System Principles

version 5.3
Contents

1 System Principles ........................................... 1
  1.1 System Principles ........................................ 1
    1.1.1 Starting the System .................................. 1
    1.1.2 Restarting and Stopping the System ...................... 1
    1.1.3 Boot Scripts .......................................... 2
    1.1.4 Code Loading Strategy ................................ 3
    1.1.5 File Types ........................................... 3
  1.2 Creating a First Target System .......................... 4
    1.2.1 Introduction ......................................... 4
    1.2.2 Creating a Target System ............................... 4
    1.2.3 Installing a Target System ............................ 5
    1.2.4 Starting a Target System ............................... 6
    1.2.5 System Configuration Parameters ....................... 6
    1.2.6 Differences from the Install Script .................... 6
    1.2.7 Listing of target_system.erl ......................... 7

List of Tables .................................................. 13
Chapter 1

System Principles

1.1 System Principles

1.1.1 Starting the System

An Erlang runtime system is started with the command `erl`:

```
Erlang (BEAM) emulator version 5.2.3.5 [hipe] [threads:0]
Eshell V5.2.3.5 (abort with ^G)
```

`erl` understands a number of command line arguments, see `erl(1)`. A number of them are also described in this chapter.

Application programs can access the values of the command line arguments by calling one of the functions `init:get_argument(Key)`, or `init:get_arguments()`. See `init(3)`.

1.1.2 Restarting and Stopping the System

The runtime system can be halted by calling `halt/0,1`. See `erlang(3).

The module `init` contains function for restarting, rebooting and stopping the runtime system. See `init(3)`.

```
init:restart()
init:reboot()
init:stop()
```

Also, the runtime system will terminate if the Erlang shell is terminated.
Chapter 1: System Principles

1.1.3 Boot Scripts

Default Boot Script

The runtime system is started using a boot script. The boot script contains instructions on which code to load and which processes and applications to start.

A boot script file has the extension .script. The runtime system uses a binary version of the script. A binary boot script file has the extension .boot.

See script(4) for a detailed description of the syntax and contents of the boot script.

Erlang/OTP comes with two boot scripts:

- start_clean.boot Loads the code for and starts the applications Kernel and STDLIB.
- start_sasl.boot Loads the code for and starts the applications Kernel, STDLIB and SASL.

Which of start_clean and start_sasl to use as default is decided by the user when installing Erlang/OTP using Install. The user is asked “Do you want to use a minimal system startup instead of the SASL startup”. If the answer is yes, then start_clean is used, otherwise start_sasl is used. A copy of the selected boot script is made, named start.boot.

User-Defined Boot Scripts

It is sometimes useful or necessary to create a user-defined boot script. This is true especially when running Erlang in embedded mode, see Code Loading Strategy [page 3].

It is possible to write a boot script manually. The recommended way to create a boot script, however, is to generate the boot script from a release resource file Name.rel, using the function systools:make_script/1,2. This requires that the source code is structured as applications according to the OTP design principles. (The program does not have to be started in terms of OTP applications but can be plain Erlang).

Read more about .rel files in OTP Design Principles and rel(4).

The binary boot script file Name.boot is generated from the boot script file Name.script using the function systools:script2boot(File).

Start the runtime system using the command line flag -boot:

% erl -boot <Name>
1.1.4 Code Loading Strategy

The runtime system can be started in either embedded or interactive mode. Which one is decided by the command line flag -mode.

```
% erl -mode <Mode>
```

Default mode is interactive.

- In embedded mode, all code is loaded during system start-up according to the boot script. (Code can also be loaded later by explicitly ordering the code server to do so).
- In interactive mode, code is dynamically loaded when first referenced. When a call to a function in a module is made, and the module is not loaded, the code server searches the code path and loads the module into the system.

Initially, the code path consists of the current working directory and all object code directories under `ROOT/lib`, where `ROOT` is the installation directory of Erlang/OTP. Directories can be named `Name[-Vsn]` and the code server, by default, chooses the directory with the highest version number among those which have the same `Name`. The `-Vsn` suffix is optional. If an `ebin` directory exists under the `Name[-Vsn]` directory, it is this directory which is added to the code path.

The code path can be extended by using the command line flags `-pa Directories` and `-pz Directories`. These will add `Directories` to the head or end of the code path, respectively.

The code server module `code` contains a number of functions for modifying and checking the search path, see `code(3)`.

1.1.5 File Types

The following file types are defined in Erlang/OTP:

<table>
<thead>
<tr>
<th>File Type</th>
<th>File Name/Extension</th>
<th>Documented in</th>
</tr>
</thead>
<tbody>
<tr>
<td>module</td>
<td>.erl</td>
<td>Erlang Reference Manual</td>
</tr>
<tr>
<td>include file</td>
<td>.hrl</td>
<td>Erlang Reference Manual</td>
</tr>
<tr>
<td>release resource file</td>
<td>.rel</td>
<td>rel(4)</td>
</tr>
<tr>
<td>application resource file</td>
<td>.app</td>
<td>app(4)</td>
</tr>
<tr>
<td>boot script</td>
<td>.script</td>
<td>script(4)</td>
</tr>
<tr>
<td>binary boot script</td>
<td>.boot</td>
<td>-</td>
</tr>
<tr>
<td>configuration file</td>
<td>.config</td>
<td>config(4)</td>
</tr>
<tr>
<td>application upgrade file</td>
<td>.appup</td>
<td>appup(4)</td>
</tr>
<tr>
<td>release upgrade file</td>
<td>relup</td>
<td>relup(4)</td>
</tr>
</tbody>
</table>

Table 1.1: File Types
1.2 Creating a First Target System

1.2.1 Introduction

When creating a system using Erlang/OTP, the most simple way is to install Erlang/OTP somewhere, install the application specific code somewhere else, and then start the Erlang runtime system, making sure the code path includes the application specific code.

Often it is not desirable to use an Erlang/OTP system as is. A developer may create new Erlang/OTP compliant applications for a particular purpose, and several original Erlang/OTP applications may be irrelevant for the purpose in question. Thus, there is a need to be able to create a new system based on a given Erlang/OTP system, where dispensable applications are removed, and a set of new applications that are included in the new system. Documentation and source code is irrelevant and is therefore not included in the new system.

This chapter is about creating such a system, which we call a target system.

In the following sections we consider creating target systems with different requirements of functionality:

- a basic target system that can be started by calling the ordinary erl script,
- a simple target system where also code replacement in run-time can be performed, and
- an embedded target system where there is also support for logging output from the system to file for later inspection, and where the system can be started automatically at boot time.

We only consider the case when Erlang/OTP is running on a UNIX system.

There is an example Erlang module target_system.erl that contains functions for creating and installing a target system. That module is used in the examples below. The source code of the module is listed at the end of this chapter.

1.2.2 Creating a Target System

It is assumed that you have a working Erlang/OTP system structured according to the OTP Design Principles.

Step 1. First create a .rel file (see rel(4)) that specifies the erts version and lists all applications that should be included in the new basic target system. An example is the following mysystem.rel file:

```erlang
%% mysystem.rel
{release, [
    {MYSYSTEM, "FIRST"},
    {erts, "5.1"},
    [{kernel, "2.7"},
     {stdlib, "1.10"},
     {sasl, "1.9.3"},
     {pea, "1.0"}]
].
```

The listed applications are not only original Erlang/OTP applications but possibly also new applications that you have written yourself (here exemplified by the application pea).

Step 2. From the directory where the mysystem.rel file reside, start the Erlang/OTP system:

```shell
erl -pa /home/user/target_system/myapps/pea-1.0/ebin
```
where also the path to the pea-1.0 ebin directory is provided.

Step 2. Now create the target system:

```erlang
1> target_system:create("mysystem").
```

The `target_system:create/1` function does the following:

1. Reads the `mysystem.rel` file, and creates a new file `plain.rel` which is identical to former, except that it only lists the kernel and stdlib applications.
2. From the `mysystem.rel` and `plain.rel` files creates the files `mysystem.script`, `mysystem.boot`, `plain.script`, and `plain.boot` through a call to `systools:make_script/2`.
3. Creates the file `mysystem.tar.gz` by a call to `systools:make_tar/2`. That file has the following contents:

   ```text
   erts-5.1/bin/
   releases/FIRST/start.boot
   releases/mysystem.rel
   lib/kernel-2.7/
   lib/stdlib-1.10/
   lib/sasl-1.9.3/
   lib/pea-1.0/
   
   The file releases/FIRST/start.boot is a copy of our mysystem.boot, and a copy of the original mysystem.rel has been put in the releases directory.
   
4. Creates the temporary directory `tmp` and extracts the tar file `mysystem.tar.gz` into that directory.
5. Deletes the `erl` and `start` files from `tmp/erts-5.1/bin`. Why.
6. Creates the directory `tmp/bin`.
7. Copies the previously created file `plain.boot` to `tmp/bin/start.boot`.
8. Copies the files `epmd`, `run_erl`, and `to_erl` from the directory `tmp/erts-5.1/bin` to the directory `tmp/bin`.
9. Creates the file `tmp/releases/start_erl.data` with the contents “5.1 FIRST”.
10. Recreates the file `mysystem.tar.gz` from the directories in the directory `tmp`, and removes `tmp`.

### 1.2.3 Installing a Target System

Step 3. Install the created target system in a suitable directory.

```erlang
3> target_system:install("mysystem", "/usr/local/erl-target").
```

The function `target_system:install/2` does the following:

1. Extracts the tar file `mysystem.tar.gz` into the target directory `/usr/local/erl-target`.
2. In the target directory reads the file `releases/start_erl.data` in order to find the Erlang runtime system version (“5.1”).
3. Substitutes `%FINAL_ROOTDIR%` and `%EMU%` for `/usr/local/erl-target` and `beam`, respectively, in the files `erl.src`, `start.src`, and `start_erl.src` of the target `erts-5.1/bin` directory, and puts the resulting files `erl`, `start`, and `run_erl` in the target `bin` directory.
4. Finally the target `releases/RELEASES` file is created from data in the `releases/mysystem.rel` file.
1.2.4 Starting a Target System

Now we have a target system that can be started in various ways.
We start it as a basic target system by invoking

/usr/local/erl-target/bin/erl

where only the kernel and stdlib applications are started, i.e. the system is started as an ordinary development system. There are only two files needed for all this to work: bin/erl file (obtained from erls-5.1/bin/erl.src) and the bin/start.boot file (a copy of plain.boot).

We can also start a distributed system (requires bin/epmd).
To start all applications specified in the original mysystem.rel file, use the -boot flag as follows:

/usr/local/erl-target/bin/erl -boot /usr/local/erl-target/releases/FIRST/start

We start a simple target system as above. The only difference is that also the file releases/RELEASES is present for code replacement in run-time to work.

To start an embedded target system the shell script bin/start is used. That shell script calls bin/run.erl, which in turn calls bin/start.erl (roughly, start.erl is an embedded variant of erl).

The shell script start is only an example. You should edit it to suite your needs. Typically it is executed when the UNIX system boots.

run.erl is a wrapper that provides logging of output from the run-time system to file. It also provides a simple mechanism for attaching to the Erlang shell (to.erl).

start.erl requires the root directory ("/usr/local/erl-target"), the releases directory ("/usr/local/erl-target/releases"), and the location of the start.erl.data file. It reads the run-time system version ("5.1") and release version ("FIRST") from the start.erl.data file, starts the run-time system of the version found, and provides -boot flag specifying the boot file of the release version found ("releases/FIRST/start.boot").

start.erl also assumes that there is sys.config in release version directory ("releases/FIRST/sys.config"). That is the topic of the next section (see below).

The start.erl shell script should normally not be altered by the user.

1.2.5 System Configuration Parameters

As was pointed out above start.erl requires a sys.config in the release version directory ("releases/FIRST/sys.config"). If there is no such a file, the system start will fail. Hence such a file has to be added as well.

If you have system configuration data that are neither file location dependent nor site dependent, it may be convenient to create the sys.config early, so that it becomes a part of the target system tar file created by target_system:create/1. In fact, if you create, in the current directory, not only the mysystem.rel file, but also a sys.config file, that latter file will be tacitly put in the appropriate directory.

1.2.6 Differences from the Install Script

The above install/2 procedure differs somewhat from that of the ordinary Install shell script. In fact, create/1 makes the release package as complete as possible, and leave to the install/2 procedure to finish by only considering location dependent files.
## 1.2.7 Listing of target_system.erl

```erlang
-module(target_system).
-include_lib("kernel/include/file.hrl").
-export([create/1, install/2]).
define(BUFSIZE, 8192).

%% Note: RelFileName below is the *stem* without trailing .rel,
%% .script etc.
%%
%% create(RelFileName) ->
%%
create(RelFileName) ->
  RelFile = RelFileName ++ ".rel",
  io:fwrite("Reading file: \"~s\" ...\n", [RelFile]),
  {ok, [RelSpec]} = file:consult(RelFile),
  io:fwrite("Creating file: \"~s\" from \"~s\" ...\n",
            ["plain.rel", RelFile]),
  {release,
   {RelName, RelVsn},
   {erts, ErtsVsn},
   AppVsns} = RelSpec,
  PlainRelSpec = {release,
                  {RelName, RelVsn},
                  {erts, ErtsVsn},
                  lists:filter(fun({kernel, _}) ->
                                true;
                              ({stdlib, _}) ->
                                true;
                              (_) ->
                                false
                           end, AppVsns)},
  {ok, Fd} = file:open("plain.rel", [write]),
  io:fwrite(Fd, "~p.\n", [PlainRelSpec]),
  file:close(Fd),
  io:fwrite("Making \"plain.script\" and \"plain.boot\" files ...\n"),
  make_script("plain"),
  io:fwrite("Making \"~s.script\" and \"~s.boot\" files ...\n",
            [RelFileName, RelFileName]),
  make_script(RelFileName),
  TarFileName = io_lib:fwrite("~s.tar.gz", [RelFileName]),
  io:fwrite("Creating tar file \"~s\" ...\n",
           [TarFileName]),
  make_tar(RelFileName),
  io:fwrite("Creating directory \"tmp\" ...\n"),
  file:make_dir("tmp"),
  io:fwrite("Extracting \"~s\" into directory \"tmp\" ...\n",
           [TarFileName]),

System Principles
Chapter 1: System Principles

```
extract_tar(TarFileName, "tmp"),

TmpBinDir = filename:join(["tmp", "bin"]),
ErtsBinDir = filename:join(["tmp", "erts-" ++ ErtsVsn, "bin"]),
io:fwrite("Deleting \"erl\" and \"start\" in directory \"s\" ...\n" [ErtsBinDir]),
file:delete(filename:join([ErtsBinDir, "erl"])),
file:delete(filename:join([ErtsBinDir, "start"])),
io:fwrite("Creating temporary directory \"s\" ...\n" [TmpBinDir]),
file:make_dir(TmpBinDir),
io:fwrite("Copying file \"plain.boot\" to \"s\" ...\n", [filename:join([TmpBinDir, "start.boot"])]),
copy_file("plain.boot", filename:join([TmpBinDir, "start.boot"])),
io:fwrite("Copying files \"epmd\", \"run_erl\" and \"to_erl\" from \n" [ErtsBinDir, TmpBinDir]),
copy_file(filename:join([ErtsBinDir, "epmd"]),
filename:join([TmpBinDir, "epmd"]), [preserve]),
copy_file(filename:join([ErtsBinDir, "run_erl"]),
filename:join([TmpBinDir, "run_erl"]), [preserve]),
copy_file(filename:join([ErtsBinDir, "to_erl"]),
filename:join([TmpBinDir, "to_erl"]), [preserve]),
StartErlDataFile = filename:join(["tmp", "releases", "start_erl.data"]),
io:fwrite("Creating \"s\" ...\n", [StartErlDataFile]),
StartErlData = io:fwrite("s \n", [ErtsVsn, RelVsn]),
write_file(StartErlDataFile, StartErlData),
io:fwrite("Recreating tar file \"s\" from contents in directory " [TarFileName]),
{ok, Tar} = erl_tar:open(TarFileName, [write, compressed]),
{ok, Cwd} = file:get_cwd(),
file:set_cwd("tmp"),
erl_tar:add(Tar, "bin", []),
erl_tar:add(Tar, "erts-" ++ ErtsVsn, []),
erl_tar:add(Tar, "releases", []),
erl_tar:add(Tar, "lib", []),
erl_tar:close(Tar),
file:set_cwd(Cwd),
io:fwrite("Removing directory \"s\" ...\n"),
remove_dir_tree("tmp"),
ok.

install(RelFileName, RootDir) ->
  TarFile = RelFileName ++ ".tar.gz",
io:fwrite("Extracting \"s ...\n", [TarFile]),
extract_tar(TarFile, RootDir),
StartErlDataFile = filename:join([RootDir, "releases", "start_erl.data"]),
{ok, StartErlData} = read_txt_file(StartErlDataFile),
```

1.2: Creating a First Target System

`[ErlVsn, RelVsn|_] = string:tokens(StartErlData, ", \n"),
ErtsBinDir = filename:join([RootDir, "erts-" ++ ErlVsn, "bin"]),
BinDir = filename:join([RootDir, "bin"]),
io:fwrite("Substituting in erl.src, start.src and start_erl.src to
"form erl, start and start_erl ...
"),
subst_src_scripts(["erl", "start", "start_erl"], ErtsBinDir, BinDir,
["FINAL_ROOTDIR", RootDir], ["EMU", "beam"],
[preserve]),
io:fwrite("Creating the RELEASES file ...
"),
create_RELEASES(RootDir,
    filename:join([RootDir, "releases", RelFileName])).

%% LOCALS

%% make_script(RelFileName)
%%
make_script(RelFileName) ->
    Opts = [no_module_tests],
systools:make_script(RelFileName, Opts).

%% make_tar(RelFileName)
%%
make_tar(RelFileName) ->
    RootDir = code:root_dir(),
systools:make_tar(RelFileName, [{erts, RootDir}]).

%% extract_tar(TarFile, DestDir)
%%
extract_tar(TarFile, DestDir) ->
erl_tar:extract(TarFile, [{cwd, DestDir}, compressed}]).

create_RELEASES(DestDir, RelFileName) ->
    release_handler:create_RELEASES(DestDir, RelFileName ++ ".rel").

subst_src_scripts(Scripts, SrcDir, DestDir, Vars, Opts) ->
    lists:foreach(fun(Script) ->
        subst_src_script(Script, SrcDir, DestDir, Vars, Opts)
        end, Scripts).

subst_src_script(Script, SrcDir, DestDir, Vars, Opts) ->
    subst_file(filename:join([SrcDir, Script ++ ".src"],
        Vars, Opts).

subst_file(Src, Dest, Vars, Opts) ->
    {ok, Conts} = read_txt_file(Src),
    NConts = subst(Conts, Vars),
    write_file(Dest, NConts),
case lists:member(preserve, Opts) of
    true ->
        {ok, FileInfo} = file:read_file_info(Src),
        file:write_file_info(Dest, FileInfo);
false ->
  ok
end.

%% subst(Str, Vars)
%% Vars = [{Var, Val}]
%% Var = Val = string()
%% Substitute all occurrences of %Var% for Val in Str, using the list
%% of variables in Vars.
%%
subst(Str, Vars) ->
  subst(Str, Vars, []).subst([[%, C| Rest]], Vars, Result) when $a =< C, C =< $z ->
    subst_var([C| Rest], Vars, Result, []);
subst([[%, C| Rest]], Vars, Result) when $A =< C, C =< $Z ->
    subst_var([C| Rest], Vars, Result, []);
subst([[%, C| Rest]], Vars, Result) when C == $_ ->
    subst_var([C| Rest], Vars, Result, []);
subst([C| Rest], Vars, Result) ->
    subst(Rest, Vars, [C| Result]);
subst([], _Vars, Result) ->
    lists:reverse(Result).

subst_var([[%| Rest]], Vars, Result, VarAcc) ->
  Key = lists:reverse(VarAcc),
  case lists:keysearch(Key, 1, Vars) of
    {value, {Key, Value}} ->
      subst(Rest, Vars, lists:reverse(Value, Result));
    false ->
      subst(Rest, Vars, [[%| VarAcc ++ [%| Result]])
  end;
subst_var([C| Rest], Vars, Result, VarAcc) ->
  subst_var(Rest, Vars, Result, [C| VarAcc]);
subst_var([], Vars, Result, VarAcc) ->
  subst([], Vars, [VarAcc ++ [%| Result]]).

copy_file(Src, Dest) ->
  copy_file(Src, Dest, []).copy_file(Src, Dest, Opts) ->
  {ok, InFd} = file:rawopen(Src, {binary, read}),
  {ok, OutFd} = file:rawopen(Dest, {binary, write}),
  do_copy_file(InFd, OutFd),
  file:close(InFd),
  file:close(OutFd),
  case lists:member(preserve, Opts) of
    true ->
      {ok, FileInfo} = file:read_file_info(Src),
      file:write_file_info(Dest, FileInfo);
    false ->
      ok
  end.
do_copy_file(InFd, OutFd) ->
    case file:read(InFd, ?BUFSIZE) of
        {ok, Bin} ->
            file:write(OutFd, Bin),
            do_copy_file(InFd, OutFd);
        eof ->
            ok
    end.

write_file(FName, Conts) ->
    {ok, Fd} = file:open(FName, [write]),
    file:write(Fd, Conts),
    file:close(Fd).

read_txt_file(File) ->
    {ok, Bin} = file:read_file(File),
    {ok, binary_to_list(Bin)}.

remove_dir_tree(Dir) ->
    remove_all_files(".", [Dir]).

remove_all_files(Dir, Files) ->
    lists:foreach(fun(File) ->
        FilePath = filename:join([Dir, File]),
        {ok, FileInfo} = file:read_file_info(FilePath),
        case FileInfo#file_info.type of
            directory ->
                {ok, DirFiles} = file:list_dir(FilePath),
                remove_all_files(FilePath, DirFiles),
                file:del_dir(FilePath);
            _ ->
                file:delete(FilePath)
        end
    end, Files).
# List of Tables

1.1 File Types ......................................................... 3