Creating a User Space Live Patch

User space live patching with `libpulp` enables SUSE Linux Enterprise Server administrators to apply live security patches to shared system libraries without restarting applications or incurring downtime. By dynamically replacing functions in active process memory, live patching ensures continuous service availability, accelerates vulnerability remediation and maintains operational integrity across enterprise systems.

Prerequisites

- GCC compiler and development toolchain installed
- The `libpulp` library and ULP tools available on the system

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Contents

1 Creating user space live patches 3

2 Creating a live patch for a system library 3

3 Testing the live patch 6

4 Files required in a live patch package 6

5 Making an RPM from the live patch 7

6 Deploying the live patch package 7

7 Legal Notice 8

A GNU Free Documentation License 8

1 Creating user space live patches

The following sections describe how to create live patches for libraries using the `libpulp`. The task comprises the following actions:

- creating the patch
- testing the patch
- packing the patch into an RPM
- deploying the patch

For more information regarding `libpulp`, refer to the ULP documentation (https://documentation.suse.com/sles/html/SLES-administration/#cha-ulp).

2 Creating a live patch for a system library

In the procedure below, you will create a live patch for the `malloc` function. The patched function will initialize the memory allocated by the function with the string `glibc-livepatches`. To create the live patch, proceed as follows:

1. Create a test program that checks if a live patch has been applied. The program should just allocate a region in memory and check if the string is there. An example follows:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <stdbool.h>
#include <string.h>

#define NUM_ATTEMPTS 30
#define LEN 32

static const char *const lp_string = "glibc-livepatch";

int main(int argc, char *argv[])
{
  for (int i = 0; i < NUM_ATTEMPTS; i++) {
    bool flag = false;
    char *m = malloc(LEN);
    m[LEN-1] = '\0';
```

```
    fprintf(stderr, "%s\n", m);

    if (m) {
      if (!strcmp(m, lp_string)) {
        flag = true;
      }
      free(m);
    }

    m = calloc(1, 32);
    if (m) {
      free(m);
    } else if (flag) {
      return 0;
    }
    sleep(1);
  }

  return 1;
}
```

2. Compile the program:

```
> gcc -o test test.c
```

3. Create a file containing the new `malloc` function, for example, `libc_livepatch1.c`.
   The code snippet shown below implements the new `malloc` function by using the `calloc` function to allocate memory and then overwrite its content with the *glibc-livepatch* string. The file is called `libc_livepatch1.c`.

```
#include <stdlib.h>
#include <string.h>

#define MIN(x, y) ((x) < (y) ? (x) : (y))

static const char *const lp_string = "glibc-livepatch";

void *malloc_lp(size_t s)
{
  char *block = calloc(1, s);
  if (block && s > 0) {
    int lp_string_len = strlen(lp_string);
    int copy_len = MIN(lp_string_len + 1, s);

    memcpy(block, lp_string, copy_len);
    block[s-1] = '\0';
```

```
  }
  return block;
}
```

Compile the file for x86 as follows:

```
> gcc -fPIC -fpatchable-function-entry=16,14 -shared -o  libc_livepatch1.so
 libc_livepatch1.c
```

4. Create a live patch description file. The file must contain the following information:

   - A path to the live patch container, in this case the path to the `libc_livepatch1.so.6` file.
   - A path to the target library— `/lib64/libc.so.6` in this case.
   - The function name that will be patched and its replacement. You can also describe multiple replacements.
   - The description file for the example live patch looks as follows:

     ```
     libc_livepatch1.so
     @/lib64/libc.so.6
     __libc_malloc:malloc_lp
     ```

     The patch is for the `__libc_malloc` function, not for `malloc`, because the `malloc` name is an indirect function, not a regular function, and in the end it calls the `__libc_malloc` function. For details about ifunc, refer to the indirect function (https://sourceware.org/glibc/wiki/GNU_IFUNC) description.

5. Build the live patch container:

```
> gcc -fPIC -fpatchable-function-entry=16,14 -shared -o libc_livepatch1.so
 libc_livepatch1.c
```

6. Embed the description file into the live patch container:

```
> ulp packer libc_livepatch1.dsc
```

3 Testing the live patch

After you prepare the live patch and its test program as described in *Section 2, "Creating a live patch for a system library"*, you can test if the live patch works:

1. Launch the test program:

```
> LD_PRELOAD=/usr/lib64/libpulp.so.0 ./test
```

2. Install the live patch:

```
> ulp trigger libc_livepatch.so
```

If the installation was successful, the ULP tool displays the message `SUCCESS`. You should also see the `glibc-livepatch` message from the test program.

4 Files required in a live patch package

To prepare a live patch package, use the glibc-livepatches (https://build.opensuse.org/package/show/SUSE:SLE-15-SP7:Update/glibc-livepatches) as a reference source. The package contains the following files:

- `glibc-livepatches.spec`; for details, refer to *Section 4.1, "The `glibc-livepatches.spec` file"*.
- `glibc-livepatches-`*`VERSION`*`.tar.xz`; for details, refer to *Section 4.2, "The `glibc-livepatches.tar.xz` file"*.

4.1 The `glibc-livepatches.spec` file

The `glibc-livepatches.spec` file contains instructions on how to prepare, build, install and apply the live patch.

The file also calls the `ulp_post_hook` script. The script calls the ULP trigger with extracted boilerplate code to avoid adding such a code to every package. To check the code, view the file `/usr/lib/user-space-livepatch/rpm-helper`. The call to the ULP trigger is performed with the **`--revert-all`** command that reverts all already installed patches. Make sure that your patch is cumulative and contains fixes for the previous versions of the patch.

4.2 The `glibc-livepatches.tar.xz` file

The `glibc-livepatches.tar.xz` file contains the actual source code of the live patch. The archive must also contain information about all `glibc` versions issued for the particular SLES version.

5 Making an RPM from the live patch

To prepare a live patch package, follow the steps below:

1. Extract the `glibc-livepatches` package.
2. Add the live patch source files.
3. Run the following command to update the package so that it includes all `glibc` versions released for the particular SLES version.

   ```
   > make download
   ```

4. Run the following command to check if the live patch is buildable.

   ```
   > make
   ```

   If the process is successfully completed, one `.so` file is created for each `glibc` version. For example, `libc_2.31-150300.26.5_livepatch1.so`.

5. To ensure that your package does not contain any of your temporary build files, run the command:

   ```
   > make clean
   ```

6. To create a new `.tar.xz`, run the command:

   ```
   > make dist
   ```

7. Build the package with OSC (https://github.com/openSUSE/osc).
8. If the build is successful, you can upload the package to a repository.

6 Deploying the live patch package

If you have the `RPM` package ready and tested, you can submit a merge request to the `glibc-livepatches` SLES16.1 update repository.

```
> osc -A https://api.suse.de mr YOUR_HOME glibc-livepatches SUSE:SLE-15-SP5:GA
```

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