java 8 Development Kit (JDK 8), for example OpenJDK 8
- Apache Ant
- Python 3, invoked as python3
- Some scripts require Python 2.7, invoked as python2
- Some runtime contexts that process split Zip files and some unit tests require the zip program (zip and unzip are installed by default on most Linux systems).

Installing Git

You can check if Git is installed on your system by typing git --version at the command line and seeing if you get a valid response. If you need to install Git, select your operating system below and follow the instructions (as root, except for Homebrew on MacOS):
AlmaLinux OS

To install Git, run this Dnf command (as root):

dnf --assumeyes install git

Arch Linux

To install Git, run this Pacman command (as root):

pacman -Sy --noconfirm git

CentOS

CentOS Stream 8-9

To install Git, run this Dnf command (as root):

dnf --assumeyes install git

CentOS 8

To install Git, run this Dnf command (as root):

dnf --assumeyes install git

CentOS 7

To install Git, run this Yum command (as root):

yum --assumeyes install git

Debian

To install Git, run these Apt commands (as root):

apt update
apt install --assume-yes git
EuroLinux

EuroLinux 8-9

To install Git, run this Dnf command (as root):

dnf --assumeyes install git

EuroLinux 7

To install Git, run this Yum command (as root):

yum --assumeyes install git

Fedora Linux

To install Git, run this Dnf command (as root):

dnf --assumeyes install git

Linux Mint

To install Git, run these Apt commands (as root):

apt update
apt install --assume-yes git

MacOS

Homebrew

To install Git, run this Homebrew command:

brew install git

MacPorts

To install Git, run this MacPorts command (as root):

sudo port install git
OpenSUSE

OpenSUSE Leap 15

To install Git, run these Zypper commands (as root):

```bash
zypper refresh
zypper --non-interactive install git
```

OpenSUSE Tumbleweed

To install Git, run these Zypper commands (as root):

```bash
zypper refresh
zypper --non-interactive install git
```

Oracle Linux

Oracle Linux 8-9

To install Git, run this Dnf command (as root):

```bash
dnf --assumeyes install git
```

Oracle Linux 7

To install Git, run this Yum command (as root):

```bash
yum --assumeyes install git
```

RHEL

RHEL 7

To install Git, run this Yum command (as root):

```bash
yum --assumeyes install git
```
RHEL 8-9

To install Git, run this Dnf command (as root):

```
dnf --assumeyes install git
```

Rocky Linux

To install Git, run this Dnf command (as root):

```
dnf --assumeyes install git
```

Scientific Linux

To install Git, run this Yum command (as root):

```
yum --assumeyes install git
```

Ubuntu

To install Git, run these Apt commands (as root):

```
apt update
apt install --assume-yes git
```

Installing the Java Development Kit

1. You can check if a Java Development Kit (JDK) is installed on your system by typing `javac -version` at the command line and seeing if you get a valid response. (The version numbers output by Java 8 software sometimes use the notation 1.8, for example `1.8.0_382`.)

   If you need to install a JDK, we recommend OpenJDK; select your operating system below and follow the instructions (as root, except for Homebrew on MacOS):

   AlmaLinux OS

   To install OpenJDK, run this Dnf command (as root):

   ```
dnf --assumeyes install java-1.8.0-openjdk-devel
```
Arch Linux

To install OpenJDK, run this Pacman command (as root):

```
pacman -Sy --noconfirm jdk8-openjdk
```

CentOS

CentOS Stream 8-9

To install OpenJDK, run this Dnf command (as root):

```
dnf --assumeyes install java-1.8.0-openjdk-devel
```

CentOS 8

To install OpenJDK, run this Dnf command (as root):

```
dnf --assumeyes install java-1.8.0-openjdk-devel
```

CentOS 7

To install OpenJDK, run this Yum command (as root):

```
yum --assumeyes install java-1.8.0-openjdk-devel
```

Debian

To install OpenJDK, run these Apt commands (as root):

```
apt update
apt install --assume-yes openjdk-8-jdk
```

EuroLinux

EuroLinux 8-9

To install OpenJDK, run this Dnf command (as root):

```
dnf --assumeyes install java-1.8.0-openjdk-devel
```
EuroLinux 7

To install OpenJDK, run this Yum command (as root):

```
yum --assumeyes install java-1.8.0-openjdk-devel
```

Fedora Linux

To install OpenJDK, run this Dnf command (as root):

```
dnf --assumeyes install java-1.8.0-openjdk-devel
```

Linux Mint

To install OpenJDK, run these Apt commands (as root):

```
apt update
apt install --assume-yes openjdk-8-jdk
```

MacOS

Homebrew

To install OpenJDK, run this Homebrew command:

```
brew install openjdk@8
```

Note: You may be directed to create symlinks and/or update your PATH to make OpenJDK visible to your system, for instance:

```
For the system Java wrappers to find this JDK, symlink it with:
    sudo ln -sfn /usr/local/opt/openjdk@8/libexec/openjdk.jdk /Library/Java/
    →JavaVirtualMachines/openjdk-8.jdk

openjdk@8 is keg-only, which means it was not symlinked into /usr/local, because this is an alternate version of another formula.

If you need to have openjdk@8 first in your PATH, run:
    echo 'export PATH="/usr/local/opt/openjdk@8/bin:$PATH"' >> ~/.zshrc

For compilers to find openjdk@8 you may need to set:
    export CPPFLAGS="-I/usr/local/opt/openjdk@8/include"
```
MacPorts

To install OpenJDK, run this MacPorts command (as root):

```
sudo port install openjdk
```

OpenSUSE

OpenSUSE Leap 15

To install OpenJDK, run these Zypper commands (as root):

```
zypper refresh
zypper --non-interactive install java-1_8_0-openjdk-devel
```

OpenSUSE Tumbleweed

To install OpenJDK, run these Zypper commands (as root):

```
zypper refresh
zypper --non-interactive install java-1_8_0-openjdk-devel
```

Oracle Linux

Oracle Linux 8-9

To install OpenJDK, run this Dnf command (as root):

```
dnf --assumeyes install java-1.8.0-openjdk-devel
```

Oracle Linux 7

To install OpenJDK, run this Yum command (as root):

```
yum --assumeyes install java-1.8.0-openjdk-devel
```

RHEL

RHEL 8-9

To install OpenJDK, run this Dnf command (as root):

```
dnf --assumeyes install java-1.8.0-openjdk-devel
```
**RHEL 7**

To install OpenJDK, run this Yum command (as root):

```
yum --assumeyes install java-1.8.0-openjdk-devel
```

**Rocky Linux**

To install OpenJDK, run this Dnf command (as root):

```
dnf --assumeyes install java-1.8.0-openjdk-devel
```

**Scientific Linux**

To install OpenJDK, run this Yum command (as root):

```
yum --assumeyes install java-1.8.0-openjdk-devel
```

**Ubuntu**

To install OpenJDK, run these Apt commands (as root):

```
apt update
apt install --assume-yes openjdk-8-jdk
```

2. Set the `JAVA_HOME` environment variable to the directory in which the JDK is installed, for example `/usr/lib/jvm/java-8-openjdk` or similar for Linux or `/usr/local/opt/openjdk@8/libexec/openjdk.jdk/Home` for MacOS with Homebrew. It is expected that the file `$JAVA_HOME/lib/tools.jar` exists.

**Installing Apache Ant**

You can check if Ant is installed on your system by typing `ant -version` at the command line and seeing if you get a valid response. If you need to install Ant, select your operating system below and follow the instructions (as root, except for Homebrew on MacOS):

**AlmaLinux OS**

To install Ant, run this Dnf command (as root):

```
dnf --assumeyes install ant
```
Arch Linux

To install Ant, run this Pacman command (as root):

```
pacman -Sy --noconfirm ant
```

CentOS

CentOS Stream 8-9

To install Ant, run this Dnf command (as root):

```
dnf --assumeyes install ant
```

CentOS 8

To install Ant, run this Dnf command (as root):

```
dnf --assumeyes install ant
```

CentOS 7

To install Ant, run this Yum command (as root):

```
yum --assumeyes install ant
```

Debian

To install Ant, run these Apt commands (as root):

```
apt update
apt install --assume-yes ant
```

EuroLinux

EuroLinux 8-9

To install Ant, run this Dnf command (as root):

```
dnf --assumeyes install ant
```
EuroLinux 7
To install Ant, run this Yum command (as root):

```
yum --assumeyes install ant
```

Fedora Linux
To install Ant, run this Dnf command (as root):

```
dnf --assumeyes install ant
```

Linux Mint
To install Ant, run these Apt commands (as root):

```
apt update
apt install --assume-yes ant
```

MacOS

Homebrew
To install Ant, run this Homebrew command:

```
brew install ant
```

MacPorts
To install Ant, run this MacPorts command (as root):

```
sudo port install apache-ant
```

OpenSUSE

OpenSUSE Leap 15
To install Ant, run these Zypper commands (as root):

```
zypper refresh
zypper --non-interactive install ant
```
OpenSUSE Tumbleweed

To install Ant, run these Zypper commands (as root):

```
zypper refresh
zypper --non-interactive install ant
```

Oracle Linux

Oracle Linux 8-9

To install Ant, run this Dnf command (as root):

```
dnf --assumeyes install ant
```

Oracle Linux 7

To install Ant, run this Yum command (as root):

```
yum --assumeyes install ant
```

RHEL

RHEL 8-9

To install Ant, run this Dnf command (as root):

```
dnf --assumeyes install ant
```

RHEL 7

To install Ant, run this Yum command (as root):

```
yum --assumeyes install ant
```

Rocky Linux

To install Ant, run this Dnf command (as root):

```
dnf --assumeyes install ant
```
**Scientific Linux**

To install Ant, run this Yum command (as root):

```
yum --assumeyes install ant
```

**Ubuntu**

To install Ant, run these Apt commands (as root):

```
apt update
apt install --assume-yes ant
```

**Cloning the Git Repository**

To clone the lockss-daemon repository from Git, use one of these commands:

```
# GitHub account with SSH key
git clone git@github.com:lockss/lockss-daemon

# Anonymous access
git clone https://github.com/lockss/lockss-daemon
```

This will create a lockss-daemon directory.

**JUnit Prerequisites**

JUnit 3.8.1 is included is included in the LOCKSS source distribution to run unit tests, but the Ant targets that invoke JUnit (test-xxx) require the JUnit JAR to be on Ant's CLASSPATH. The easiest way to do this is to copy lib/junit.jar (relative to the root of the lockss-daemon Git tree) into Ant's lib directory (relative to its installation directory on the system).

**4.1.2 Tour of lockss-daemon**

The main components of the lockss-daemon repository are as follows:

- `build.xml` is the Ant build file. Type `ant -projecthelp` (or `ant -p`) will output a list of available build targets. The `lib` directory contains Java (JAR) dependencies for the project at large.

- The `src` tree contains the source code of the LOCKSS system proper, and `test/src` its unit tests. The `ant/src` tree contains the source code for an ancillary prerequisite.

- The `plugins/src` tree contains the source code of plugins written by the LOCKSS Program to support the preservation activities of LOCKSS networks such as the Global LOCKSS Network (GLN) and the CLOCKSS Archive, and `plugins/test/src` the unit tests.

- The `tools/src` tree contains the source code of ancillary tools sometimes used in the context of LOCKSS development, and `tools/test/src` the unit tests.

- The `tdb` directory contains the archival unit (AU) inventory of content managed by the LOCKSS Program on behalf of various LOCKSS networks such as the GLN and CLOCKSS.
4.2 License Templates

Unless otherwise noted, software released by the LOCKSS Program is made available under the terms of the 3-Clause BSD License, a permissive open-source license. You can use the templates below to add the license to files of various kinds:

- Bash: see Shell
- Dockerfile: see Shell
- HTML: see XML
- Java
- Plain Text
- Python
- Shell
- XML
- YAML: see Shell

4.2.1 Plain Text

The following template can be used in plain text contexts, for example the LICENSE file at the top of a Git repository.

---

Copyright (c) 2000-2024, Board of Trustees of Leland Stanford Jr. University

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.

2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

3. Neither the name of the copyright holder nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE

(continues on next page)

---

1 See also the Software License page on the LOCKSS Web site.
4.2.2 Java

The following template can be used for Java files.

```java
/*

Copyright (c) 2000-2024, Board of Trustees of Leland Stanford Jr. University

Redistribution and use in source and binary forms, with or without
modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice,
   this list of conditions and the following disclaimer.

2. Redistributions in binary form must reproduce the above copyright notice,
   this list of conditions and the following disclaimer in the documentation
   and/or other materials provided with the distribution.

3. Neither the name of the copyright holder nor the names of its contributors
   may be used to endorse or promote products derived from this software without
   specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS"
AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE
LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR
CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF
SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS
INTERUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN
CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE)
ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE
POSSIBILITY OF SUCH DAMAGE.

*/
```
4.2.3 Python

The following template can be used for Python files.

```python
__copyright__ = '''\nCopyright (c) 2000-2024, Board of Trustees of Leland Stanford Jr. University
'''

__license__ = '''\nRedistribution and use in source and binary forms, with or without
modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice,
   this list of conditions and the following disclaimer.

2. Redistributions in binary form must reproduce the above copyright notice,
   this list of conditions and the following disclaimer in the documentation
   and/or other materials provided with the distribution.

3. Neither the name of the copyright holder nor the names of its contributors
   may be used to endorse or promote products derived from this software without
   specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS"
AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE
LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR
CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF
SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS
INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN
CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE)
ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE
POSSIBILITY OF SUCH DAMAGE.
'''
```

4.2.4 Shell

The following template can be used for Shell files.

Tip: This also works for Bash files, Dockerfile files, Python requirements files, or YAML files.

```bash
# Copyright (c) 2000-2024, Board of Trustees of Leland Stanford Jr. University
#
# Redistribution and use in source and binary forms, with or without
# modification, are permitted provided that the following conditions are met:
#
# 1. Redistributions of source code must retain the above copyright notice,
#    this list of conditions and the following disclaimer.
#
# 2. Redistributions in binary form must reproduce the above copyright notice,
#    this list of conditions and the following disclaimer in the documentation
#    and/or other materials provided with the distribution.

(continues on next page)```
4.2.5 XML

The following template can be used for XML files.

**Tip:** This also works for HTML files.

```xml
<!--
Copyright (c) 2000-2024, Board of Trustees of Leland Stanford Jr. University

Redistribution and use in source and binary forms, with or without
modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice,
   this list of conditions and the following disclaimer.

2. Redistributions in binary form must reproduce the above copyright notice,
   this list of conditions and the following disclaimer in the documentation
   and/or other materials provided with the distribution.

3. Neither the name of the copyright holder nor the names of its contributors
   may be used to endorse or promote products derived from this software without
   specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS"
AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE
LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR
CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF
SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS
INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN
CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE)
ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE
POSSIBILITY OF SUCH DAMAGE.
-->
4.3 REST APIs

The API of each LOCKSS REST service is described in a Swagger 2.0 specification, which can be found relative to the root of the component's Git repository in the file `src/main/resources/swagger/swagger.yaml`. The specification can be used as input into another tool, to produce clients and server stubs in a variety of languages and frameworks, and documentation. This guide contains HTML renderings of each specification generated with Swagger Codegen.
5.1 Introduction

This section offers a conceptual tour of LOCKSS plugins and a brief XML format reference.

5.1.1 LOCKSS Plugin Concepts

LOCKSS Plugin

A LOCKSS plugin is a bundle of descriptors, rules and code loaded into the LOCKSS software, describing how to harvest and process a preservation target.

A preservation target might be an individual Web site, or a family of related Web sites (for instance all Web sites powered by the same content publishing platform), or a corpus of Web-accessible resources discovered through some interface (for example an OAI-PMH server, or a service with an API).

Archival Unit

In almost all cases, the preservation target is preserved in plugin-defined chunks called archival units (or AUs for short).

What these chunks are depends on the situation, but generally the goal is to split the preservation target into chunks of manageable size that are expected to become unchanging eventually, for instance time-bound chunks. For example, in a LOCKSS plugin for a preservation target that consists of serial publications, an AU could be equated with one volume or one year of one publication.
Plugin Configuration Parameters

A LOCKSS plugin leaves placeholders in rules and code called Plugin Configuration Parameters. An AU is identified by a plugin and values for each of the plugin's configuration parameters. When the parameter values for an AU are substituted for the placeholders in the plugin's rules and code, the result is rules and code suited for that specific AU.

Typical plugin parameters include a URL prefix or URL fragment (e.g. base URL, directory name...), an identifier (e.g. ISSN of a journal, ISBN of a book, publication code, database identifier of an object...), a year or a date range, a part number (e.g. volume number, numbered subdivision...), and more.

Plugin Format

A LOCKSS plugin is expressed as a mapping from keys to values. Except for rare exceptions that are built into the LOCKSS software, LOCKSS plugins consist of an XML file containing these key-value pairs, accompanied by optional Java class files (compiled Java code), bundled together in a JAR file (a Zip file of Java class files and associated metadata).

Plugin Feature Categories

This guide groups plugin components into conceptual categories, which are introduced briefly in subsections below and have a dedicated section each in this guide:

- **Identification Features**: features related to the identification, versioning and parameterization of the plugin.
- **Crawl Control Features**: features related to the definition and behavior of content crawls.
- **Crawl Validation Features**: features related to content validation in the context of a crawl.
- **Poll Control Features**: features that influence the operation of the LOCKSS audit and repair protocol.
- **Hash Filtering Features**: features related to content canonicalization for inter-node comparison purposes.
- **Metadata Extraction Features**: features related to the extraction and interpretation of metadata from preserved content.
- **Web Replay Features**: features related to supporting the replay of Web content.
- **Inheritance Features**: features related to sharing similar behavior among a set of plugins.
- **Miscellaneous Features**.

Identification Features

All plugins define a number of identifying aspects:

- **Plugin Identifier**: a unique identifier for the plugin.
- **Plugin Name**: a user-friendly name for the plugin.
- **Plugin Version**: the plugin's version number.
- **Plugin Configuration Parameters**: a list of configuration parameter descriptors, defining the placeholders in use in the plugin's rules and code.
- **AU Name**: a rule to generate a default name for each AU based on the plugin name and the plugin parameters, in the event the AU does not have a name in the AU inventory.
- **Required Daemon Version**: the release number of the earliest version of the LOCKSS software that supports all the features required by the plugin.
The Identification chapter covers these plugin aspects.

Crawl Control Features

The following plugin aspects can be involved in controlling how content is crawled:

- **Start URLs**: one or more URLs from which the crawl of an AU begins.

- **Crawl Seed**: in lieu of a list of start URLs, code called a crawl seed can compute the starting points of the crawl of an AU, for instance by interacting with an API.

- **Permission URLs**: one or more URLs giving the LOCKSS software permission to crawl an AU, if permission is not given on the start URLs.

- **Per-Host Permission Path**: path where permission statement may be found on hosts not listed in start URLs or Permission URLs. Useful for sites such as Internet Archive that have banks of similar hosts with unpredictable names.

- **Permitted Host Pattern**: pattern rules to allow collection from hosts that cannot explicitly grant permission, for example CDN hosts used to distribute standard components used by web sites such as Javascript libraries.

- **Crawl Rules**: sequential rules determining if a URL discovered during the crawl of an AU should in turn be fetched as part of the AU or not.

- **Crawl Window**: a crawl window controls what times of day or days of the week crawls against the preservation target are allowed; by default an AU is eligible to crawl at any time.

- **Recrawl Interval**: the amount of time before an AU that has previously been crawled successfully is eligible to attempt crawling again.

- **Refetch Depth**: number of links away from the start URL(s) that will be fetched by normal crawls. Deep crawls may be used to cause all URLs in an AU to be refetched (subject to If-Modified-Since).

- **Fetch Pause Time**: the minimum amount of time between two fetches of consecutive URLs in the crawl of an AU.

- **Crawl Rate Limiter**: fine-grained control of the maximum rate at which URLs may be fetched, based on media type, URL pattern, day of week or time of day.

- **Crawl Pool**: controls the number of simultaneous crawls that may be running against any one host or platform.

- **Response Handler**: custom action taken when fetching a URL results in certain error conditions or HTTP response codes.

- **URL Normalizer**: code that normalizes URL variants into canonical URLs.

- **Link Extractor**: media type-specific code that extracts or extrapolates URLs from the collected content, to allow the crawler to follow links. Link extractors are built in for most standard media types that contain links (HTML, CSS, PDF, etc.); plugins may supply link extractors for additional media types or extend the built-in extractors to handle additional constructs.

- **Crawl Filter**: code that filters content before a link extractor is run. Supplements the crawl rules in cases where more context it needed to determine whether a link should be followed.

- **URL Fetcher**: custom code to fetch URLs, for cases that require a more elaborate interaction than a single GET.

- **URL Consumer**: custom code to store collected URLs in the repository. E.g., for sites that redirect permanent URLs to one-time URLs, to store the content at the permanent URL, or to adapt to sites undergoing HTTP to HTTPS transitions

The Crawl Control chapter covers these plugin aspects.
Crawl Validation Features

A plugin can optionally define aspects that help verify that the crawl is obtaining the content it is supposed to:

- **Redirect to Login URL Pattern**: determines whether an HTTP redirect returned by the site is actually a redirect to a login page.
- **Login Page Checker**: determines if a URL fetched successfully (HTTP 200) is in fact a login page or some other undesirable substitute for the intended content.
- **Content Validator**: code that determines if certain URLs pass a validation test, most often a media type check or format validation test.
- **Substance Patterns**: pattern rules to check that at least one URL processed during the crawl of an AU is substantive (non-trivial), for example to verify that at least one substantive object was processed rather than just tables of contents.
- **Substance Predicate**: code that determines whether a collected URL has substantive content. Alternative to substance patterns, allows programmatic substance determination.

The *Crawl Validation* chapter covers these plugin aspects.

Poll Control Features

These plugin elements include:

- **Exclude URLs From Polls Pattern**: patterns for URLs that should not be included in polls.
- **Poll Result Weight**: patterns for URLs to allow some disagreements to influence the results more than others.
- **Repair From Publisher When Too Close**: instructs the poller to fetch a new copy of files from the origin site when too-few peers agree on the content.
- **Repair From Peer If Missing**: patterns for URLs that should be fetched from a peer, when the poller detects that they're missing.

The *Poll Control* chapter covers these plugin aspects.

Hash Filtering Features

Many plugins designed to harvest and preserve Web-native content need to go to some lengths to enable comparison of (hashes of) content between the nodes in a LOCKSS network, because fetching a given URL is likely to result in non-identical results from node to node, or from fetch to fetch on the same node. This is due to a raft of causes: advertising banners, personalization ("You are logged in as...", "Downloaded by..."), time-variable content (current date, news ticker), location-variable content (CDN URLs, institution-dependent integration with a link resolver), related content widgets ("You may also be interested in..."), reverse citations and pingbacks ("This page has been referenced by..."), tracking data and watermarking embedded in the content, temporary system messages ("The site will be down for maintenance from..."), and more. Some of these variations now appear outside HTML in media types like PDF or Microsoft PowerPoint files.

To canonicalize content before comparison between nodes in the LOCKSS audit and repair protocol, a plugin can define a hash filter for each affected media type. The LOCKSS plugin framework offers a variety of utility classes specifically for HTML and PDF filtering, as part of its general content filtering framework.

See the *Hash Filtering* chapter for more details.
**Metadata Extraction Features**

The LOCKSS plugin framework enables the extraction of metadata from ingested content, through an extensible metadata extraction framework; a plugin can optionally define:

- **Article Iterator**: code that traverses the AU and enumerates all the logical items (journal articles, electronic books, electronic theses and dissertations, repository objects...) found in it, as bundles of related URLs.

- **Article Metadata Extractor**: code that extracts metadata from the logical items enumerated by the article iterator using file metadata extractors, and that post-processes and stores the extracted metadata in the LOCKSS metadata database.

- **File Metadata Extractor**: code that extracts metadata from files with a given media type.

The *Metadata Extraction* chapter covers these plugin aspects.

**Web Replay Features**

A plugin can define optional elements that are applied by the embedded ServeContent Web replay engine:

- **Link Rewriter**: code used by the built-in ServeContent replay engine that changes intra-site links or other URLs to point back to the ServeContent host. Link rewriters are built in for most standard media types that contain links (html, css, javascript, etc.); plugins may supply link rewriters for additional media types or extend the built in rewriters to handle additional constructs.

- **Rewrite HTML Meta URLs**: pattern that determines which HTML meta tags have values that should be rewritten during web replay. Some tags (e.g., citation URLs) should not be rewritten to point back to the ServeContent host.

The *Web Replay* chapter covers these plugin aspects.

**Inheritance Features**

Commonalities among a set of similar plugins may be abstracted out in to a parent plugin, to reduce duplication. Each child plugin inherits all the elements of the parent plugin.

- **Parent Plugin**: names the parent plugin from which this plugin should inherit elements.

- **Parent Plugin Version**: the version number of the parent plugin, to guard against changed to a parent inadvertently changing the behavior of a child plugin.

The *Inheritance* chapter covers these plugin aspects.

**Miscellaneous Features**

- **Feature Version Map**: associates version strings with several of the plugin elements. For polling-related elements such as hash filters, the version is used to determine which other peers a peer may invite into polls - the plugin’s polling version must be the same across all peers participating in a poll. For metadata extractors and substance checker patterns, the version is used to detect when a change in the plugin may require content to be reprocessed.

- **Feature URLs**: provides information to allow the Open URL resolver to locate articles, issue ToCs, etc.

- **Bulk Content**: declares that the AUs managed by the plugin are not organized semantically (e.g., they may span publications). Affects metadata extraction.

- **Archive File Types**: specifying the types of archive files (zip, tar, etc.) in this plugin’s AUs whose members will be individually accessible. Usually used with bulk content plugins to index metadata for archive members.
• **AU Config User Message**: text displayed when a user adds one or more AUs managed by this plugin. Typically used when a site requires crawlers to register with them.

• **Plugin Notes**: commentary displayed along with a plugin’s definition in the UI.

**Minimalistic Plugin**

A simple plugin will likely have at minimum:

- Identifying aspects, including configuration parameters.
- Start URLs, and optionally permission URLs.
- Crawl rules.

If extracting metadata from the preserved content into the LOCKSS metadata database is desired, the plugin will also need:

- Metadata extraction elements, including an article iterator.

If the preserved content consists of non-static HTML Web pages, it will likely need:

- Hash filters.

Use of other aspects is situation-dependent, varying in need based on characteristics and behavior of the preservation target. This guide gives some guidance about when certain components are needed and to what purpose.

**Plugin Compatibility Between LOCKSS 1.x and LOCKSS 2.x**

Conceptually, LOCKSS plugins are the same in the classic LOCKSS system (LOCKSS 1.x) and in the rearchitected LOCKSS system (LOCKSS 2.x), although future features will only be developed for the rearchitected LOCKSS system without being backported to the classic LOCKSS system, as the classic system becomes deprecated.

**5.1.2 LOCKSS Plugin Format**

A LOCKSS plugin is expressed as a mapping from keys to values. Except for rare exceptions that are built into the LOCKSS software, LOCKSS plugins consist of an XML file containing these key-value pairs, accompanied by optional Java class files (compiled Java code), bundled together in a JAR file (a Java-specific Zip file).

The XML format of the plugin is a single `<map>` element, containing any number of `<map entry>` elements. Each map entry is a key-value pair, namely a plugin key which must be the first child of the `<entry>` element and must be of type `String`, and a plugin value which must be the second child of the `<entry>` element. See the Plugin Value Types for more about possible plugin values.

The order of the key-value pairs does not matter. The effect of specifying multiple entries with the same key is undefined.

Example:

```xml
<map>

<!-- plugin key with string value -->
<entry>
    <string>key_one</string>
    <string>Lots Of Copies Keep Stuff Safe</string>
</entry>

<!-- plugin key with integer value -->
</map>
```

(continues on next page)
<entry>
   <string>key_two</string>
   <int>3000</int>
</entry>

<!-- plugin key with long integer value (e.g. number of milliseconds) -->
<entry>
   <string>key_three</string>
   <long>1209600000</long>
</entry>

<!-- plugin key with list value (e.g. list of strings) -->
<entry>
   <string>key_four</string>
   <list>
      <string>List item one</string>
      <string>List item two</string>
      <string>List item three</string>
   </list>
</entry>

<!-- plugin key with map value (e.g. mapping from string to string) -->
<entry>
   <string>key_five</string>
   <map>
      <entry>
         <string>subkey1</string>
         <string>subvalue1</string>
      </entry>
      <entry>
         <string>subkey2</string>
         <string>subvalue2</string>
      </entry>
      <entry>
         <string>subkey3</string>
         <string>subvalue3</string>
      </entry>
   </map>
</entry>
</map>
Plugin Value Types

Plugin values can be of the following types:

<table>
<thead>
<tr>
<th>XML Element</th>
<th>Plugin Value Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;string&gt;</td>
<td>String</td>
</tr>
<tr>
<td>&lt;int&gt;</td>
<td>Integer</td>
</tr>
<tr>
<td>&lt;long&gt;</td>
<td>Long Integer</td>
</tr>
<tr>
<td>&lt;list&gt;</td>
<td>List</td>
</tr>
<tr>
<td>&lt;map&gt;</td>
<td>Map</td>
</tr>
</tbody>
</table>

String

XML Element

<string>

Description

An arbitrary string of characters.

Because the plugin is expressed as XML, some characters in the string must be properly encoded:

- & is encoded as &amp;.
- < is encoded as &lt;.
- > is encoded as &gt;.
- Non-printable characters and characters outside the 7-bit ASCII set are encoded with numeric character references¹, either decimal character references (for example é encoded as &#0233; or &#233;) or hexadecimal character references (for example é encoded as &#x00e9; or &#00e9; or &e9; or &xe9;).

Examples

<string>This is a string value</string>

<string>Taylor &Francis</string>

<string>Vive la difference !</string>

Integer

XML Element

<int>

Description

An integer value. Represented internally as a 32-bit integer.

Example

¹ See also:
- https://www.w3.org/TR/2006/REC-xml11-20060816/#dt-charref
- https://www.w3.org/TR/2008/REC-xml-20081126/#dt-charref
Long Integer

XML Element

<long/>

Description
A long integer value. Represented internally as a 64-bit integer.

Example
<long>5000000000</long>

List

XML Element

<list/>

Description
A <list> elements containing an ordered sequence of values (typically all of the same type).

Example
<!-- list of strings -->
<list>
  <string>Item one</string>
  <string>Item two</string>
  <string>Item three</string>
</list>

Map

XML Element

<map/>

Description
A <map> element containing an unordered sequence of map entries expressed as <entry> elements. Each map entry is a key-value pair; the key must be the first child of the <entry> element and must be a String, and the value must be the second child of the <entry> element.

The effect of specifying the same key in more than one map entry is undefined.

Example
<!-- mapping from string to string -->
<map>
  <entry>
    <string>key1</string>
    <string>value1</string>
  </entry>
  <entry>
    <string>key2</string>
    <string>value2</string>
  </entry>
</map>

(continues on next page)
5.2 Identification

This section introduces plugin features related to the identification, versioning and parameterization of the plugin.

5.2.1 Plugin Identifier

**Plugin Key**

`plugin_identifier`

**Plugin Value Type**

`String`

**Sample**

```
<entry>
  <string>plugin_identifier</string>
  <string>edu.example.plugin.publisherx.PublisherXPlugin</string>
</entry>
```

**Description**

A unique identifier for the plugin.

The plugin identifier uniquely identifies the plugin. It is used as part of AUIDs (the unique identifier of each AU) and to name a Java package where the plugin's Java code lives. As such, the plugin identifier is really a **fully-qualified Java class name**, which consists of a Java package name and a Java class name.

Just like a file path such as `/home/jsmith/documents/myfile.txt` is a hierarchical path from more general directories (home) to more specific directories (jsmith, then documents) and ending with a file name (myfile.txt), a fully-qualified Java class name is a hierarchical path starting with the institution responsible for the plugin (conventionally by reversed Internet domain name), for example `edu.stanford.library` for the organization whose Web site is `library.stanford.edu`, followed by more levels (typically the next one `plugin`, and then another to identify the plugin family or individual plugin), and finally ending with a “file name”. The separators are periods.

**Example**

In the Global LOCKSS Network (GLN), the plugin maintained by the LOCKSS Program to process volumes of journals by Oxford University Press (OUP) hosted on the Silverchair platform has the identifier `org.lockss.plugin.silverchair.oup.OupSilverchairPlugin`:

- `org.lockss` is the reverse of `lockss.org`.
- `plugin` is the root level of all plugins maintained by the LOCKSS Program.
• silverchair is a level grouping all Silverchair-based plugins.
• oup is the most specific level identifying the OUP plugin.
• OupSilverchairPlugin is the class name.

(You can find this plugin on GitHub at https://github.com/lockss/lockss-daemon/blob/master/plugins/src/orgLOCKSS Documentation Portal

lockss/plugin/silverchair/oup/OupSilverchairPlugin.xml.)

File Path
In a source code repository, the plugin identifier translates into a file path like so: org.lockss.
plugin.silverchair.oup.OupSilverchairPlugin corresponds to org/lockss/plugin/silverchair/
oup/OupSilverchairPlugin.xml.

5.2.2 Plugin Name

Plugin Key

plugin_name

Plugin Value Type

String

Sample

<entry>
  <string>plugin_name</string>
  <string>Publisher X Journals Plugin</string>
</entry>

Description
A user-friendly name for the plugin.
This name is only displayed in a few places in the LOCKSS Web user interface, for instance in the Plugins table.

Example
In the Global LOCKSS Network (GLN), the plugin to process volumes of journals by Oxford University Press (OUP) hosted on the Silverchair platform has the name Oxford University Press Journals Plugin.

<entry>
  <string>plugin_name</string>
  <string>Oxford University Press Plugin</string>
</entry>

(You can find this plugin on GitHub at https://github.com/lockss/lockss-daemon/blob/master/plugins/src/org/lockss/plugin/silverchair/oup/OupSilverchairPlugin.xml.)
5.2.3 Plugin Version

Plugin Key
   plugin_version

Plugin Value Type
   String (not integer)

Sample

```xml
<entry>
   <string>plugin_version</string>
   <string>7</string>
</entry>
```

Description
The plugin's version number.

The first release of a plugin is typically numbered 1, and the next revision 2, and so on, although the releases do not have to be numerically consecutive as long as they only go up with time.

Although only the numeric part is important, the integer can be followed by a hyphen and an arbitrary string, which is why this value is of type is string and not integer.

5.2.4 Plugin Configuration Parameters

Plugin Key
   plugin_config_props

Plugin Value Type
   List of <org.lockss.daemon.ConfigParamDescr> stanzas

Sample

```xml
<entry>
   <string>plugin_config_props</string>
   <list>
      <org.lockss.daemon.ConfigParamDescr>
         <key>base_url</key>
         <displayName>Base URL</displayName>
         <description>Usually of the form http://&lt;journal-name&gt;.com/</description>
         <type>3</type>
         <size>40</size>
         <definitional>true</definitional>
         <defaultOnly>false</defaultOnly>
      </org.lockss.daemon.ConfigParamDescr>
      <org.lockss.daemon.ConfigParamDescr>
         <key>journal_id</key>
         <displayName>Journal Identifier</displayName>
         <description>Identifier for journal (often used as part of file names)</description>
         <type>1</type>
         <size>40</size>
         <definitional>true</definitional>
      </org.lockss.daemon.ConfigParamDescr>
   </list>
</entry>
```
Description

A list of **configuration parameter descriptors**, defining the placeholders in use in the plugin’s rules and code.

A plugin's rules and code (start and permission URLs, crawl rules, substance patterns...) are made general by identifying placeholders for AU-specific values and substituting them later. These placeholders for variable values are called **plugin configuration parameters**.

Defining the necessary configuration parameters for a given plugin comes mostly from studying the URL structure of the preservation target, finding patterns, and identifying the parts of those patterns that differ between Archival Units.

Structure

Each plugin configuration parameter is represented by a `<org.lockss.daemon.ConfigParamDescr>` stanza that looks like this:

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>...</key>
  <type>...</type>
  <displayName>...</displayName>
  <description>...</description>
  <size>...</size>
  <definitional>...<!-- default: true --></definitional>
  <defaultOnly>...<!-- default: false --></defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

Only `<key>` and `<type>` are required.

Each `<org.lockss.daemon.ConfigParamDescr>` stanza contains the following important elements:

- `<key>`: the **parameter key**, an identifier for the configuration parameter, standing in as a placeholder for the AU-specific value in rules and code. Example: `base_url` for a base URL (URL prefix common to all or most URLs in an AU).
- `<type>`: the **parameter type**, an integer describing the type of value the configuration parameter represents (string, integer, etc.). See **Parameter Types** below for details.
- `<definitional>`: whether the parameter is a **definitional parameter** or **non-definitional parameter**, expressed as the booleans `true` or `false`. Most parameters are definitional (`true`), meaning the parameter is part of the set of parameters that together form the unique identity of the AU.
- `<defaultOnly>`: set to `false` in almost all cases.

The other elements only play a role in the Manual Add/Edit screen in the LOCKSS Web user interface:

5.2. Identification
Parameter Types

The following plugin configuration parameter types are defined in the LOCKSS software:

<table>
<thead>
<tr>
<th>Parameter Type Code</th>
<th>Parameter Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>String</td>
</tr>
<tr>
<td>2</td>
<td>Integer</td>
</tr>
<tr>
<td>3</td>
<td>URL</td>
</tr>
<tr>
<td>4</td>
<td>Year</td>
</tr>
<tr>
<td>5</td>
<td>Boolean</td>
</tr>
<tr>
<td>6</td>
<td>Non-Negative Integer</td>
</tr>
<tr>
<td>7</td>
<td>String Range</td>
</tr>
<tr>
<td>8</td>
<td>Numeric Range</td>
</tr>
<tr>
<td>9</td>
<td>Set</td>
</tr>
<tr>
<td>10</td>
<td>User Credentials</td>
</tr>
<tr>
<td>11</td>
<td>Long Integer</td>
</tr>
<tr>
<td>12</td>
<td>Time Interval</td>
</tr>
</tbody>
</table>

**String**

Parameter Type Code

1

Description

A non-empty string.

Built-In Examples

Volume Name, Journal Directory, Journal Abbreviation, Journal Identifier, Journal ISSN, Publisher Name, OAI Spec, Crawl Proxy, Crawl Test Substance Threshold

**URL**

Parameter Type Code

3

Description

Used most frequently as a URL prefix. This must be a valid URL string according to Java's java.net.URL constructor (https://docs.oracle.com/javase/8/docs/api/java/net/URL.html#URL-java.lang.String-).

Built-In Examples

Base URL, Second Base URL, OAI Request URL

See Also

Derivative URL Parameters
User Credentials

Parameter Type Code
10

Description
A colon-separated username and password, for instance myuser:mypass.

Built-In Examples
Username and Password

Integer

Parameter Type Code
2

Description
The integer can be negative. Represented internally as a 32-bit integer.

Non-Negative Integer

Parameter Type Code
6

Description
The integer can be zero but cannot be negative. Represented internally as a 32-bit integer.

Built-In Examples
Volume Number

Long Integer

Parameter Type Code
11

Description
The value can be negative. Represented internally as a 64-bit integer.

Year

Parameter Type Code
4

Description
A four-digit year, or the special value 0 to denote an unspecified year.

Built-In Examples
Year

See Also
Derivative Year Parameters
**Time Interval**

**Parameter Type Code**
12

**Description**
Specified as a long integer followed by a suffix indicating a time unit: ms for milliseconds, s for seconds, m for minutes, h for hours, d for days, w for weeks (7 days), y for years (365 days). If there is no suffix, the default interpretation is milliseconds. The time unit suffixes are case-insensitive.

**Built-In Examples**

- *New Content Crawl Interval*

**String Range**

**Parameter Type Code**
7

**Description**
The range is specified with two strings separated by a dash (-) and is inclusive. If there is a single string with no dash, the range is interpreted to contain only that string.

**Built-In Examples**

- *Issue Range*

**Numeric Range**

**Parameter Type Code**
8

**Description**
The range is specified with two integers separated by a dash (-). If there is a single integer, the range is interpreted to contain only that integer.

**Built-In Examples**

- *Numeric Issue Range*

**Set**

**Parameter Type Code**
9

**Description**
Specified as a comma-separated list of strings, with whitespace surrounding strings ignored, and empty strings discarded.

The string \{n,m\}, where n and m are integers, will be replaced by all the integers in the range from n to m inclusive. For instance, the set \{2002-2005\}, 2003Supp, 2004Supp is equivalent to 2002, 2003, 2003Supp, 2004, 2004Supp, 2005.

**Built-In Examples**

- *Issue Set*
**Boolean**

Parameter Type Code  
5

Description  
The canonical values are true or false, although yes, on and 1 are recognized as true, and no, off and 0 are recognized as false. All these value strings are case-insensitive.

**Built-In Examples**  
AU Down, AU Off-Limits, AU Closed

**Built-In Definitional Parameters**

The LOCKSS software defines a number of built-in definitional parameters.

Definitional parameters give an AU its identity -- change the value for a definitional parameter and you will be describing a different slice of content (different year, different directory, etc.).

**Base URL**

Parameter Key  
base_url

Parameter Type  
URL

Canonical Form

```
<org.lockss.daemon.ConfigParamDescr>
  <key>base_url</key>
  <type>3</type>
  <displayName>Base URL</displayName>
  <description>Usually of the form http://&lt;journal-name&gt;.com/</description>
  <size>40</size>
  <definitional>true</definitional>
  <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

**Second Base URL**

Parameter Key  
base_url2

Parameter Type  
URL

Canonical Form

```
<org.lockss.daemon.ConfigParamDescr>
  <key>base_url2</key>
  <type>3</type>
  <displayName>Second Base URL</displayName>
  <description>Use if AU spans two hosts</description>
</org.lockss.daemon.ConfigParamDescr>
```
Year

Parameter Key

year

Parameter Type

Year

Canonical Form

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>year</key>
  <type>4</type>
  <displayName>Year</displayName>
  <description>Four digit year (e.g., 2004)</description>
  <size>4</size>
  <definitional>true</definitional>
  <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

Volume Number

Parameter key

volume

Parameter Type

Non-Negative Integer

Canonical Form

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>volume</key>
  <type>6</type>
  <displayName>Volume No.</displayName>
  <description>Numeric volume number, e.g. 7</description>
  <size>8</size>
  <definitional>true</definitional>
  <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```
Volume Name

Parameter Key
volume_name

Parameter Type
String

Canonical Form

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>volume_name</key>
  <type>1</type>
  <displayName>Volume Name</displayName>
  <description>Volume name, e.g. 23A</description>
  <size>20</size>
  <definitional>true</definitional>
  <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

Issue Range

Parameter Key
issue_range

Parameter Type
String Range

Canonical Form

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>issue_range</key>
  <type>7</type>
  <displayName>Issue Range</displayName>
  <description>A Range of issues in the form: aaa-zzz</description>
  <size>20</size>
  <definitional>true</definitional>
  <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

Numeric Issue Range

Parameter Key:
num_issue_range

Parameter Type
Numeric Range

Canonical Form

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>num_issue_range</key>
  <displayName>Numeric Issue Range</displayName>
</org.lockss.daemon.ConfigParamDescr>
```
Issue Set

Parameter Key

issue_set

Parameter Type

Set

Canonical Form

```
<org.lockss.daemon.ConfigParamDescr>
  <key>issue_set</key>
  <type>9</type>
  <displayName>Issue Set</displayName>
  <description>A comma delimited list of issues. (eg issue1, issue2)</description>
  <size>20</size>
  <definitional>true</definitional>
  <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

Journal Directory

Parameter Key

journal_dir

Parameter Type

String

Canonical Form

```
<org.lockss.daemon.ConfigParamDescr>
  <key>journal_dir</key>
  <type>1</type>
  <displayName>Journal Directory</displayName>
  <description>Directory name for journal content (i.e. 'american_imago').</description>
  <size>40</size>
  <definitional>true</definitional>
  <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```
Journal Abbreviation

Parameter Key
   journal_abbr

Parameter Type
   String

Canonical Form

```xml
<org.lockss.daemon.ConfigParamDescr>
   <key>journal_abbr</key>
   <type>1</type>
   <displayName>Journal Abbreviation</displayName>
   <description>Abbreviation for journal (often used as part of file names).</description>
   <size>10</size>
   <definitional>true</definitional>
   <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

Journal Identifier

Parameter Key
   journal_id

Parameter Type
   String

Canonical Form

```xml
<org.lockss.daemon.ConfigParamDescr>
   <key>journal_id</key>
   <type>1</type>
   <displayName>Journal Identifier</displayName>
   <description>Identifier for journal (often used as part of file names).</description>
   <size>40</size>
   <definitional>true</definitional>
   <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

Journal ISSN

Parameter Key
   journal_issn

Parameter Type
   String

Canonical Form
Publisher Name

Note: Use of this parameter is not recommended. It is unlikely the publisher name will appear in URLs, as opposed to a publisher abbreviation or code.

Parameter Key
publisher_name

Parameter Type
String

Canonical Form

OAI Request URL

Parameter Key
oai_request_url

Parameter Type
URL

Canonical Form
OAI Spec

Parameter Key
- oai_spec

Parameter Type
- String

Canonical Form

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>oai_spec</key>
  <type>1</type>
  <displayName>OAI Spec</displayName>
  <description>Spec for journal in the OAI crawl</description>
  <size>40</size>
  <definitional>true</definitional>
  <defaultOnly>false</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

Built-In Non-Definitional Parameters

The LOCKSS software also defines a number of non-definitional parameters.

Non-definitional parameters are necessary as placeholders in plugin rules and code, but they do not contribute to the AU’s identity — you may need to change the value of a non-definitional parameter but it will not change which slice of content the AU corresponds to.

Some non-definitional parameters might be listed in the plugin itself, like the user_pass parameter for user credentials, if all AUs are expected to supply a value for the parameter, but most others are involved in the lifecycle of an AU and need not be listed in the plugin, like the pub_down parameter for AUs that are not currently allowed to crawl.

Username and Password

Parameter Key
- user_pass

Parameter Type
- User Credentials

Canonical Form

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>user_pass</key>
  <type>10</type>
  <displayName>Username:Password</displayName>
  <description>Colon-separated username and password string, e.g. myuser:mypass</description>
  <size>30</size>
</org.lockss.daemon.ConfigParamDescr>
```
Some harvesting processes may require user credentials (username and password). A non-definitional parameter is needed because the username and password might be different for different harvesting nodes, or may change over time, without changing the identity of the AU (for instance its year).

**AU Down**

**Parameter Key**
pub_down

**Parameter Type**
Boolean

**Canonical Form**

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>pub_down</key>
  <type>5</type>
  <displayName>Pub Down</displayName>
  <description>If true, AU is no longer available from the publisher</description>
  <size>4</size>
  <definitional>false</definitional>
  <defaultOnly>true</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

**Description**
This non-definitional parameter is used routinely in the title database files of LOCKSS networks, but does not need to appear explicitly in plugins.

When this parameter value is supplied as true for an AU, the AU is considered to be "down", meaning that it is currently unavailable from its source and should not attempt to crawl or recrawl.

The name pub_down, for "publisher down", reflects the idea that the entire publisher site (content provider) might be unavailable, but this parameter can be used to mark individual AUs as being down outside the context of an entire content provider being unavailable.

**AU Off-Limits**

**Parameter Key**
pub_never

**Parameter Type**
Boolean

**Canonical Form**

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>pub_never</key>
  <type>5</type>
</org.lockss.daemon.ConfigParamDescr>
```
Description
This non-definitional parameter is used routinely in the title database files of LOCKSS networks, but does not need to appear explicitly in plugins.

When this parameter value is supplied as `true` for an AU, the AU is considered to be "off-limits", meaning that the LOCKSS software will not satisfy a proxy request for a URL it determines to be in this AU by going to the original Web site.

**AU Closed**

**Parameter Key**
`au_closed`

**Parameter Type**
`Boolean`

**Canonical Form**

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>au_closed</key>
  <type>5</type>
  <displayName>AU Closed</displayName>
  <description>If true, AU is complete, no more content will be added</description>
  <size>4</size>
  <definitional>false</definitional>
  <defaultOnly>true</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

Description
This non-definitional parameter is used routinely in the title database files of LOCKSS networks, but does not need to appear explicitly in plugins.

When this parameter value is supplied as `true` for an AU, the AU is marked as "closed", meaning it is considered that no more content will be added to it in the future.

**Crawl Proxy**

**Parameter Key**
`crawl_proxy`

**Parameter Type**
`String`

**Canonical Form**

5.2. Identification
**Description**

This non-definitional parameter is used routinely in the title database files of LOCKSS networks, but does not need to appear explicitly in plugins.

When this parameter value is supplied as a host:port pair (for example `proxy.myuniversity.edu:8080`) for an AU, crawls of the AU will be proxied through the given proxy. When this parameter value is supplied as the special value `DIRECT` for an AU, crawls of the AU will not be proxied, even if the LOCKSS node is configured to always use a crawl proxy.

**New Content Crawl Interval**

**Parameter Key**

`nc_interval`

**Parameter Type**

*Time Interval*

**Canonical Form**

```xml
<org.lockss.daemon.ConfigParamDescr>
  <key>nc_interval</key>
  <type>12</type>
  <displayName>Crawl Interval</displayName>
  <description>The interval at which the AU should crawl the publisher site.</description>
  <size>10</size>
  <definitional>false</definitional>
  <defaultOnly>true</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>
```

**Description**

This non-definitional parameter is used routinely in the title database files of LOCKSS networks, but does not need to appear explicitly in plugins.

When this parameter value is supplied as a time interval for an AU, crawls of the AU will be attempted with the given requested interval rather than the LOCKSS node's default new content crawl interval.
Crawl Test Substance Threshold

Parameter Key

crawl_test_substance_threshold

Parameter Type

String

Canonical Form

<org.lockss.daemon.ConfigParamDescr>
  <key>crawl_test_substance_threshold</key>
  <type>1</type>
  <displayName>Crawl Test Substance Threshold</displayName>
  <description>Minimum number of substance URLs necessary for successful abbreviated crawl test.</description>
  <size>20</size>
  <definitional>false</definitional>
  <defaultOnly>true</defaultOnly>
</org.lockss.daemon.ConfigParamDescr>

Description

This non-definitional parameter is used in special circumstances, for networks set up to perform abbreviated test crawls.

Derivative Parameters

For parameters of type URL and Year, the system automatically brings into existence derivative parameters with special names, as if those parameters had also been defined by the plugin.

Tip: Derivative parameters have fallen out of favor. The contemporary way to achieve the same effect is through parameter functors.

Derivative URL Parameters

For any parameter of type URL with key urlkey, the following derivative parameters are automatically defined:

- urlkey_host of type String, whose value is just the host portion of the corresponding URL value. For example, if base_url has a value of https://www.publisher.com/jabc/, base_url_host has a value of www.publisher.com.
- urlkey_path of type String, whose value is just the path portion of the corresponding URL value. For example, if base_url has a value of https://www.publisher.com/jabc/, base_url_path has a value of /jabc/.
Derivative Year Parameters

For any parameter of type *Year* with key *yearkey*, the following derivative parameter is automatically defined:

- *au_short_yearkey* of type *Integer*, whose value is the corresponding year value modulo 100. For example, if *year* has a value of 1998, *au_short_year* has a value of 98; if *year* has a value of 2002, *au_short_year* has a value of 2 (the integer 2, not the string 02).

**Tip:** In many cases, what is useful is the zero-padded, two-character string from the derivative short year, not the potentially single-digit integer; use %02d in the printf format string.

### 5.2.5 AU Name

**Plugin Key**

*au_name*

**Plugin Value Type**

*String*

**Plugin Value Format**

The value is a printf format string, that expands to a string. The printf format string can use plugin configuration parameter keys (e.g. *base_url, journal_issn, volume_name*) as values.

**Sample**

```
<entry>
  <string>au_name</string>
  <string>"Publisher X Journals Plugin, Base URL %s, Journal Identifier %s, Volume %s", base_url, journal_id, volume_name</string>
</entry>
```

**Description**

A rule to generate a default name for each AU, based on the plugin name and the plugin parameters. The rule is used to generate a name for the AU if it is not listed in the title database (AU inventory).

Conventionally, this is made of a comma-separated list of the *Plugin Name* and the display name and value of each of the *Plugin Configuration Parameters*, from more general (e.g. *base_url*) to more specific (e.g. *volume_name*).

### 5.2.6 Required Daemon Version

**Plugin Key**

*required_daemon_version*

**Plugin Value Type**

*String*

**Sample**

```
<entry>
  <string>required_daemon_version</string>
  <string>1.74.7</string>
</entry>
```
5.3 Crawl Control

This section introduces plugin features related to the definition and behavior of content crawls.

5.3.1 Start URLs

Plugin Key

`au_start_url`

Plugin Value Type

One of:

- String
- List of String

Plugin Value Format

The strings are printf format strings, that expand to URLs. The printf format strings accept expressions made of plugin configuration parameter keys and a small language of functions modifying them (e.g. `url_host(...)` applied to a plugin configuration parameter of type URL, resulting in the host portion of the URL).

Sample

```xml
<entry>
  <string>au_start_url</string>
  <string>%s%s/vol%s/index.html", base_url, journal_id, volume_name</string>
</entry>
```

Description

One or more URLs from which the crawl of an AU begins.

5.3.2 Crawl Seed

Note: This page is under construction.

Plugin Key

`plugin_craw_seed_factory`

Plugin Value Type

`String`

The string is the fully-qualified name of a Java class implementing the `org.lockss.crawler.CrawlSeedFactory` interface.

Sample
Description
In lieu of a list of start URLs, code called a crawl seed can compute the starting points of the crawl of an AU, for instance by interacting with an API.

5.3.3 Permission URLs

Plugin Key
au_permission_url

Plugin Value Type
One of:
- String
- List of String

Plugin Value Format
The strings are printf format strings, that expand to URLs. The printf format strings accept expressions made of plugin configuration parameter keys and a small language of functions modifying them (e.g. url_host(...) applied to a plugin configuration parameter of type URL, resulting in the host portion of the URL).

Sample

<entry>
  <string>au_permission_url</string>
  <string>%slockss.txt", base_url</string>
</entry>

Description
One or more URLs giving the LOCKSS software permission to crawl an AU, if permission is not given on the start URLs.

5.3.4 Per-Host Permission Path

Plugin Key
plugin_per_host_permission_path

Plugin Value Type
String

Sample

<entry>
  <string>plugin_per_host_permission_path</string>
  <string>/lockss.txt</string>
</entry>

Description
Relative path where a permission statement may be found on hosts not listed in start URLs or permission URLs.
Useful for sites that have banks of similar hosts with unpredictable names, but with a predictable path to the permission URL on each.

### 5.3.5 Permitted Host Pattern

**Note:** This page is under construction.

**Plugin Key**

`au_permitted_host_pattern`

**Plugin Value Type**

One of:

- `String`
- `List of String`

**Plugin Value Format**

The strings are `printf` format strings, that expand to regular expressions used to match against host names. The `printf` format strings accept expressions made of plugin configuration parameter keys and a small language of functions modifying them (e.g. `url_host(...)`) applied to a plugin configuration parameter of type `URL`, resulting in the host portion of the URL.

**Example**

```
<entry>
  <string>au_permitted_host_pattern</string>
  <string>"cdnjs.cloudflare.com|fast.fonts.net"</string>
</entry>
```

**Description**

Pattern rules to allow collection from hosts that cannot explicitly grant permission, such as content distribution network hosts used to distribute standard components used by Web sites like Javascript libraries and Web fonts.

### 5.3.6 Crawl Rules

**Plugin Key**

`au_crawlrules`

**Plugin Value Type**

`List of String`

**Plugin Value Format**

The strings consist of:

- An integer crawl rule code,
- A comma,
- A `printf` format string that expands into a regular expression used to match against URLs. The `printf` format string accepts expressions made of plugin configuration parameter keys and a small language of functions modifying them (e.g. `url_host(...)`) applied to a plugin configuration parameter of type `URL`, resulting in the host portion of the URL.

**Sample**

5.3. Crawl Control 65
Description
Sequential rules determining if a URL discovered during the crawl of an AU should in turn be fetched as part of the AU or not.

Given a URL, the crawler tries each crawl rule in the order of the list, until one of them produces an outcome for the URL. If none of the crawl rules result in an outcome for the URL, the default outcome is Exclude (the URL is excluded from the AU).

Crawl Rule Types

The crawl rule codes are:

<table>
<thead>
<tr>
<th>Crawl Rule Code</th>
<th>Crawl Rule Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Include</td>
</tr>
<tr>
<td>2</td>
<td>Exclude</td>
</tr>
<tr>
<td>3</td>
<td>Include No Match</td>
</tr>
<tr>
<td>4</td>
<td>Exclude No Match</td>
</tr>
<tr>
<td>5</td>
<td>Include Match Else Exclude</td>
</tr>
<tr>
<td>6</td>
<td>Exclude Match Else Include</td>
</tr>
</tbody>
</table>

Include

Crawl Rule Code
1

Description
If the URL matches the regular expression, include the URL in the AU; otherwise, this rule produces no outcome for the URL.
Exclude

Crawl Rule Code
2

Description
If the URL matches the regular expression, exclude the URL from the AU; otherwise, this rule produces no outcome for the URL.

Include No Match

Crawl Rule Code
3

Description
If the URL does not match the regular expression, include the URL in the AU; otherwise, this rule produces no outcome for the URL.

Exclude No Match

Crawl Rule Code
4

Description
If the URL does not match the regular expression, exclude the URL from the AU; otherwise, this rule produces no outcome for the URL.

Include Match Else Exclude

Crawl Rule Code
5

Description
If the URL matches the regular expression, include the URL in the AU; otherwise, exclude the URL from the AU.

Exclude Match Else Include

Crawl Rule Code
6

Description
If the URL matches the regular expression, exclude the URL from the AU; otherwise, include the URL in the AU.
5.3.7 Crawl Window

Plugin Key
au_crawlwindow, au_crawlwindow_ser

Plugin Value Type
au_crawlwindow value type: \textit{String} representing the fully-qualified name of a Java class implementing the \texttt{org.lockss.plugin.definable.DefinableArchivalUnit.ConfigurableCrawlWindow} interface, which is a factory for the \texttt{org.lockss.daemon.CrawlWindow} interface.

au_crawlwindow_ser value type: a serialized \texttt{org.lockss.daemon.CrawlWindow} object.

Description
A crawl window controls what times of day or days of the week crawls against the preservation target are allowed; by default an AU is eligible to crawl at any time.

5.3.8 Recrawl Interval

Plugin Key
au_def_new_content_crawl

Plugin Value Type
\textit{Long Integer}

Sample

```xml
<entry>
  <string>au_def_new_content_crawl</string>
  <long>1209600000</long>
</entry>
```

Description
The amount of time (in milliseconds) before an AU that has previously been crawled successfully is eligible to attempt crawling again.

Sample values:

- 31449600000 for 52 weeks (364 days).
- 1209600000 for 2 weeks (the most typical value in the Global LOCKSS Network).
- 604800000 for 1 week.
- 86400000 for 24 hours.
5.3.9 Refetch Depth

Note: This page is under construction.

Plugin Key
    au_refetch_depth

Plugin Value Type
    Integer

Sample

    <entry>
    <string>au_refetch_depth</string>
    <int>2</int>
    </entry>

Description
Number of links away from a start URL that will be fetched by normal crawls. Deep crawls may be used to cause all URLs in an AU to be refetched (subject to If-Modified-Since).

5.3.10 Fetch Pause Time

Plugin Key
    au_def_pause_time

Plugin Value Type
    Long Integer

Sample

    <entry>
    <string>au_def_pause_time</string>
    <long>3000</long>
    </entry>

Description
The minimum amount of time (in milliseconds) between two fetches of consecutive URLs in the crawl of an AU.

The most common value in the Global LOCKSS Network is 3000 for no more frequently than every 3 seconds.

5.3.11 Crawl Rate Limiter

Note: This page is under construction.

Plugin Key
    ?

Plugin Value Type
    ?
5.3.12 Crawl Pool

Plugin Key

plugin_fetch_rate_limiter_source

Plugin Value Type

String

Description

A specification for how AUs are split into crawl pools. Only one new content crawl from a given crawl pool can happen at once. In the default crawl pool scheme, there is one crawl pool per plugin, but this plugin key can be used to define a new behavior.

The possible values are:

- **au**: Each AU has its own crawl pool.
- **plugin**: The pool name is the Plugin Identifier.
- **key**: str: The pool name is the string str.
- **host:urlparamkey**: The pool name is the string host: followed by the value of the AU’s parameter named urlparamkey. If there is no such parameter, or if the parameter is not of type URL, the default crawl pool scheme applies.
- **title_attribute:auattrkey** and **title_attribute:auattrkey:dflt**: The pool name is the string attr: followed by the value of the AU’s attribute named auattrkey. When the attribute is unset, if the longer form is used then use dflt as the value instead; otherwise the default crawl pool scheme applies.

5.3.13 Response Handler

Note: This page is under construction.

Plugin Key

plugin_cache_result_list

Plugin Value Type

List of String

The list represents a mapping; each string is of the form $x=y$, mapping from the left-hand side $x$ which can be:

- An HTTP response code (integer).
- One of a finite set of Java exceptions (string).

to the right-hand side $y$ which can be:

- The fully-qualified name of a Java class extending the org.lockss.util.urlconn.CacheException class.
- The fully-qualified name of a Java class implementing the org.lockss.util.urlconn.CacheResultHandler interface.

Sample
5.3.14 URL Normalizer

Note: This page is under construction.

Plugin Key
au_url_normalizer

Plugin Value Type
String

Plugin Value Format
The value is the fully-qualified name of a Java class that implements the org.lockss.plugin.UrlNormalizer interface.

Sample

<entry>
  <string>au_url_normalizer</string>
  <string>edu.example.plugin.publisherx.PublisherXUrlNormalizer</string>
</entry>

Description
A URL normalizer maps URL variants to a canonical representation, for example by re-arranging equivalent URL query strings into a canonical order, removing extraneous URL substrings (for instance session IDs), canonicalizing the case (for instance to lowercase), etc. so that equivalent variants are stored only once under the canonical name.

5.3.15 Link Extractor

Note: This page is under construction.

Plugin Key
mediatypelink_extractor_factory, where mediatype is a media type like text/html

Plugin Value Type
String

Plugin Value Format
The value is the fully qualified name of a Java class implementing the org.lockss.plugin.LinkExtractorFactory interface.

Sample
Description
The LOCKSS software comes with built-in code to extract URLs from HTML and CSS files encountered during the crawl of an AU. A URL extracted in this manner is then subject to the URL Normalizer, then the Crawl Rules determine if it should in turn be included in the AU. If URLs need to be extracted from other file types, or if the extraction behavior for built-in types like HTML and CSS needs to be extended or customized, this plugin feature can be used to point the plugin at new link extraction code.

5.3.16 Crawl Filter

Note: This page is under construction.

Plugin Key
mediatype_crawl_filter_factory, where mediatype is a media type like text/html

Plugin Value Type
String

Plugin Value Format
The value is the fully qualified name of a Java class implementing the org.lockss.plugin.FilterFactory interface.

Sample

<entry>
  <string>text/html_crawl_filter_factory</string>
  <string>edu.example.plugin.publisherx.PublisherXHtmlCrawlFilterFactory</string>
</entry>

Description
If files of a given media type need to be pre-processed (filtered) before URLs are extracted by the crawler using a Link Extractor, this plugin feature can be used to point at custom filtering code.

Crawl filters are somewhat related to hash filters.

5.3.17 URL Fetcher

Note: This page is under construction.

Plugin Key
plugin_url_fetcher_factory

Plugin Value Type
String

Plugin Value Format
The value is the fully qualified name of a Java class implementing the org.lockss.plugin.UrlFetcherFactory interface, which is a factory for the org.lockss.plugin.UrlFetcher interface.
Sample

```xml
<entry>
    <string>plugin_url_fetcher_factory</string>
    <string>edu.example.plugin.publisherx.PublisherXUrlFetcherFactory</string>
</entry>
```

Description

*Under construction*

## 5.3.18 URL Consumer

**Note:** This page is under construction.

**Plugin Key**

`plugin_url_consumer_factory`

**Plugin Value Type**

`String`

**Plugin Value Format**

The value is the fully qualified name of a Java class implementing the `org.lockss.plugin.UrlConsumerFactory` interface, which is a factory for the `org.lockss.plugin.UrlConsumer` interface.

**Sample**

```xml
<entry>
    <string>plugin_url_consumer_factory</string>
    <string>edu.example.plugin.publisherx.PublisherXUrlConsumerFactory</string>
</entry>
```

Description

*Under construction*

## 5.4 Crawl Validation

This section introduces features related to content validation in the context of a crawl.

### 5.4.1 Redirect to Login URL Pattern

**Plugin Key**

`au_redirect_to_login_url_pattern`

**Plugin Value Type**

`String`

**Plugin Value Format**

The string is a `printf` format string that expands to a regular expression used to match against URLs. The `printf` format string accepting expressions made of plugin configuration parameter keys.

**Sample**
### au_redirect_to_login_url_pattern

```xml
<entry>
  <string> au_redirect_to_login_url_pattern </string>
  <string> "^%ssignup-login.*", base_url </string>
</entry>
```

**Description**

Determines whether an HTTP redirect returned by the crawled site is actually a redirect to a login page.

During the crawl of an AU, a redirect from a URL that is accepted by the crawl rules to a URL that is not is a non-fatal crawl error, meaning it gets reported at the end of the crawl rather than immediately stopping it.

If a Web site issues an HTTP redirect to a login page URL when an IP address accesses a URL it is not authorized to view, it is often desirable to recognize this situation differently than other redirects to URLs outside the crawl rules. This key is used to identify such redirects and treat them as fatal crawl errors instead of non-fatal crawl errors.

#### 5.4.2 Login Page Checker

**Note:** This page is under construction.

**Plugin Key**

`au_login_page_checker`

**Plugin Value Type**

`String`

**Plugin Value Format**

The value is the fully qualified name of a Java class implementing the `org.lockss.daemon LoginPageChecker` interface.

**Sample**

```xml
<entry>
  <string> au_login_page_checker </string>
  <string> edu.example.plugin.publisherx.PublisherXLoginPageChecker </string>
</entry>
```

**Description**

When fetching a URL that the requesting IP address is not authorized to retrieve, some Web sites respond with HTTP success code accompanied by an HTML page that is really a login page or error page, rather than with an HTTP error code. A login page checker is a general interface for checking the contents of a URL and determine if it is a login page rather than the intended content.

#### 5.4.3 Content Validator

**Note:** This page is under construction.

**Plugin Key**

`mediatype_content_validator_factory`, where `mediatype` is a media type like `application/pdf`

**Plugin Value Type**

`String`
Plugin Value Format
The value is the fully qualified name of a Java class implementing the org.lockss.plugin.ContentValidatorFactory interface, which is a factory for the org.lockss.plugin.ContentValidator interface.

Sample

```xml
<entry>
  <string>application/pdf_content_validator_factory</string>
  <string>edu.example.plugin.publisherx.PublisherXPdfValidatorFactory</string>
</entry>
```

Description
A content validator can be used to reject files of a given media type, by examining the headers and/or the content of a crawled URL.

### 5.4.4 Substance Patterns

**Note:** This page is under construction.

**Plugin Key**
au_substance_url_pattern and au_non_substance_url_pattern

**Plugin Value Type**
String

**Plugin Value Type**
The strings are printf format strings that expand to regular expressions used to match against URL. The printf format strings accepting expressions made of plugin configuration parameter keys.

Sample

```xml
<string>au_substance_url_pattern</string>
<string>"^%s/%s/(fulltext|pdf)/", base_url, journal_id</string>
```

**Description**
It can be useful to test whether at least one URL in an AU is "of substance", meaning that it is one of the objects of preservation interest and not simply navigation pages and ancillary files (icons, CSS stylesheets, Javascript code). The substance pattern can be used to characterize the URLs of an AU that are of substance. Conversely, the non-substance pattern can be used to characterize the URLs of an AU that are not of substance.

### 5.4.5 Substance Predicate

**Note:** This page is under construction.

**Plugin Key**
plugin_substance_predicate_factory

**Plugin Value Type**
String

5.4. Crawl Validation
Plugin Value Type
The value is the fully qualified name of a Java class implementing the org.lockss.plugin.SubstancePredicateFactory interface, which is a factory for the org.lockss.plugin.SubstancePredicate interface.

Sample

```xml
<entry>
  <string>plugin_substance_predicate_factory</string>
  <string>edu.example.plugin.publisherx.PublisherXSubstancePredicateFactory</string>
</entry>
```

Description
An alternative to the regular expressions in the Substance Patterns is a substance predicate, which is implemented as Java code.

5.5 Poll Control

This section introduces plugin features that influence the operation of the LOCKSS audit and repair protocol.

5.5.1 Exclude URLs From Polls Pattern

Plugin Key
au_exclude_urls_from_polls_pattern

Plugin Value Type
One of:
- `String`
- `List` of `String`

Sample

```xml
<entry>
  <string>au_exclude_urls_from_polls_pattern</string>
  <list>
    <string>"^%scss/.*\.css\?version=", base_url</string>
    <string>"^%sfiles/[0-9]+/.*\.js", base_url</string>
  </list>
</entry>
```

Description
URLs characterized by the regular expressions expanded from the printf strings are excluded (ignored) during polls of the AU.
5.5.2 Poll Result Weight

Plugin Key
au_url_poll_result_weight

Plugin Value Type
- *List of String*

Plugin Value Format
Each string in the list consists of:
- A regular expression,
- A comma,
- A weight between 0.0 and 1.0.

Sample

```xml
<entry>
<string>au_url_poll_result_weight</string>
<list>
  <string>\.css|js|png|jpe?g|png|gif|tiff\?ver=.*$, 0</string>
</list>
</entry>
```

Description
This mechanism is a generalization of *Exclude URLs From Polls Pattern*, which can only exclude URLs from a poll (equivalent of assigning the corresponding URLs a weight of 0.0). Here, URLs can be assigned a partial weight, to reduce the importance of certain families of URLs in polls.

5.5.3 Repair From Publisher When Too Close

*Note:* This page is under construction.

Plugin Key
plugin_repair_from_publisher_when_too_close

Plugin Value Type
?

Description
*Under construction*

5.5.4 Repair From Peer If Missing

*Note:* This page is under construction.

Plugin Key
au_repair_from_peer_if_missing_url_pattern

Plugin Value Type
One of:
• **String**
• **List of String**

**Plugin Value Format**
The strings are `printf` format strings that expand to regular expressions used to match against URLs. The `printf` format strings accept expressions made of plugin configuration parameter keys.

**Sample**

```xml
<entry>
  <string>au_repair_from_peer_if_missing_url_pattern</string>
  <list>
    <string>"^%s.*\.(css|js|png|jpe?g|png|gif|tiff)\?ver=.*$", base_url</string>
    <string>"https://code.jquery.org/"</string>
  </list>
</entry>
```

**Description**
When this feature is set, if during a poll the poller determines it is missing a URL that matches one of the patterns, it will seek a repair from a peer. This can be useful when a family of URLs keeps getting new variants (with unique names) rapidly, to allow the variants to spread among the network of peers.

### 5.6 Hash Filtering

This section introduces plugin features related to content canonicalization for inter-node comparison purposes.

#### 5.6.1 Hash Filter

**Plugin Key**

`mediatype_filter_factory`, where `mediatype` is a media type like `text/html`

**Value Type**

**String**

**Plugin Value Type**

The string is the fully-qualified name of a Java class implementing the `org.lockss.plugin.FilterFactory` interface.

**Sample**

```xml
<entry>
  <string>text/html_filter_factory</string>
  <string>edu.example.plugin.publisherx.PublisherXHtmlHashFilterFactory</string>
</entry>
```

**Description**
To canonicalize content before comparison between nodes in the LOCKSS audit and repair protocol, a plugin can define a hash filter for each affected media type. The goal is to pre-process content so that it is fit for a **logical comparison** between nodes, even if different nodes do not have byte-identical versions. This occurs frequently in HTML content that has personalizations ("You are logged in as..."), advertising, and other variable content ("You may also be interested in...", "Top 10 viewed articles this week...", "Recently added articles...") other than the main content. It can be needed for other media types like PDF and RIS because of timestamping, watermarking, and other dynamic server behaviors.
The `org.lockss.plugin.FilterFactory` interface defines a `createFilteredInputStream` method that accepts an `org.lockss.plugin.ArchivalUnit` object, an `InputStream` of the URL's raw content, and a string representing the encoding, and returns an `InputStream` of the canonicalized byte stream, which does not need to be a valid object of that media type (it is only used to compute a checksum).

As part of its general content filtering framework, the LOCKSS plugin framework offers a variety of utility classes specifically for HTML Filters and PDF Filters.

### 5.6.2 HTML Filters

**Note:** This page is under construction.

HTML is the media type most frequently in need of transformation and canonicalization, as part of a Hash Filter or Crawl Filter. To this end, the LOCKSS software contains a variety of utility classes that can be used as building blocks to construct effective HTML filters.

#### HtmlFilterInputStream

The `org.lockss.filter.html.HtmlFilterInputStream` class is a way to parse an `InputStream` of HTML content and apply a transform of type `org.lockss.filter.html.HtmlNodeFilterTransform` to it, resulting in a new `InputStream`.

The `org.lockss.filter.html.HtmlNodeFilterTransform` class provides two kinds of transforms, that either filter out all HTML nodes that match a predicate ("exclude transform", very common use pattern) or collect only HTML nodes that match a predicate ("include transform", less common use pattern). The code of the library used to implement `org.lockss.filter.html.HtmlFilterInputStream` and `org.lockss.filter.html.HtmlNodeFilterTransform` refers to these predicates as `org.htmlparser.NodeFilter`.

Whether an "exclude" transform or an "include" transform, most often the predicate is really the union of many smaller predicates, which can be grouped together by the `org.htmlparser.filters.OrFilter` class (and other similar boolean operators).

Although some complex cases call for the definition of a custom predicate, most typical situations can be handled by predicates predefined in the `org.lockss.filter.html.HtmlNodeFilters` utility class:

- `org.lockss.filter.html.HtmlNodeFilters.tag(String tag)`: predicate that matches a tag with the given name. (Many LOCKSS plugins make direct use of the underlying `org.htmlparser.filtersTagNameFilterTagNameFilter(String) class, but using the utility method is recommended.)
- `org.lockss.filter.html.HtmlNodeFilters.tagWithAttribute(String tag, String attr)`: predicate that matches a tag with the given name, that defines an attribute with the specified key (regardless of the value).
- `org.lockss.filter.html.HtmlNodeFilters.tagWithAttribute(String tag, String attr, String val)`: predicate that matches a tag with the given name, that defines an attribute with the specified key and value. The variant `org.lockss.filter.html.HtmlNodeFilters.divWithAttribute(String attr, String val)` assumes a `<div>` tag.
- `org.lockss.filter.html.HtmlNodeFilters.tagWithAttributeRegex(String tag, String attr, String regex)`: predicate that matches a tag with the given name, that defines an attribute with the specified key, whose value matches the given regular expression. The variant `org.lockss.filter.html.HtmlNodeFilters.tagWithAttributeRegex(String tag, String attr, String regex, boolean ignoreCase)` adds a flag for whether the regular expression is case-insensitive.
- `org.lockss.filter.html.HtmlNodeFilters.comment()`: predicate that matches any HTML comment.

### 5.6. Hash Filtering
• org.lockss.filter.html.HtmlNodeFilters.commentWithString(String str): predicate that matches HTML comments containing the given string. The variant org.lockss.filter.html.HtmlNodeFilters.commentWithString(String str, boolean ignoreCase) adds a flag for whether the test is case-insensitive.

• org.lockss.filter.html.HtmlNodeFilters.commentWithRegex(String regex): predicate that matches HTML comments matching the given regular expression. The variant org.lockss.filter.html.HtmlNodeFilters.commentWithRegex(String regex, boolean ignoreCase) adds a flag for whether the regular expression is case-insensitive.

WhiteSpaceFilter

The org.lockss.filterWhiteSpaceFilter class is a Reader implementation that canonicalizes whitespace by collapsing consecutive whitespace characters to a single one. This is useful because many transformations may leave different numbers of consecutive whitespace characters (perhaps zero) depending on the whitespace surrounding the outermost tags of various removed nodes.

In many LOCKSS plugins, the typical way to use WhiteSpaceFilter is to turn an InputStream into a Reader, apply WhiteSpaceReader, and turn the result back into an InputStream for further processing:

```java
InputStream i1 = ...; // an input stream
String e1 = ...; // the encoding of the input stream
Reader r1 = FilterUtil.getReader(i1, e1);
Reader r2 = new WhiteSpaceFilter(r1);
InputStream i2 = new ReaderInputStream(r2);
```

5.6.3 PDF Filters

Note: This page is under construction.

Increasingly, some content providers generate PDF files dynamically, making each fetch of the same URL slightly different, just like HTML pages in many cases. To allow the nodes in a LOCKSS network to canonicalize PDF files for comparison purposes, the LOCKSS software contains a PDF processing and filtering framework that can be used as building blocks to construct PDF filters\(^1\).

The interface of this framework and general tools are in the org.lockss.pdf package, with an implementation based on Apache PDFBox 1.8 in the org.lockss.pdf.pdfbox package.

Under construction.

\(^1\) Additionally, there is legacy code based on (pre-Apache) PDFBox 0.7.3 which is deprecated, and an experimental library based on Apache PDFBox 2.0 which is in active development.
5.7 Metadata Extraction

This section introduces plugin features related to the extraction and interpretation of metadata from preserved content.

5.7.1 Introduction to Metadata Extraction

Once content is successfully crawled into an archival unit (AU) in a LOCKSS node, optionally with the help of hash filters and related plugin features, the AU is preserved by polling and repairing with other nodes in the network holding the same AU. If metadata extraction from preserved data is desired beyond the preservation of the data itself and the metadata database is enabled, the plugin needs to specify metadata extraction features.

Metadata extraction relies on a trio of related concepts:

- An **Article Iterator** groups an AU's URLs into one cluster per article ("article" in the sense of "object" or "item"). The URLs are represented internally as `org.lockss.plugin.CachedUrl` objects. The object representing an article's cluster of URLs is of type `org.lockss.plugin.ArticleFiles`, and is essentially a mapping from string roles to URLs.

  An article iterator is merely an object implementing `java.util.Iterator<ArticleFiles>`, that comes from a factory implementing the `org.lockss.plugin.ArticleIteratorFactory` interface.

- A media type-specific **File Metadata Extractor** parses the contents of a URL and emits any number of intermediate metadata records.

  A file metadata extractor is an object implementing the `org.lockss.extractor.FileMetadataExtractor` interface and emitting metadata records of type `org.lockss.extractor.ArticleMetadata` through an object implementing the `org.lockss.extractor.FileMetadataExtractor.Emitter` interface. The latter is called for each (`CachedUrl, ArticleFiles`) pair, creating a one-to-many relationship from `CachedUrl` to `ArticleFiles`.

- An **Article Metadata Extractor** receives each article's `ArticleFiles` object, and emits any number of processed metadata records (of the same type `ArticleMetadata`).

  An article metadata extractor implements the `org.lockss.extractor.ArticleMetadataExtractor` interface and emits `ArticleMetadata` objects through an object implementing the `org.lockss.extractor.ArticleMetadataExtractor.Emitter` interface. The latter is called for each (`ArticleFiles, ArticleMetadata`) pair, creating a one-to-many relationship from `ArticleFiles` to `ArticleMetadata`.

  The article metadata extractor picks and chooses URLs of interest from the `ArticleFiles` instance, invokes the file metadata extractors for the corresponding media types yielding intermediate `ArticleMetadata` objects, and emits appropriate final `ArticleMetadata` objects from them.

Although in principle there are file metadata extractors for multiple media types, a one-to-many relationship from `CachedUrl` to `ArticleFiles` in file metadata extractors, and a one-to-many relationship from `ArticleFiles` to `ArticleMetadata` in article metadata extractors, in many situations plugins derive all the metadata they need from a single media type, there is a one-to-one-to-one correspondence between a `CachedUrl, ArticleFiles` and `ArticleMetadata` triple, and the intermediate metadata records can often be emitted as final metadata records.

This process can be summarized in the following diagram:
5.7.2 Article Iterator

Plugin Key

`plugin_article_iterator_factory`

Plugin Value Type

`String`

Plugin Value Type

The string is the fully-qualified name of a Java class implementing the `org.lockss.plugin.ArticleIteratorFactory` interface.

Sample

```
<entry>
  <string>plugin_article_iterator_factory</string>
  <string>edu.example.plugin.publisherx.PublisherXArticleIteratorFactory</string>
</entry>
```

Description

The article iterator is part of the `metadata-extraction` pipeline. Its function is enumerate the articles (where "article" is meant as "item" or "object") in the archival unit (AU). Each article is represented by an `ArticleFiles` instance.

Rather than traversing the AU's URLs manually through the `ArchivalUnit` interface and implementing typical inner workings of a Java `Iterator`, many article iterators make use of utility classes available in the LOCKSS software, such as `SubTreeArticleIterator` and `SubTreeArticleIteratorBuilder`. 
**ArticleFiles**

An `org.lockss.plugin.ArticleFiles` instance groups the main URLs of an article (item) together and labels them. It is a mapping from roles to URLs\(^1\) (which are internally represented as objects implementing `org.lockss.plugin.CachedUrl`).

Roles are arbitrary strings, but many typical role strings are defined as constants in the `ArticleFiles` class, for example:

- `ArticleFiles.ROLE_FULL_TEXT_HTML`: a URL for the full text of a work, in HTML form.
- `ArticleFiles.ROLE_FULL_TEXT_PDF`: a URL for the full text of a work, in PDF form.
- `ArticleFiles.ROLE_FULL_TEXT_EPUB`: a URL for the full text of a work, in EPUB form.
- `ArticleFiles.ROLE_FULL_TEXT_XML`: a URL for the full text of a work, in XML form.
- `ArticleFiles.ROLE_ABSTRACT`: a URL for a work's abstract.
- `ArticleFiles.ROLE_REFERENCES`: a URL for a work's list of works cited.
- `ArticleFiles.ROLE_FIGURES`: a URL for a landing page of the work's figures and illustrations.
- `ArticleFiles.ROLE_TABLES`: a URL for a landing page of the work's tables.
- `ArticleFiles.ROLE_SUPPLEMENTARY_MATERIALS`: a URL for a landing page of the work's supplementary materials.
- `ArticleFiles.ROLE_CITATION`: a URL for a landing page for the work's citation files.
- `ArticleFiles.ROLE_CITATION_BIBTEX`: a URL for a BibTeX citation file for the work.
- `ArticleFiles.ROLE_CITATION_ENDNOTE`: a URL for an EndNote citation file for the work.
- `ArticleFiles.ROLE_CITATION_RIS`: a URL for a RIS citation file for the work.
- `ArticleFiles.ARTICLE_METADATA`: a URL from which metadata for the work can be found.

In addition to the mapping from roles to URLs, one URL has a special status in the `ArticleFiles` instance as the designated, "best" fulltext URL for the work. It is referred to as the full text URL or full text CU (for `CachedUrl`) of the article, and is set via the `setFullTextCu(...)` method. In plugins written by the LOCKSS Program, for articles with multiple fulltext representations, HTML is favored above all, then PDF, then EPUB, and lastly XML (in subjective order of richness of rendering experience in a Web browser).

**SubTreeArticleIterator**

The `org.lockss.plugin.SubTreeArticleIterator` class implements `Iterator<ArticleFiles>` and can be returned by an article iterator factory. It traverses an AU's URLs, restricting them in various ways according to a specification. These restrictions include considering only certain subdirectory trees (hence the name), applying regular expressions, selecting a media type, or applying a custom condition.

The `SubTreeArticleIterator.Spec` class contains the specification:

- The specification identifies root URLs, limiting which AU URLs are enumerated to those under these root URLs only. This restriction applies to the directory structure, not the URL strings -- in effect, root URLs end with a slash. Root URLs can be specified directly with `setRoot(...)` or `setRoots(...)`, or via printf templates (which expand to URLs) expressed as single Java strings with `setRootTemplate(...)` or `setRootTemplates(...)`. The printf templates are expressed as single Java strings, which can be tricky to read, for example: "%s%s/%d/", base_url, journal_id, year" (with the convention that the base URL value ends with a slash). If the specification specifies no root URL, all URLs in the AU are enumerated.

\(^1\) Technically a mapping from roles to arbitrary Java objects.

### 5.7. Metadata Extraction

83
• The specification can optionally have an **include pattern** or an **exclude pattern**. With an include pattern, URLs below each root URL that match the include pattern are considered (but others are ignored). With an exclude pattern, URLs below each root URL that match the exclude pattern are ignored (but others are considered). No error will happen if both are specified, but the exclude pattern will be ignored in favor of the include pattern. These patterns (regular expressions) can be specified directly with `setIncludeSubTreePattern(...)` or `setExcludeSubTreePattern(...)`, or via printf templates (which expand to regular expressions) expressed as single Java strings with `setIncludeSubTreePatternTemplate(...)` or `setExcludeSubTreePatternTemplate(...)`.  

• The specification can optionally have a **general pattern**, which is a regular expression applied to any URL still under consideration. It can be specified directly with `setPattern(...)`, or via a printf template (which expands to a regular expression) expressed as a single Java string with `setPatternTemplate(...)`.  

• The specification can have an optional media type (for example text/html), and only URLs under consideration that have this media type will be enumerated. There is currently no way to specify multiple media types, which can be problematic for media types with multiple common representations, like text/xml and application/xml. The class could be enhanced in the future to allow multiple media types.

The logic for which URLs are enumerated is found in the `isArticleCu(...)` method, which can be customized in a subclass.

By default, for each successful URL, this iterator makes one `ArticleFiles` instance that has its designated full text URL set, and no roles set. This behavior can be customized in `visitArticleCu(...)` and `createArticleFiles(...)` in a subclass.

**SubTreeArticleIteratorBuilder**

The `org.lockss.plugin.SubTreeArticleIteratorBuilder` class assists in the creation of a `SubTreeArticleIterator` instance under circumstances where the URLs of various aspects of an article (for example its abstract URL, its full text HTML URL, its full text PDF URL, etc.) can all be derived from one another through **mutually compatible regular expressions** and replacement strings.

An example of such mutual compatibility would be a journal where articles have full text HTML URLs that look like this: http://www.example.com/vol12/iss3/art45 and full text PDF URLs that look like this: http://www.example.com/pdf/article_12_3_45.pdf (assuming these URLs represent volume 12, issue 3, page 45). A regular expression for the full text HTML URLs (expressed as a Java string) could be `"/vol(\d+)/iss(\d+)/art(\d+)$"`, and the replacement string `"/pdf/article_$1_$2_$3.pdf"` would yield the corresponding full text PDF URL from a match; likewise a regular expression for the full text PDF URL could be `"/pdf/article_(\d+)_(.\d+)\.pdf$"`, and the replacement string `"/vol$1/iss$2/art$3"` would yield the corresponding full text HTML URL from a match.

The `SubTreeArticleIteratorBuilder` class has convenience methods to:

• Create a `SubTreeArticleIterator.Spec` specification. See `setSpec(...)`, or use `newSpec()` to manipulate an empty Spec from scratch.

• Define **major aspects** with one or more regular expressions matching the aspect's URLs, one or more replacement strings yielding the aspect's URLs from matchers for URLs of other major aspects, and one or more roles for the aspect.

• Define **minor aspects** with one or more replacement strings yielding the aspect's URLs from matchers for URLs of major aspects, and one or more roles for the aspect.

The key differences between major and minor aspects are:

• URLs enumerated by the `SubTreeArticleIterator` are tried against the regular expressions of the major aspects only.

• The earliest URL for a major aspect to match for a given article is also designated as the article's full text CU.
All aspects are defined with the variants of the `addAspect(...)` method and associated methods.

When an `ArticleFiles` is complete, methods like `setRoleFromOtherRoles(...)` and `setFullTextFromRoles(...)` can be used to designate additional roles or the full text CU from the value associated with an ordered list of possibilities from other roles.

The `getSubTreeArticleIterator()` method can finally be used to obtain a `SubTreeArticleIterator` instance behaving in the specified manner.

### 5.7.3 File Metadata Extractor

**Plugin Key**

`mediatype>_metadata_extractor_factory_map`, where `mediatype` is a media type like `text/html`

**Plugin Value Type**

`Map` from `String` to `String`

**Plugin Value Type**

The values are the fully-qualified name of a Java class implementing the `org.lockss.extractor.FileMetadataExtractorFactory` interface.

**Sample**

```xml
<entry>
  <string>text/html_metadata_extractor_factory_map</string>
  <map>
    <entry>
      <string>*</string>
      <string>edu.example.plugin.publisherx.PublisherXHtmlMetadataExtractorFactory</string>
    </entry>
  </map>
</entry>
```

If the media type is represented under multiple guises in the plugin's AUs, for example XML represented as both `text/xml` and `application/xml`, you will need multiple entries in the plugin.

**Description**

File metadata extractors are part of the `metadata extraction` pipeline. Their function is to parse the contents of a particular URL based on its media type and file format, and emit any number of `ArticleMetadata` metadata records, and they are invoked as part of the execution of an `Article Metadata Extractor`.

**SimpleFileMetadataExtractor**

The `org.lockss.extractor.SimpleFileMetadataExtractor` utility class is used as a base class for the common case where a file metadata extractor produces a single metadata record (or `null`), rather than an arbitrary number of metadata records. It defines one abstract method:

```java
public abstract ArticleMetadata extract(MetadataTarget target, 
                                       CachedUrl cu) 
    throws IOException, PluginException;
```
and its `extract(MetadataTarget target, CachedUrl cu, Emitter emitter)` method simply calls `extract(MetadataTarget target, CachedUrl cu)` and emits the returned `ArticleMetadata` if it is not null.

Utility classes based on `SimpleFileMetadataExtractor` include `JsoupTagExtractor` and `RisMetadataExtractor`.

**JsoupTagExtractor**

The `org.lockss.extractor.JsoupTagExtractor` utility class can be used to build HTML or XML file metadata extractors that use the `jsoup` parser.

By default, it maps the value of the `name` attribute of HTML `<meta>` tags to the value of their `content` attribute in the `ArticleMetadata` object's raw multi-map.

However if the media type is `text/xml`, `application/xml` or `application/xhtml+xml`, or if the extractor is created with selector strings, for each selector string, and for each element matched by the selector string, it maps the selector string to the selector value in the raw multi-map. The selector strings are those understood by the `select(...)` method of `jsoup`'s `Document` class.

Subclasses provide the recipe multi-map (cook map) to process raw data into metadata.

---

**Note:** The `org.lockss.extractor.JsoupXmlTagExtractor` class exists but its functionality has been absorbed into `org.lockss.extractor.JsoupTagExtractor`, which is capable of handling HTML without selector strings as well as HTML and XML with selector strings. It may be removed in a future version of the LOCKSS system and should not be used for new plugin implementations -- use `JsoupTagExtractor` instead.

The `org.lockss.extractor.SimpleHtmlMetaTagMetadataExtractor` class also exists and scrapes HTML `<meta>` tags using a regular expression-based approach. It is at risk of being deprecated in a future version of the LOCKSS system, and is not recommended for new plugin implementations -- use `JsoupTagExtractor` instead.

---

**RisMetadataExtractor**

The `org.lockss.extractor.RisMetadataExtractor` utility class parses RIS metadata files (media type `application/x-research-info-systems`).

By default, it maps RIS tags to their values in the `ArticleMetadata` object's raw multi-map, and its recipe map (cook map) maps the following raw keys (RIS tags) to the following `MetadataField` instances:

- **TI** to the article title (`MetadataField.FIELD_ARTICLE_TITLE`)
- **AU** to an author (`MetadataField.FIELD_AUTHOR`)
- **JF** to the journal title (`MetadataField.FIELD_PUBLICATION_TITLE`)
- **DO** to the DOI (`MetadataField.FIELD_DOI`)
- **PB** to the publisher name (`MetadataField.FIELD_PUBLISHER`)
- **VL** to the journal volume (`MetadataField.FIELD_VOLUME`)
- **IS** to the journal issue (`MetadataField.FIELD_ISSUE`)
- **SP** to the start page (`MetadataField.FIELD_START_PAGE`)
- **EP** to the end page (`MetadataField.FIELD_END_PAGE`)
- **DA** to the publication date (`MetadataField.FIELD_DATE`)
• SN to the ISSN (MetadataField.FIELD_ISSN) for a journal (TY tag equal to JOUR) or ISBN (MetadataField.FIELD_ISBN) for a book (TY tag equal to BOOK, CHAP, EBOOK, ECHAP, EDBOOK)

but the behavior is customizable.

**SourceXmlMetadataExtractor**

Because the LOCKSS Program processes large amounts of bulk content on behalf of the CLOCKSS Archive, which is often in the form of bundles of content with multi-article metadata in XML (for example JATS format), there are utility classes in the org.lockss.plugin.clockss package of the plugins tree of the lockss-daemon project to generalize this kind of data processing.

Plugins can only reference classes found in the plugin JAR itself, in lockss-core and in its dependencies (if using the re-architected LOCKSS system), or in the main tree of lockss-daemon and in its dependencies (if using the classic LOCKSS system), so these classes in the plugins tree of lockss-daemon are not directly accessible to arbitrary plugins (without some manipulation, like injecting additional classes in plugin JARs). However there is growing interest in re-using these utility classes in the broader LOCKSS community, so some of these classes will be "promoted" to lockss-core so they can be used by third-party plugins in a future version of the LOCKSS system.

The org.lockss.plugin.clockss.SourceXmlMetadataExtractorFactory, org.lockss.plugin.clockss.SourceXmlMetadataExtractorFactory, SourceXmlMetadataExtractorFactory, SourceXmlMetadataExtractorFactory and org.lockss.plugin.clockss.SourceXmlSchemaHelper classes define a framework for processing XML metadata in some format, and mapping from XPath expressions to text values in the ArticleMetadata object’s raw multi-map. The format-specific logic is confined in the SourceXmlSchemaHelper object.

The SourceXmlSchemaHelper class consists of a global map and an article map. Both map XPath strings to the corresponding values. The article map, aided by the getArticleNode() method which gives an XPath for the top-level node of each article in the XML file, is used to designate XPaths for each emitted article from the file. The optional global map is used to designate XPaths that apply to all emitted articles from the file, and can be used for XML formats that hoist some data above the level of each article (for instance publication-level or issue-level data).

This framework also offers some features to perform deduplication or recombination, verify some URLs or file paths, and SourceXmlSchemaHelper’s getCookMap() method provides the recipe multi-map to produce metadata from the raw multi-map.

There is also an effort underway to define an equivalent framework for similarly structured metadata in JSON, using the Jayway JsonPath library.

### 5.7.4 Article Metadata Extractor

**Plugin Key**

`plugin_article_metadata_extractor_factory`

**Plugin Value Type**

`String`

The string is the fully-qualified name of a Java class implementing the org.lockss.extractor.ArticleMetadataExtractorFactory interface.

**Sample**

```xml
<entry>
<string>plugin_article_metadata_extractor_factory</string>
<string>edu.example.plugin.publisherx.PublisherXArticleMetadataExtractorFactory</string>
</entry>
```
Description

The article metadata extractor is part of the metadata extraction pipeline. Its function is to process each article (where "article" is meant as "item" or "object") in the archival unit (AU) and emit any number of metadata records from it. Each metadata record is represented by an ArticleMetadata instance. The article metadata extractor is aided in its task by file metadata extractors.

**ArticleMetadata**

An `org.lockss.extractor.ArticleMetadata` object contains two multi-maps (one-to-many mappings, using the Apache Commons Collections `org.apache.commons.collections4.map.MultiValueMap` class internally): a raw multi-map, and a metadata multi-map often called the cooked multi-map by analogy. The raw multi-map is for general-purpose storage of data extracted from content, where the keys are arbitrary strings, and the multiple values are either strings or maps from string to string. The cooked multi-map is the final representation of the metadata information contained in the object, where the keys are `MetadataField` instances, and the multiple values are strings.

`org.lockss.extractor.MetadataField` objects represent not only the key of a metadata field but also its cardinality (single or multiple) and a validator. Many are built into the `MetadataField` class itself, including single cardinality fields for journal volume, issue, start page and end page; single cardinality fields for DOI, ISSN, eISSN, ISBN that accept a string potentially prefixed with doi:, issn:, eissn: and isbn: (as is often found on publisher websites); multiple cardinality fields for authors; etc.

The plugin-dependent way to populate the cooked multi-map from the raw multi-map is given by a recipe multi-map sometimes confusingly referred to as the cook map, which maps raw keys (string) to one or more cooked keys (`MetadataField`). For each raw key-cooked key pair, each raw multi-value corresponding to the raw key is validated and stored by the cooked field into a cooked multi-value.

**BaseArticleMetadataExtractor**

Most plugins do not implement arbitrary logic in the article metadata extractor, but simply use the `org.lockss.extractor.BaseArticleMetadataExtractor` class.

This utility article metadata extractor is parameterized with a single target `ArticleFiles` role, parses the URL in the `ArticleFiles` that has the target role using the appropriate file metadata extractor for its media type, and post-processes each emitted `ArticleMetadata` object by adding bibliographic metadata drawn from the AU’s listing in the title database (AU inventory) if such data is not extracted from the content already.

The logic for what gets post-processed from the title database into the `ArticleMetadata` instance is in the `addTdbDefaults(...)` method, which can be overridden to customize. If the AU is not labeled as bulk content (disparate content from many sources), the publication type, series name, ISSN, eISSN, ISBN, eISBN, publication name, volume, issue, and publication date are set from the corresponding value in the title database, if available and if not already set from the actual metadata extraction.

Additionally, the `checkAccessUrl(...)` method ensures that the URL set under the `MetadataField.FIELD_ACCESS_URL` metadata key for the article is actually in the AU, and if not, it is reset to the full text URL for the article.

The implementation of `ArticleMetadataExtractorFactory` is often simply to return a new `BaseArticleMetadataExtractor` for a given target role (usually `ArticleFiles.ARTICLE_METADATA`), with no further code:

```java
@override
class ArticleMetadataExtractorFactory

public ArticleMetadataExtractor createArticleMetadataExtractor(MetadataTarget target)
throws PluginException {
    return new BaseArticleMetadataExtractor(ArticleFiles.ROLE_ARTICLE_METADATA);
}
```
Because of this, many plugins do not define a separate Java class for the article metadata extractor factory but simply let their article iterator factory also implement `ArticleMetadataExtractorFactory`:

```java
public class PublisherXArticleIteratorFactory
    implements ArticleIteratorFactory, ArticleMetadataExtractorFactory {

    @Override
    public Iterator<ArticleFiles> createArticleIterator(ArchivalUnit au,
        MetadataTarget target)
        throws PluginException {
        // ...
    }

    @Override
    public ArticleMetadataExtractor createArticleMetadataExtractor(MetadataTarget target)
        throws PluginException {
        return new BaseArticleMetadataExtractor(ArticleFiles.ROLE_ARTICLE_METADATA);
    }
}
```

### 5.8 Web Replay

This section introduces plugin features related to supporting the replay of Web content.

#### 5.8.1 Link Rewriter

**Note:** This page is under construction.

**Plugin Key**

`mediatype_link_rewriter_factory`, where `mediatype` is a media type like `text/html`

**Plugin Value Type**

`String`

**Plugin Value Type**

The value is the fully qualified name of a Java class implementing the `org.lockss.extractor.LinkRewriterFactory` interface.

**Sample**

```
<entry>
    <string>text/html_link_rewriter_factory</string>
    <string>edu.example.plugin.publisherx.PublisherXHtmlLinkRewriterFactory</string>
</entry>
```

**Description**

When content is replayed through the LOCKSS system's ServeContent Web replay engine, links have to be rewritten so that they point to other ServeContent URLs where applicable. ServeContent contains logic to handle typical cases in HTML and CSS, but some specific use cases may require additional or custom link rewriting. To accomplish this, the plugin defines link rewriters for the affected media types.
For example, a Web site could have image tags for journal article figures that look like this: `<img src="fig1_small.jpg" data-target="fig1_large.jpg" />`, and Javascript code in the page such that when the small version of the image is clicked, an image viewer widget is displayed with the large version of the image instead. ServeContent has internal logic that knows to look for the `src` attribute of `<img>` tags, but would not know to also process this non-standard `data-target` attribute so the image viewer widget works with a preserved copy of the large version of the image. Depending on the situation, this might require a custom rewriter for just HTML, or for HTML plus Javascript.

### 5.8.2 Rewrite HTML Meta URLs

**Note:** This page is under construction.

**Plugin Key**

```
plugin_rewrite_html_meta_urls
```

**Plugin Value Type**

- List of String

**Plugin Value Type**

Each string in the list is a value of the `name` attribute of HTML `<meta>` tags.

**Sample**

```
<entry>
  <string>plugin_rewrite_html_meta_urls</string>
  <list>
    <string>citation_abstract_url</string>
    <string>citation_pdf_url</string>
  </list>
</entry>
```

**Description**

This plugin feature enables a canned HTML `Link Rewriter` that seeks out `<meta name="..." content="...">` tags where the value of the `name` attribute matches one of the specified names, and rewrites the URL that is the value of their `content` attribute.

### 5.9 Inheritance

This section introduces plugin features related to sharing similar behavior among a set of plugins.

#### 5.9.1 Parent Plugin

**Plugin Key**

```
plugin_parent
```

**Plugin Value Type**

- String

**Plugin Value Format**

The value is the `Plugin Identifier` of this plugin's parent.

**Sample**

---

Chapter 5. LOCKSS Plugin Developer Guide
Description
Declares that this plugin uses the specified plugin as its parent. This plugin inherits the key-value pairs from the parent plugin, and additionally adds values for keys not found in the parent or redefines the value for a key found in the parent.

If the parent plugin maps a key to a specific value and this plugin wishes to undo the effect and simply use whatever the default is for the key in the system, this plugin can map the key to the special value `<org.lockss.util.Default />`.

### 5.9.2 Parent Plugin Version

**Plugin Key**
plugin_parent_version

**Plugin Value Type**
String, not integer

**Plugin Value Format**
The value is the Parent Plugin's Plugin Version.

**Sample**

```xml
<entry>
  <string>plugin_parent_version</string>
  <string>2</string>
</entry>
```

**Description**
Declares the intended version of this plugin's Parent Plugin.

### 5.10 Appendix

This appendix gives a brief overview of printf Format Strings and Regular Expressions.

#### 5.10.1 printf Format Strings

**Note:** This page is under construction.

A printf format string is a template for generating a string of text from variable parts. It consists of a format specification containing literal elements and format specifiers (placeholders with formatting hints), and a list of expressions for each placeholder's value.

A printf interpreter is a template engine that accepts a printf format string as input and produces an output string from it, based on its implementation-dependent capabilities to compute the value of expressions and on context-dependent variables.
The LOCKSS software contains a printf interpreter where the expressions are names of Plugin Configuration Parameters and AU attributes, optionally modified by a small number of processing functions.

**printf Format String Format**

A printf format specification starts and ends with a quotation mark (") and follows the printf specification syntax. For each format specifier in the format specification, the value of an expression is computed and substituted for the format specifier. The successive expressions correspond to the format specifiers in the order they appear in the format specification.

The format specification and the expressions are comma-separated, with whitespace surrounding the elements trimmed. Anything that is not recognized as a format specifier is interpreted to be a literal part of the output string.

**printf Format Specifiers**

Format specifiers begin with a percent sign (%) and end with a type field, separated by optional characters further constraining the formatting of the placeholder's value. The most important type fields are:

- `%s`: for string-valued expressions.
- `%d`: for integer-valued expressions.
- `%%`: for a literal percent sign.

**String**

The most common format specifier is `%s` for string-valued expressions. Example:

Input:

"The base URL is %s", base_url

Output in a context where base_url is http://www.example.com/:

The base URL is http://www.example.com/

**Integer**

The format specifier `%d` is used for an integer-valued expression. Example:

Input:

"The year is %d", year

Output in a context where year is the integer 2022:

The year is 2022
Percent Sign

Because the percent sign is used to introduce format specifiers, there is type field to indicate that a placeholder is for a literal percent sign, and that type field is also the percent sign. Examples:

Input: "100%% of the time"
Output: 100% of the time

Input: "100% of the time"
Output: error

References

- printf format string on Wikipedia

5.10.2 Regular Expressions

Note: This page is under construction.

A regular expression is a character string that specifies a text search pattern. The search pattern can then be applied to an input string. If a portion of the input string matches the search pattern, the matching portions or designated subparts of it can be extracted.

A regular expression engine is a software library capable of applying search patterns specified in an implementation-dependent regular expression language to arbitrary input strings.

The LOCKSS software uses the Java regular expression engine, but because Java did not always have built-in regular expression support, in some contexts the LOCKSS software uses the older Apache ORO regular expression engine. Typical use of regular expressions in LOCKSS plugins should not result in noticeable differences between the two engines' capabilities.

References

- Regular expression on Wikipedia
Note: The LOCKSS Network Administrator Guide is under construction.

Welcome to the LOCKSS Network Administrator Guide. This section of the LOCKSS Documentation Portal contains information aimed at administrators of LOCKSS networks.
INDEX

C
CLASSPATH, 29

E
environment variable
  CLASSPATH, 29
  JAVA_HOME, 25
  PATH, 23

J
JAVA_HOME, 25

P
PATH, 23