Extending Condor

Condor Week 2010

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Some classifications

Application Program Interfaces (APIs)

- Job Control
- Operational Monitoring

★ Extensions ★

Job Control APIs

The biggies:

- Command Line Tools
- Web Service Interface (SOAP)

  http://condor-wiki.cs.wisc.edu/index.cgi/wiki?p=SoapWisdom
- DRMAA
- Condor DBQ

Operational Monitoring APIs

- Via Web Services (SOAP)
- Via Relational Database: Quill
  - Job, Machine, and Matchmaking data echoed into PostgreSQL RDBMS
- Via a file: the Event Log
  - Structured journal of job events
  - Sample code in C++ to read/parse these events
- Via Enterprise messaging: Condor AMQP
  - EventLog events echoed into Qpid
  - *Plug:* Vidhya Murali's talk tomorrow afternoon

Extending Condor

- APIs: How to interface w/ Condor
- Extensions: Changing Condor's behavior
  - Hooks
  - Plugins

Job Wrapper Hook

- Allows an administrator to specify a "*wrapper*" script to handle the execution of all user jobs
- Set via condor_config "USER_JOB_WRAPPER"
- Wrapper runs as the user, command-line args are passed, machine & job ad is available.
- Errors can be propagated to the user.
- Example: *condor_limits_wrapper.sh*

Job Fetch & Prepare Hooks

- Job Fetch hooks
  - Call outs from the condor_startd
  - Extend claiming
  - Normally jobs are pushed from schedd to startd – now jobs can be "pulled" from anywhere
- Job Running Hooks
  - Call outs from the condor_starter
  - Transform the job classad
  - Perform any other pre/post logic

What hooks are available?

- Fetch Hooks (condor_startd):
  - FETCH_JOB
  - REPLY_FETCH
  - EVICT_CLAIM
- Running Hooks (condor_starter):
  - PREPARE_JOB
  - UPDATE_JOB_INFO
  - JOB_EXIT

HOOK_FETCH_JOB

- Invoked by the startd whenever it wants to try to fetch new work
  - FetchWorkDelay expression
- Hook gets a current copy of the slot ClassAd
- Hook prints the job ClassAd to STDOUT
- If STDOUT is empty, there's no work

HOOK_REPLY_FETCH

- Invoked by the startd once it decides what to do with the job ClassAd returned by HOOK_FETCH_WORK
- Gives your external system a chance to know what happened
- argv[1]: "accept" or "reject"
- Gets a copy of slot and job ClassAds
- Condor ignores all output
- Optional hook

HOOK_EVICT_CLAIM

- Invoked if the startd has to evict a claim that's running fetched work
- Informational only: you can't stop or delay this train once it's left the station
- STDIN: Both slot and job ClassAds
- STDOUT: > /dev/null

HOOK_PREPARE_JOB

- Invoked by the condor_starter when it first starts up (only if defined)
- Opportunity to prepare the job execution environment
  - Transfer input files, executables, etc.
- INPUT: both slot and job ClassAds
- OUTPUT: ignored, but starter won't continue until this hook exits
- *Not specific to fetched work*

HOOK_UPDATE_JOB_INFO

- Periodically invoked by the starter to let you know what's happening with the job
- INPUT: both ClassAds
  - Job ClassAd is updated with additional attributes computed by the starter:
    - ImageSize, JobState, RemoteUserCpu, etc.
- OUTPUT: ignored

HOOK_JOB_EXIT

- Invoked by the starter whenever the job exits for any reason
- Argv[1] indicates what happened:
  - "exit": Died a natural death
  - "evict": Booted off prematurely by the startd (PREEMPT == TRUE, condor_off, etc)
  - "remove": Removed by condor_rm
  - "hold": Held by condor_hold

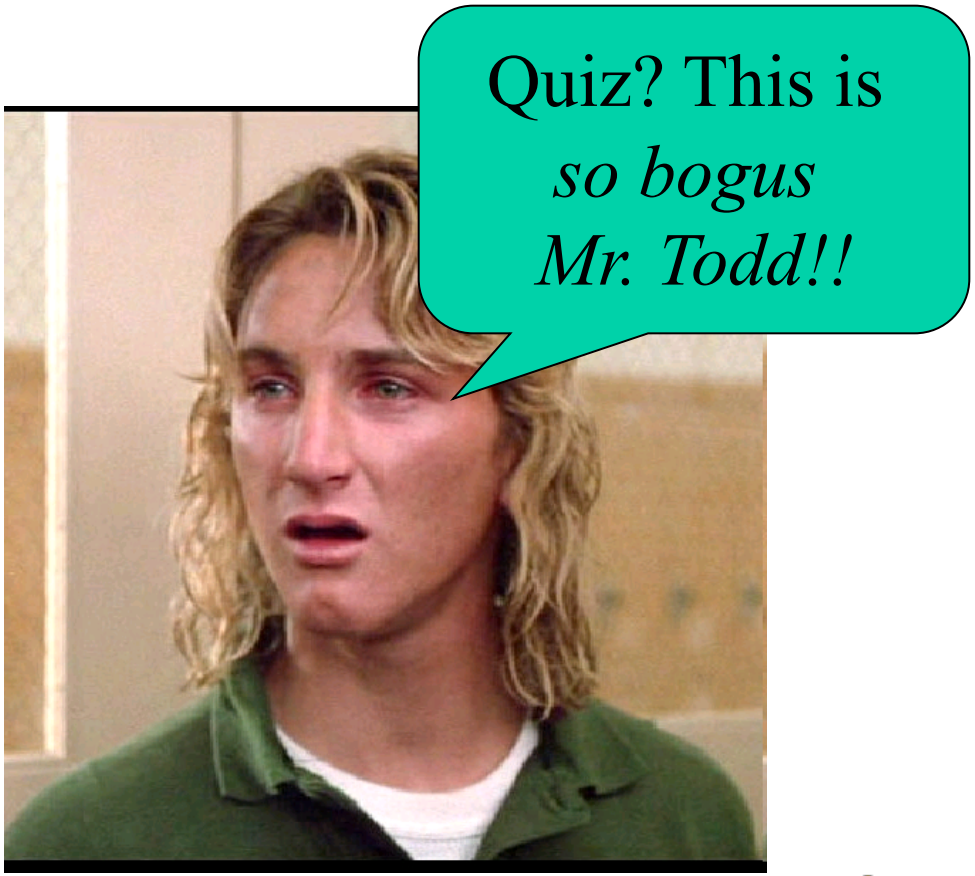
POP QUIZ!!!

Given

- Job Wrapper hook
- Job Fetch hooks
- Job Running hooks

Which one is redundent?

Why?



Sidebar: "Toppings"

- If work arrived via fetch hook "foo", then prepare hooks "foo" will be used.
- What if an individual job could specify a job prepare hook to use???
- Prepare hook to use can be alternatively specified in job classad via attribute "HookKeyword"
- How *cool is that???*

Toppings: Simple Example

- In condor_config:

```
ANSYS_HOOK_PREPARE_JOB= \
    $(LIBEXEC)/ansys_prepare_hook.sh
```

- Contents of ansys_prepare_hook.sh:

```
#!/bin/sh
#Read and discard the job classad
cat >/dev/null
echo'Cmd="/usr/local/bin/ansys"'
```

Topping Example, cont.

- In job submit file:

```
universe=vanilla
executable=whatever
arguments=…
+HookKeyword="ANSYS"
queue
```

Job Router Hooks

JOB_ROUTER_ENTRIES_CMD
- read the routing table from an external program
- optional periodic refresh

<hookname>_HOOK_TRANSLATE
- transform original job to "routed" job

<hookname>_HOOK_UPDATE_JOB_INFO
- periodically update routed job ClassAd

<hookname>_HOOK_JOB_FINALIZE
- handle job completion and update original job ClassAd

<hookname>_HOOK_JOB_CLEANUP
- handle cleaning up when done managing job

Configuration Hook

- Instead of reading from a file, run a program to generate Condor config settings
- Append "|" to CONDOR_CONFIG or LOCAL_CONFIG_FILE. Example:

```
LOCAL_CONFIG_FILE = \
      /opt/condor/sbin/make_config
```

File Transfer Hooks

- Allows the administrator to configure hooks for handling URLs during Condor's file transfer
- Enables transfer from third party directly to execute machine, which can offload traffic from the submit point
- Can be used in a number of clever ways

File Transfer Hooks

- API is extremely simple
- Must support being invoked with the "-classad" option to advertise its abilities:

```
#!/bin/env perl

if ($ARGV[0] eq "-classad") {
    print "PluginType = \"FileTransfer\"\n";
    print "SupportedMethods = \"http,ftp,file\"\n";
    exit 0;
}
```

File Transfer Hooks

- When invoked normally, a plugin simply transfers the URL (first argument) into filename (second argument)

```
# quoting could be an issue but this runs in user space

$cmd = "curl " . $ARGV[0] . " -o " . $ARGV[1];
system($cmd);
$retval = $?;

exit $retval;
```

File Transfer Hooks

- In the condor_config file, the administrator lists the transfer hooks that can be used
- Condor invokes each one to find out its abilities
- If something that looks like a URL is added to the list of input files, the plugin is invoked on the execute machine

File Transfer Hooks

- condor_config:
  - FILETRANSFER_PLUGINS = curl_plugin, hdfs_plugin, gdotorg_plugin, rand_plugin
- Submit file:
  - transfer_input_files = normal_file, http://cs.wisc.edu/~zkm/data_file, rand://1024/random_kilobyte

File Transfer Hooks

- As you can see, the format of the URL is relatively arbitrary and is interpreted by the hook
- This allows for tricks like rand://, blastdb://, data://, etc.
- Currently a bug prevents this from working for VMWare images but soon we'll support vm:// as well.

Plugins

Plugins

- Shared Library Plugins
  - Gets mapped right into the process space of the Condor Services! May not block! Must be thread safe!
  - General and ClassAd Functions
- Condor ClassAd Function Plugin
  - Add custom built-in functions to the ClassAd Language.
  - Via condor_config "CLASSAD_LIB_PATH"
  - Cleverly used by SAMGrid

General Plugins

- In condor_config, use "PLUGINS" or "PLUGIN_DIR".
- Very good idea to do:
  - SUBSYSTEM.PLUGIN or
  - SUBSYSTEM.PLUGIN_DIR
- Implement C++ child class, and Condor will call methods at the appropriate times.
- Some general methods (initialize, shutdown), and then callbacks based on plugin type
- What's available? *Plugin Discovery…*

Plugin Discovery

cd src/

dir /s Example*Plugin.cpp

You will find:

- ExampleCollectorPlugin.cpp
- ExampleMasterPlugin.cpp
- ExampleNegotiatorPlugin.cpp
- ExampleClassAdLogPlugin.cpp
- ExampleScheddPlugin.cpp
- ExampleStartdPlugin.cpp

And a ClassAdLogPluginManager.cpp

Collector Plugin

```
struct ExampleCollectorPlugin : public CollectorPlugin
{
   void initialize();

   void shutdown();

   void update(int command, const ClassAd &ad);

   void invalidate(int command, const ClassAd &ad);
};
```

ClassAdLog Plugin Methods

```
virtual void newClassAd(const char *key) = 0;
virtual void destroyClassAd(const char *key) = 0;
virtual void setAttribute(const char *key,
                          const char *name,
                          const char *value) = 0;
virtual void deleteAttribute(const char *key,
                             const char *name) = 0;
```

Other Extending Ideas…

Custom ClassAd Attributes

- Job ClassAd
  - +Name = Value in submit file
  - SUBMIT_EXPRS in condor_config
- Machine ClassAd
  - STARTD_EXPRS in condor_config for static attributes
  - STARTD_CRON_* settings in condor_config for dynamic attributes

Thinking out of the box…

- MAIL in condor_config
- WINDOWS_SOFTKILL in condor_config
- Green Computing Settings
  - HIBERNATION_PLUGIN (called by the startd)
  - ROOSTER_WAKEUP_CMD

All else fails? Grab Source!

Condor is open source ya know…

Thank you! Questions?

Extra Slides

Web Service Interface

- Simple Object Access Protocol
  - Mechanism for doing RPC using XML (typically over HTTP or HTTPS)
  - A World Wide Web Consortium (W3C) standard
- SOAP Toolkit: Transform a WSDL to a client library

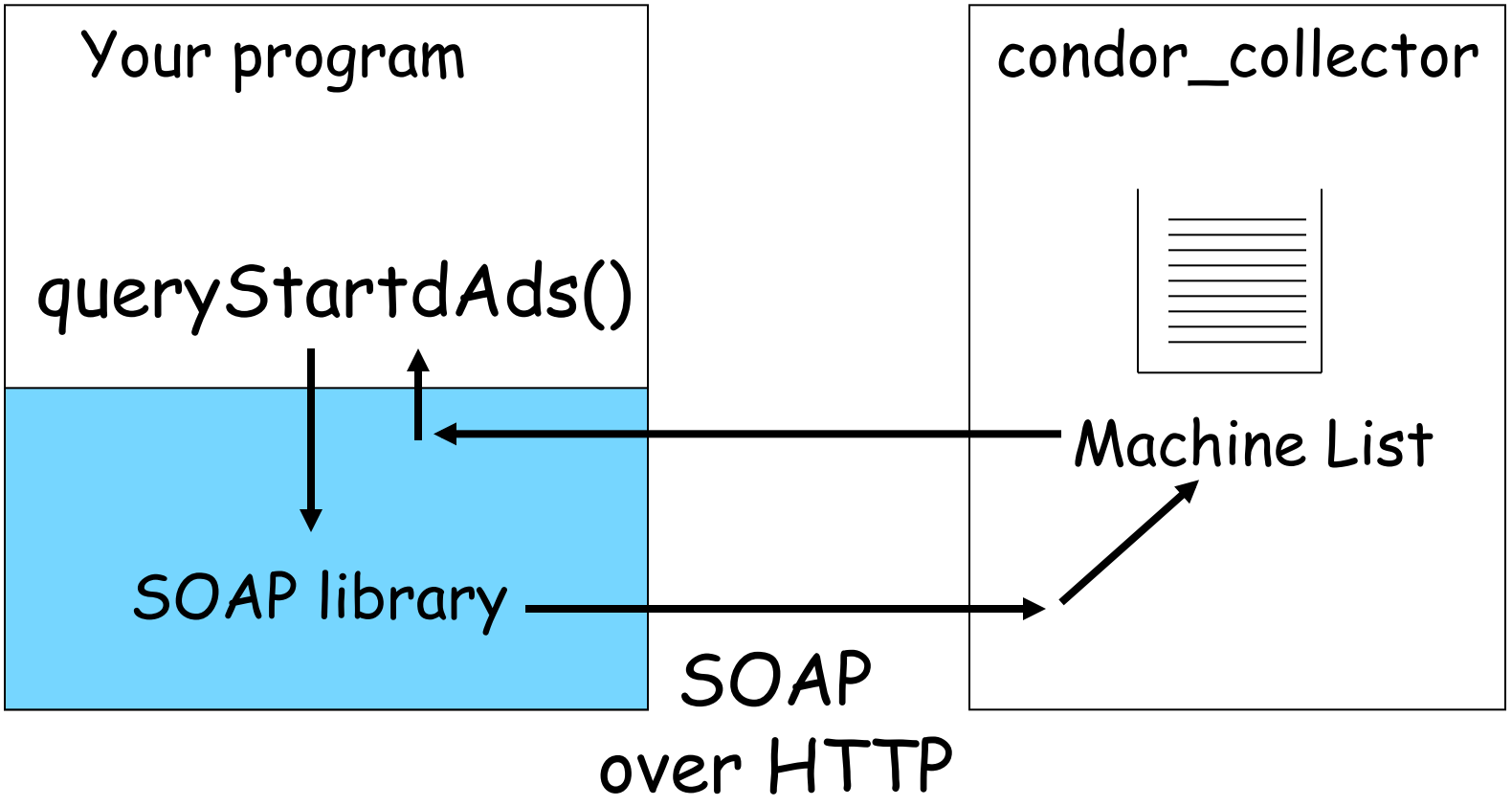
Benefits of a Condor SOAP API

- Can be accessed with standard web service tools
- Condor accessible from platforms where its command-line tools are not supported
- Talk to Condor with your favorite language and SOAP toolkit

Condor SOAP API functionality

- Get basic daemon info (version, platform)
- Submit jobs
- Retrieve job output
- Remove/hold/release jobs
- Query machine status
- Advertise resources
- Query job status

Getting machine status via SOAP



Lets get some details…

The API

- Core API, described with WSDL, is designed to be as flexible as possible
  - File transfer is done in chunks
  - Transactions are explicit
- Wrapper libraries aim to make common tasks as simple as possible
  - Currently in Java and C#
  - Expose an object-oriented interface

Things we will cover

- Condor setup
- Necessary tools
- Job Submission
- Job Querying
- Job Retrieval
- Authentication with SSL and X.509

Condor setup

- Start with a working condor_config
- The SOAP interface is off by default
  - Turn it on by adding ENABLE_SOAP=TRUE
- Access to the SOAP interface is denied by default
  - Set ALLOW_SOAP and DENY_SOAP, they work like ALLOW_READ/WRITE/…
  - Example: ALLOW_SOAP=*/*.cs.wisc.edu

Necessary tools

- You need a SOAP toolkit
  - Apache Axis (Java) - http://ws.apache.org/axis/
  - Microsoft .Net - http://microsoft.com/net/
  - gSOAP (C/C++) - http://gsoap2.sf.net/
  - ZSI (Python) - http://pywebsvcs.sf.net/
  - SOAP::Lite (Perl) - http://soaplite.com/
- You need Condor's WSDL files
  - Find them in lib/webservice/ in your Condor release
- Put the two together to generate a client library
  - $ java org.apache.axis.wsdl.WSDL2Java condorSchedd.wsdl
- Compile that client library
  - $ javac condor/*.java

All our examples are in Java using Apache Axis

Client wrapper libraries

- The core API has some complex spots
- A wrapper library is available in Java and C#
  - Makes the API a bit easier to use (e.g. simpler file transfer & job ad submission)
  - Makes the API more OO, no need to remember and pass around transaction ids
- We are going to use the Java wrapper library for our examples
  - You can download it from http://www.cs.wisc.edu/condor/birdbath/birdbath.jar

Submitting a job

- The CLI way…

cp.sub:

```
universe = vanilla
executable = /bin/cp
arguments = cp.sub cp.worked
should_transfer_files = yes
transfer_input_files = cp.sub
when_to_transfer_output = on_exit
queue 1
clusterid = X
procid = Y
owner = matt
requirements = Z
```

Explicit bits

Implicit bits

```
$ condor_submit cp.sub
```

Submitting a job

- The SOAP way…
  1. Begin transaction
  2. Create cluster
  3. Create job
  4. Send files
  5. Describe job
  6. Commit transaction

Repeat to submit multiple clusters

Repeat to submit multiple jobs in a single cluster

Submission from Java

```
Schedd schedd = new Schedd("http://…");
Transaction xact =
   schedd.createTransaction();
xact.begin(30);
int cluster = xact.createCluster();
int job = xact.createJob(cluster);
File[] files = { new File("cp.sub") };
xact.submit(cluster, job, "owner",
   UniverseType.VANILLA, "/bin/cp",
   "cp.sub cp.worked", "requirements",
   null, files);
xact.commit();
```

1. Begin transaction

2. Create cluster

3. Create job

4&5. Send files & describe job

6. Commit transaction

Submission from Java

```
Schedd schedd = new Schedd("http://…");
Transaction xact =
   schedd.createTransaction();
xact.begin(30);
int cluster = xact.createCluster();
int job = xact.createJob(cluster);
File[] files = { new File("cp.sub") };
xact.submit(cluster, job, "owner",
   UniverseType.VANILLA, "/bin/cp",
   "cp.sub cp.worked", "requirements",
   null, files);
xact.commit();
```

Schedd's location

Max time between calls (seconds)

Job owner, e.g. "matt"

Requirements, e.g. "OpSys==\"Linux\""

Extra attributes, e.g. Out="stdout.txt" or Err="stderr.txt"

Querying jobs

- The CLI way…

```
$ condor_q

-- Submitter: localhost : <127.0.0.1:1234> : localhost
 ID      OWNER            SUBMITTED     RUN_TIME ST PRI SIZE CMD
   1.0   matt          10/27 14:45   0+02:46:42 C  0   1.8  sleep 10000
…

42 jobs; 1 idle, 1 running, 1 held, 1 unexpanded
```

Querying jobs

- The SOAP way from Java…

```
String[] statusName = { "", "Idle", "Running", "Removed",
   "Completed", "Held" };
int cluster = 1;
int job = 0;

Schedd schedd = new Schedd("http://…");
ClassAd ad = new ClassAd(schedd.getJobAd(cluster, job));

int status = Integer.valueOf(ad.get("JobStatus"));
System.out.println("Job is " + statusName[status]);
```

Also, getJobAds given a constraint, e.g. "Owner==\"matt\""

Retrieving a job

- The CLI way..
- Well, if you are submitting to a local Schedd, the Schedd will have all of a job's output written back for you
- If you are doing remote submission you need `condor_transfer_data`, which takes a constraint and transfers all files in spool directories of matching jobs

Retrieving a job

- The SOAP way in Java…

```
int cluster = 1;
int job = 0;
Schedd schedd = new Schedd("http://…");
Transaction xact = schedd.createTransaction();
xact.begin(30);
FileInfo[] files = xact.listSpool(cluster, job);
for (FileInfo file : files) {
   xact.getFile(cluster, job, file.getName(), file.getSize(),
        new File(file.getName()));
}
xact.commit();
```

Discover available files

Remote file

Local file

Authentication for SOAP

- Authentication is done via mutual SSL authentication
  - Both the client and server have certificates and identify themselves
- It is not always necessary, e.g. in some controlled environments (a portal) where the submitting component is trusted
- A necessity in an open environment -- remember that the `submit` call takes the job's owner as a parameter
  - Imagine what happens if anyone can submit to a Schedd running as root…

Details on setting up authenticated SOAP over HTTPS

Authentication setup

- Create and sign some certificates
- Use OpenSSL to create a CA
  - CA.sh -newca
- Create a server cert and password-less key
  - CA.sh -newreq && CA.sh -sign
  - mv newcert.pem server-cert.pem
  - openssl rsa -in newreq.pem -out server-key.pem
- Create a client cert and key
  - CA.sh -newreq && CA.sh -sign && mv newcert.pem client-cert.pem && mv newreq.pem client-key.pem

Authentication config

- Config options…
  - ENABLE_SOAP_SSL is FALSE by default
  - <SUBSYS>_SOAP_SSL_PORT
    - Set this to a different port for each SUBSYS you want to talk to over ssl, the default is a random port
    - Example: SCHEDD_SOAP_SSL_PORT=1980
  - SOAP_SSL_SERVER_KEYFILE is required and has no default
    - The file containing the server's certificate AND private key, i.e. "keyfile" after

```
cat server-cert.pem server-key.pem >
  keyfile
```

Authentication config

- Config options continue…
  - SOAP_SSL_CA_FILE is required
    - The file containing public CA certificates used in signing client certificates, e.g. demoCA/cacert.pem
- All options except SOAP_SSL_PORT have an optional SUBSYS_* version
  - For instance, turn on SSL for everyone except the Collector with
    - ENABLE_SOAP_SSL=TRUE
    - COLLECTOR_ENABLE_SOAP_SSL=FALSE

One last bit of config

- The certificates we generated have a principal name, which is not standard across many authentication mechanisms
- Condor maps authenticated names (here, principal names) to canonical names that are authentication method independent
- This is done through mapfiles, given by SEC_CANONICAL_MAPFILE and SEC_USER_MAPFILE
- Canonical map: `SSL .*emailAddress=(.*)@cs.wisc.edu.* \1`
- User map: `(.*) \1`
- "SSL" is the authentication method, ".*emailAddress….*" is a pattern to match against authenticated names, and "\1" is the canonical name, in this case the username on the email in the principal

HTTPS with Java

- Setup keys…
  - keytool -import -keystore truststore -trustcacerts -file demoCA/cacert.pem
  - openssl pkcs12 -export -inkey client-key.pem -in client-cert.pem -out keystore
- All the previous code stays the same, just set some properties
  - javax.net.ssl.trustStore, javax.net.ssl.keyStore, javax.net.ssl.keyStoreType, javax.net.ssl.keyStorePassword
  - Example: java -Djavax.net.ssl.trustStore=truststore -Djavax.net.ssl.keyStore=keystore -Djavax.net.ssl.keyStoreType=PKCS12 -Djavax.net.ssl.keyStorePassword=pass Example https://…