

# An Overview of Config4★

[www.config4star.org](http://www.config4star.org)

## Copyright

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## What is Config4\*?

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- 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](http://www.config4star.org)
  - Provides source code and comprehensive documentation

## Why is Config4\* so good?

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- 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

## 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)

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```
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

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- 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

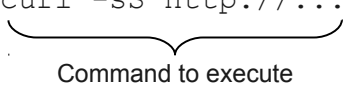
### Description of a common problem

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- 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

## 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

## 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

### 3. Fallback configuration

#### **The goal of “install and use” for applications**

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- “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**

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- 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

## 4. Adaptable configuration

## Description of a common problem

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- 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

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

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- 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");
```

## 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

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- 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

## 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

## 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

## 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

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- 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

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### ■ 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

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- 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

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- 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

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- 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')

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- 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**

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- 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

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- 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

