

An Overview of Config4★

www.config4star.org

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What is Config4*?

- Config4* is pronounced "config for star":
 - The pedantically correct "config for asterisk" does not sound as good
 - The "*" is a placeholder for the name of a programming language
- Config4* is a configuration-file parser for several languages:
 - Config4Cpp (C++ version)
 - Config4J (Java version)
 - Other programming languages may be added in the future
- Config4* is open-source and uses the MIT license:
 - Compatible with most/all other open-source and proprietary licenses
- The project website is www.config4star.org
 - Provides source code and comprehensive documentation

An Overview of Config4*

3

Why is Config4* so good?

- Config4* has useful features rarely found in other configuration technologies:
 - Each feature is useful in its own right
 - In addition, there is synergy in the interaction of the features
- Structure of this presentation:
 - First, explain the basic features of Config4* (similar to features in competing technologies)
 - Then, discuss the useful features, and the synergies between them

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4

1. Basic features

Basic features of syntax

```
# this is a comment

@include "another_file.cfg";

string_variable = "value";
list_variable = ["a", "list of", "values"];

string_concatenation = string_variable + "...";
list_concatenation = list_variable
                    + ["another", "list"];

scope_name {
    variable_inside_scope = "value";
    nested_scope {
        yet_another_variable = "...";
    }
}

# scoping operator is "."
# Example: "scope_name.variable_inside_scope"
```

Keywords are prefixed with "@"
to prevent clashes with names
of variables or scopes

Basic API (Java syntax)

```
import org.config4j.*;
...
Configuration cfg = Configuration.create();
String configFile = "file.cfg";
String scope = "foo";
String[] fontList;
String logFile;
int logLevel;
try {
    cfg.parse(configFile);
    logFile = cfg.lookupString(scope, "log_file");
    fontList = cfg.lookupList(scope, "font_list");
    logLevel = cfg.lookupInt(scope, "log_level")
} catch (ConfigurationException ex) {
    System.err.println(ex.getMessage());
}
```

Notes

- A lookup operation merges its `scope` and `localName` parameters to form a fully-scoped name:
 - Example, `lookupString("foo", "bar")` → `"foo.bar"`
 - The `scope` parameter is usually set from a command-line argument
 - One configuration file can contain scopes for many applications
- Data-type conversion:
 - Some lookup operations call `lookupString()` and then convert to the desired type
 - Examples: `lookupInt()`, `lookupFloat()`, `lookupBoolean()`, ...
- An existing configuration-file parser:
 - Might not have *all* the features shown on the previous two slides
 - But such features are sort-of common
- Now let's look at useful Config4* features rarely found elsewhere...

2. Centralised configuration

Description of a common problem

- The Acme company makes and sells software:
 - Small customers will run the software on one computer
 - These customers want the convenience of a configuration file
 - Large customers will run the software on hundreds of computers
 - They do not want to maintain hundreds of copies of a configuration file
 - They insist on having a centralised configuration repository
- It might cost Acme a lot of time and money to implement a centralised configuration mechanism:
 - Complexity of a client-server architecture?
 - Use a database? Administration skills required. License costs?
 - Extra complexity and expense if fault tolerance is required
- Config4*, with help from a utility called Curl, provides a zero-cost solution

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10

The synergy of Config4* and Curl

- Curl (an abbreviation of “Client for URL”):
 - Is an open-source utility, available for most operating systems
 - Retrieves a file from a specified URL and echoes it to the console
 - Supports many protocols: HTTP, FTP, LDAP, ...

- Example: `curl -sS http://www.example.com/file.cfg`
 - The “-sS” option instructs curl to not print any diagnostics

- Config4* can parse:

- A file: `cfg.parse("file.cfg")`

- The output of executing a command:

```
cfg.parse("exec#curl -sS http://...")
```

Command to execute

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11

The synergy of Config4* and curl (cont')

- Benefit for Acme. It satisfies small and large customers:

- Small customers use a “file.cfg” command-line argument

- A large customer runs software on many computers, and specifies “exec#curl -sS http://centralisedHost/file.cfg” as a command-line argument

- Benefits for large customers:

- They can use any protocol supported by `curl`

- They are not restricted to using only `curl` (they can use a utility that retrieves configuration from, say, a database)

- They can use a fault-tolerant database or web server, if needed

- As more and more applications use Config4*, the cost of maintaining a centralised database or web server is amortised

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12

3. Fallback configuration

The goal of “install and use” for applications

- “Install and use” applications are convenient to use:
 - Similar to “plug and play” hardware
 - Unfortunately, many applications requires a configuration step before use
 - The need to “configure before use” can irritate users
- Ideally, an application will have an *optional* configuration file:
 - Embedded configuration means it can run *without* a configuration file (thus bypassing the need to “configure before use”)
 - The embedded configuration can be overridden with an external configuration file
- Config4* enables developers to achieve this goal in two steps:
 - Run the `config2cpp` or `config2j` utility to create embedded configuration data
 - Call the `setFallbackConfiguration()` operation

The `config2cpp` and `config2j` utilities

- The `config2cpp` and `config2j` utilities:
 - Read a configuration file, and
 - Generate a C++ or Java class that provides a snapshot of the file's contents
- This provides “fallback” configuration data that can be embedded in an application
- Examples of use:


```
config2cpp -cfg Fallback.cfg -class FallbackConfig
           -singleton
config2j  -cfg Fallback.cfg -class FallbackConfig
           -singleton
```
- The generated class provides a `getString()` operation that returns the “fallback” configuration data

The `setFallbackConfiguration()` operation

- An application sets fallback configuration as follows:

```
Configuration cfg = Configuration.create();
String cfgFile = ...;
try {
    if (cfgFile != null) { cfg.parse(cfgFile); }
    cfg.setFallbackConfiguration(
        Configuration.INPUT_STRING,
        FallbackConfig.getString());
    logfile = cfg.lookupString(scope, "log_file");
} catch(ConfigurationException ex) {
    System.err.println(ex.getMessage());
}
```

- The Config4* lookup operations work as follows:
 - Search for the specified variable in the configuration object
 - If found, then return its value
 - Otherwise, search for the specified variable in the fallback configuration

Synergy of fallback and centralised configuration

- Fallback and centralised configuration are independent features
 - But they interact to provide synergy
- A Config4*-based application:
 - Can use fallback configuration to provide “install and use” convenience for new users
 - Can use an external configuration file to override fallback configuration
 - Can use `\exec#curl ...` if the user deploys the application on many computers
- Thus:
 - Config4* scales from single-user to enterprise deployments (you could even use fallback configuration in an embedded system)
 - It is difficult to think of another configuration technology that provides this level of flexibility

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17

4. Adaptable configuration

Description of a common problem

- Often, the contents of a configuration file change when:
 - Moving the application from one computer to another
 - Running the application under another user name
- Editing a configuration file to make such changes is tedious
- It would be better if a configuration file could automatically adapt to its runtime environment:
 - Then, the *same* configuration file could be used on multiple computers and by multiple users
 - Config4* provides excellent support for this

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19

The `getenv()` and `exec()` functions

- The `getenv()` function:
 - Returns the value of an environment variable
 - Is typically used to access the name of the user or the installation directory for software: `getenv("USERNAME"), getenv("FOO_HOME")`
- The `exec()` function:
 - Executes a command and returns its standard output
 - Is typically used to determine the host name: `exec("hostname")`
 - A security mechanism prevents execution of malicious commands
- These operations, combined with the “+” operator, enable a configuration file to adapt to its runtime environment.
Example:

```
log_dir = getenv("FOO_HOME") + "/logs/"  
          + exec("hostname");
```

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20

If-then-else statements and `osType()`

```
production_hosts = ["pizza", "pasta", "cheese"];
test_hosts = ["foo", "bar", "widget", "acme"];

@if (exec("hostname") @in production_hosts) {
    server_x.port = "5001";
    server_y.port = "5002";
    server_z.port = "5003";
} @elseif (exec("hostname") @in test_hosts) {
    server_x.port = "6001";
    server_y.port = "6002";
    server_z.port = "6003";
} @else {
    @error "This is not a production or test machine!";
}

@if (osType() == "windows") {
    ...
} @else { # UNIX
    ...
}
```

Adapting to command-line options

- Users may want to use command-line options to override variables in a configuration file
- Config4* supports a two-step approach for doing this:
 - Before parsing a configuration file, the application calls `insertString()` to insert *name-value* pairs obtained from the command line
 - The configuration file uses the conditional assignment (`"?="`) operator to provide default values for variables
- The following slides illustrate these steps

Using the `insertString()` operation

```
import org.config4j.*;
...
Configuration cfg = Configuration.create();
for (int i = 0; i < args.length; i++) {
    if (args[i].equals("-set")) {
        cfg.insertString(scope, args[i+1], args[i+2]);
        i = i + 2;
    }
}
try {
    cfg.parse(configFile);
    ... // calls to cfg.lookup<Type>() operations
} catch (ConfigurationException ex) {
    System.err.println(ex.getMessage());
}
```

Using the conditional assignment (`"?="`) operator

- The `?=` operator assigns a value to a variable *only if* the variable does not already exist
- Example of syntax:


```
log_level   ?= "0";
username   ?= getenv("USERNAME");
password   ?= "";
```
- Typically, such variables can be pre-set by command-line options that are processed as shown on the previous slide
- In this way, a configuration file can adapt to (be overridden by) command-line options

Synergy

- Adaptable configuration is independent of centralised configuration
- However, those features can interact to provide synergy.
- Example:
 - A large company deploys an application on 500 computers
 - A single configuration file is stored on a web server and accessed via `"exec#curl ..."`
 - That centralised configuration file can use `@if-then-@else`, `getenv()` and `exec()` to adapt its contents for each computer

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25

5. Useful data types

Durations

- Some configuration files need to specify durations:
 - For example, connection timeout, idle timeout, transaction timeout...
 - In most configuration files, these are expressed as integer values (denoting seconds or milliseconds)

- Example from a product that does *not* use Config4*:

```
refresh: 28800
retry: 7200
expire: 1209600
minimum: 86400
```

Expressed in seconds

- Equivalent in Config4* syntax:

```
refresh = "8 hours";
retry = "2 hours";
expire = "2 weeks";
minimum = "1 day";
```

Units can also be minutes, seconds or milliseconds

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27

Durations (cont')

- Config4* can convert durations into seconds or milliseconds:

```
x = cfg.lookupDurationSeconds(scope, "refresh");
y = cfg.lookupDurationMilliseconds(scope, "retry");
```
- The value `"infinite"` is converted into the value `-1`

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28

Memory sizes

- Config4* also supports memory sizes

- Examples of syntax:

```
buffer_size = "512 bytes";
cache_size  = "32 KB";
max_log_size = "1.5 GB";
```

- Config4* can convert memory sizes into bytes, KB or MB:

```
lookupMemorySizeBytes(scope, localName)
lookupMemorySizeKB(scope, localName)
lookupMemorySizeMB(scope, localName)
```

Other data-type conversions

- Other operations enable you to quickly write code to:

- Convert string values to integer constants (like `enum` in C/C++)
- Example: "red" → 0, "green" → 1, "blue" → 2
- Parse values "<units> <number>" or "<number> <units>"
- Examples:
 - "£19.99" → ("£", 19.99)
 - "42 cm" → ("cm", 42)

- You can also process a list as if it were a table. Example:

```
price_list = [
  # description      unit price
  #-----
  "apple",           "£0.49",
  "orange",          "€2.99",
];
```

6. Schema validation

Benefits of schema validation

- A *schema* is a blueprint or definition of a system.
- Examples:
 - A database schema defines the layout of a database
 - DTD, XML Schema and RELAX NG are competing schema languages for defining the permitted contents of an XML file
- Config4* has a schema language, which provides:
 - An intuitive, easy-to-use syntax
 - An easy-to-use API
 - The ability for developers to define new schema data-types.

Example configuration scope

- An application uses a configuration scope like that shown below:

```
foo_server {
  idle_timeout = "2 minutes";
  log_level = "3";
  log_file = "/tmp/foo.log";
  price_list = [
    # time      colour  price
    #-----
    "shirt",   "green", "EUR 19.99",
    "jeans",   "blue",  "USD 39.99",
  ];
}
```

- The next slide shows how to perform schema validation for such a scope

Example of schema validation (Java syntax)

```
Configuration cfg = Configuration.create();
SchemaValidator sv = new SchemaValidator();
String schema = new String[] {
  "@typedef colour = enum[red, green, blue]",
  "@typedef money = units_with_float[EUR, GBP, USD]",
  "idle_timeout = durationMilliseconds",
  "log_level = int[0,5]",
  "log_file = string",
  "price_list = table[string,item, colour,colour,
money,price]"
};
try {
  cfg.parse(configFile);
  sv.parseSchema(schema);
  sv.validate(cfg, "foo_server", "");
} catch(ConfigurationException ex) {
  System.err.println(ex.getMessage());
}
```

- A descriptive exception is thrown if schema validation fails

Comparison with XML Schema

- XML Schema:
 - Is very verbose
 - Has a steep learning curve:
 - Syntax specification is written in impenetrable legalese (about 380 pages long if you convert it from HTML into PDF format)
 - Good books on XML Schema are 400–500 pages long
 - Provides difficult-to-understand error messages
- In contrast, the Config4* schema language:
 - Is very concise
 - Is intuitive and easy to learn:
 - Syntax specification, with examples, is defined in 13 pages
 - Provides easy-to-understand error messages

7. Reuse with the @copyFrom statement

Description of problem

- Some applications are related to other applications.
Examples:
 - Applications that are developed as part of the same project
 - Replicas for a server application
- Such applications may have similar configuration settings:
 - Most variables have identical values
 - A few variables have different values
- Can such applications reuse the variables with identical values?
 - Doing this can significantly reduce the size of configuration files
 - The `@copyFrom` statement facilitates this

Example of the `@copyFrom` statement

```
server.defaults {
    timeout = "2 minutes";
    log {
        dir = getenv("FOO_HOME") + "/logs";
        level = "2";
    }
}

foo_server {
    @copyFrom "server.defaults";
    log.level = "1"; # override copied value
}

bar_server {
    @copyFrom "server.defaults";
    timeout = "30 seconds"; # override copied value
}
```

Conditional `@include` and `@copyFrom`

- Config4* provides conditional variations of the `@include` and `@copyFrom` statements
- These help a configuration file adapt to its environment.
Examples:

```
@include getenv("HOME") + "/.foo.cfg" @ifExists;

override.pizza { ... }
override.pasta { ... }
foo_server {
    ... # set default values
    @copyFrom "override." + exec("hostname") @ifExists;
}
```

8. The "uid-" prefix

The "uid-" prefix

- Let's assume you want to store details about employees
- You might try the following:

```
employee { name = "John Smith"; ... }
employee { name = "Jane Doe"; ... }
```
- That will not work:
 - Because the second occurrence of `employee` re-opens the *existing* scope, so the details of Jane Doe override those of John Smith
- Config4* provides a "uid-" prefix for such situations:
 - "uid" is an abbreviation for "unique identifier".
 - Config4* expands each name of the form `uid-employee` into `uid-<unique-number>-employee`

The "uid-" prefix (cont')

- Fixed example:

```
uid-employee { name = "John Smith; ... }
uid-employee { name = "Jane Doe"; ... }
```
- The Config4* API provides operations for processing uid entries
- The "uid-" prefix makes Config4* suitable for use as a data-file format

9. Comprehensive documentation

Comprehensive documentation

- Many open-source software projects provide minimal or no documentation:
 - Lack of documentation creates a frustrating learning curve for users
 - You might have to spend days or weeks "playing with" a project to learn if it suits your needs
- In contrast, Config4* provides comprehensive documentation:
 - Getting Started guide
 - C++ and Java API guide
 - Practical Usage guide (this provides expert advice)
 - Maintenance guide (for people interesting in extending/porting Config4*)
- The high-quality documentation (400 pages in total):
 - Significantly reduces the learning curve
 - Enables you to quickly decide if Config4* suits your needs

10. Summary

Summary

- Config4* provides features common to many other configuration technologies
- Config4* *also* provides:
 - Fallback (embedded) configuration for “install and run” applications
 - Centralised configuration (vital for large deployments)
 - Adaptable configuration:
 - @if-then-@else, getenv(), exec(), osType()
 - The ?= operator enables integration with command-line options
 - Reusable configuration (the @copyFrom statement)
 - Scopes enable one file to store configuration for multiple applications
 - Useful data-types: duration, memory sizes, tables, ...
 - Schema validation
 - The “uid-” prefix (can use Config4* as a data-file format)
 - Comprehensive, high-quality documentation