

# Logging using ParallelLogger

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## Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Terminology . . . . .	1
<b>2</b>	<b>Creating a console logger</b>	<b>2</b>
2.1	Shorthand . . . . .	2
<b>3</b>	<b>Creating a file logger</b>	<b>2</b>
3.1	Shorthand . . . . .	3
<b>4</b>	<b>Creating an e-mail logger</b>	<b>3</b>
4.1	Shorthand . . . . .	4
<b>5</b>	<b>Warnings and fatal errors</b>	<b>4</b>
<b>6</b>	<b>Logging when parallel processing</b>	<b>4</b>
<b>7</b>	<b>Shiny log viewer</b>	<b>5</b>

## 1 Introduction

This vignette describes how you can use the `ParallelLogger` package to perform logging. Logging is the activity of recording events that occur during an analysis in a log. The log can be used for example for debugging, profiling (understanding performance bottlenecks), and audits.

### 1.1 Terminology

- **Logger**: An object that can receive **events**, and writes them to a log. A logger has a **name**, a prespecified **event level** (only events at or above that level are logged), and one or more **appenders**.
- **Event**: Consists of a message and an event level.
- **Event level**: Each event has an associated level. These levels (in ranked order) are
  - **TRACE**: Events to mark the analysis has passed through some code.
  - **DEBUG**: Events to help understand the state of the code (e.g. whether a variable has a value).
  - **INFO**: Events typically displayed to the user to inform of the progress.
  - **WARN**: Events that indicate something probably requires attention.
  - **ERROR**: Events indicating something went wrong.
  - **FATAL**: Events indicating something went wrong, causing the analysis to terminate.
- **Appender**: An object that writes to a destination, for example the console or a file. An appender uses a **layout** to format its messages. There currently are three types of appenders:
  - **Console appender**: Writes to the console, created using the `createConsoleAppender` function.
  - **File appender**: Writes to a file, created using the `createFileAppender` function.
  - **E-mail appender**: Sends an e-mail, created using the `createEmailAppender` function.
- **Layout**: Objects specifying the format in which the log will be created. The following layouts are available:
  - `layoutSimple`: Only outputs the message.
  - `layoutTimestamp`: Adds the current time and date to the message.

- `layoutStackTrace`: Adds the time and date, and full stack trace to the message.
- `layoutParallel`: Includes the thread identifier, name of the package and function raising the event, the current time and date, the message level, and the message itself.
- `layoutEmail`: This layout adds the thread ID and stack trace to the message.

## 2 Creating a console logger

The code below demonstrates how one would create a logger that writes all events at level INFO or greater to the console using a layout with time stamp:

```
logger <- createLogger(name = "SIMPLE",
                      threshold = "INFO",
                      appenders = list(createConsoleAppender(layout = layoutTimestamp)))

registerLogger(logger)

logTrace("This event is below the threshold (INFO)")

logInfo("Hello world")
```

```
#> Hello world
#> 2019-10-30 01:50:00 Hello world
```

Note that the message is displayed twice. This is because there is a default logger that uses the simple layout and threshold = "INFO", and writes to console. We can remove this logger before registering our logger to avoid duplication:

```
clearLoggers()

logger <- createLogger(name = "SIMPLE",
                      threshold = "INFO",
                      appenders = list(createConsoleAppender(layout = layoutTimestamp)))

registerLogger(logger)

logInfo("Hello world")
```

```
#> 2019-10-30 01:50:00 Hello world
```

### 2.1 Shorthand

A shorthand for creating a simple console logger is offered by the `addDefaultConsoleLogger` function. The code

```
addDefaultConsoleLogger()
```

is equivalent to

```
registerLogger(createLogger(name = "SIMPLE",
                          threshold = "INFO",
                          appenders = list(createConsoleAppender(layout = layoutSimple))))
```

## 3 Creating a file logger

Probably more useful is a file logger. In the code below, we instantiate a logger that writes to file, using a threshold of TRACE (so including all events), and using the layout for parallel processing.

```

logFileName <- "log.txt"

logger <- createLogger(name = "PARALLEL",
                      threshold = "TRACE",
                      appenders = list(createFileAppender(layout = layoutParallel,
                                                         fileName = logFileName)))

registerLogger(logger)

logTrace("Executed this line")

logDebug("There are ", length(getLoggers()), " loggers")

logInfo("Hello world")

```

```
#> 2019-10-30 01:50:00 Hello world
```

We can read the log file:

```
writeLines(readChar(logFileName, file.info(logFileName)$size))
```

```
#> 2019-10-30 01:50:00 [Main thread] TRACE evaluate timing_fn Executed this line
#> 2019-10-30 01:50:00 [Main thread] DEBUG evaluate timing_fn There are 2 loggers
#> 2019-10-30 01:50:00 [Main thread] INFO evaluate timing_fn Hello world
```

And clean it up when we're done:

```
unlink(logFileName)
```

### 3.1 Shorthand

A shorthand for creating the file logger detailed here is offered by the `addDefaultFileLogger` function. The code

```
addDefaultFileLogger(logFileName)
```

is equivalent to

```
registerLogger(createLogger(name = "DEFAULT",
                          threshold = "TRACE",
                          appenders = list(createFileAppender(layout = layoutParallel,
                                                             fileName = logFileName))))
```

## 4 Creating an e-mail logger

We can also add a logger that sends an e-mail whenever an event is logged above the specified threshold. For example, for a process running on a remote machine it might be useful to receive e-mails of fatal events:

```
mailSettings <- list(from = "someone@gmail.com",
                   to = c("someone_else@gmail.com"),
                   smtp = list(host.name = "smtp.gmail.com",
                              port = 465,
                              user.name = "someone@gmail.com",
                              passwd = "super_secret!",
                              ssl = TRUE),
                   authenticate = TRUE,
                   send = TRUE)
```

```

logger <- createLogger(name = "EMAIL",
                      threshold = "FATAL",
                      appenders = list(createEmailAppender(layout = layoutEmail,
                                                            mailSettings = mailSettings)))
registerLogger(logger)

logFatal("No more data to process")

```

Note that the `mailSettings` object will be passed on to the `send.mail` function in the `mailR` package, so for more details see `?mailR::send.mail`

## 4.1 Shorthand

A shorthand for creating the e-mail logger detailed here is offered by the `addDefaultEmailLogger` function. The code

```
addDefaultEmailLogger(mailSettings)
```

is equivalent to

```

registerLogger(createLogger(name = "DEFAULT",
                           threshold = "FATAL",
                           appenders = list(createEmailAppender(layout = layoutEmail,
                                                                 mailSettings = mailSettings))))

```

## 5 Warnings and fatal errors

All R warnings and errors are automatically logged, and therefore do not require explicit logging. For example:

```

clearLoggers()
addDefaultFileLogger(logFileName)

warning("Danger!")

# This throws a warning:
as.numeric('a')

# This throws an error:
a <- b

writeLines(readChar(logFileName, file.info(logFileName)$size))

```

```

#> 2019-10-30 01:50:00 [Main thread]  WARN    evaluate    timing_fn  Danger!
#> 2019-10-30 01:50:00 [Main thread]  WARN    evaluate    timing_fn  Warning: NAs introduced by coercion
#> 2019-10-30 01:50:00 [Main thread]  FATAL    evaluate    timing_fn  Error: object a not found

```

## 6 Logging when parallel processing

The logging functions are designed to work with the parallel processing functions included in this package. The `layoutParallel` records thread identifiers, making it possible to later untangle the various threads. Below is a simple example:

```

unlink(logFileName) # Clean up log file from the previous example
clearLoggers() # Clean up the loggers from the previous example

```

```

addDefaultFileLogger(logFileName)

cluster <- makeCluster(3)

fun <- function(x) {
  ParallelLogger::logInfo("The value of x is ", x)
  # Do something
  if (x == 6)
    ParallelLogger::logDebug("X equals 6")
  return(NULL)
}

dummy <- clusterApply(cluster, 1:10, fun, progressBar = FALSE)

stopCluster(cluster)

writeLines(readChar(logFileName, file.info(logFileName)$size))

```

```

#> 2019-10-30 01:50:00 [Main thread] TRACE evaluate timing_fn Initiating cluster with 3 threads
#> 2019-10-30 01:50:01 [Thread 1] TRACE Thread 1 initiated
#> 2019-10-30 01:50:01 [Thread 2] TRACE Thread 2 initiated
#> 2019-10-30 01:50:01 [Thread 3] TRACE Thread 3 initiated
#> 2019-10-30 01:50:01 [Thread 1] INFO The value of x is 1
#> 2019-10-30 01:50:01 [Thread 2] INFO The value of x is 2
#> 2019-10-30 01:50:01 [Thread 3] INFO The value of x is 3
#> 2019-10-30 01:50:01 [Thread 1] INFO The value of x is 4
#> 2019-10-30 01:50:01 [Thread 2] INFO The value of x is 5
#> 2019-10-30 01:50:01 [Thread 3] INFO The value of x is 6
#> 2019-10-30 01:50:01 [Thread 2] INFO The value of x is 7
#> 2019-10-30 01:50:01 [Thread 1] INFO The value of x is 8
#> 2019-10-30 01:50:01 [Thread 3] DEBUG X equals 6
#> 2019-10-30 01:50:01 [Thread 2] INFO The value of x is 9
#> 2019-10-30 01:50:01 [Thread 1] INFO The value of x is 10
#> 2019-10-30 01:50:01 [Main thread] TRACE evaluate timing_fn Stopping cluster
#> 2019-10-30 01:50:01 [Thread 2] TRACE Thread 2 terminated
#> 2019-10-30 01:50:01 [Thread 3] TRACE Thread 3 terminated

```

## 7 Shiny log viewer

A Shiny app for viewing a log file created using the `layoutParallel` is included in the package. To explore the log created in the prior example, run

```
launchLogViewer(logFileName)
```

to launch the viewer shown in Figure 1.

## Log File Viewer - C:\Users\mschuemi\Git\OhdsiRTools\vignettes\log.txt

Level:  Search:

Level	Timestamp	Thread	Level	Package	Function	Message
TRACE	2018-04-23 15:06:04	[Main thread]	TRACE			Initiating cluster with 3 threads
All	2018-04-23 15:06:10	[Thread 1]	TRACE			Thread 1 initiated
All	2018-04-23 15:06:10	[Thread 2]	TRACE			Thread 2 initiated
All	2018-04-23 15:06:10	[Thread 3]	TRACE			Thread 3 initiated
	2018-04-23 15:06:10	[Thread 3]	INFO			The value of x is 3
	2018-04-23 15:06:10	[Thread 2]	INFO			The value of x is 2
	2018-04-23 15:06:10	[Thread 1]	INFO			The value of x is 1
	2018-04-23 15:06:10	[Thread 3]	INFO			The value of x is 4
	2018-04-23 15:06:10	[Thread 2]	INFO			The value of x is 5
	2018-04-23 15:06:10	[Thread 1]	INFO			The value of x is 6
	2018-04-23 15:06:10	[Thread 3]	INFO			The value of x is 7
	2018-04-23 15:06:10	[Thread 2]	INFO			The value of x is 8
	2018-04-23 15:06:10	[Thread 2]	INFO			The value of x is 10
	2018-04-23 15:06:10	[Thread 3]	INFO			The value of x is 9
	2018-04-23 15:06:10	[Thread 1]	DEBUG			X equals 6
	2018-04-23 15:06:11	[Main thread]	TRACE			Stopping cluster
	2018-04-23 15:06:11	[Thread 1]	TRACE			Thread 1 terminated
	2018-04-23 15:06:11	[Thread 2]	TRACE			Thread 2 terminated
	2018-04-23 15:06:11	[Thread 3]	TRACE			Thread 3 terminated

Showing 1 to 19 of 19 entries

Figure 1: Shiny log viewer app