

SmPL: A Domain-Specific Language for Specifying Collateral Evolutions in Linux Device Drivers

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The collateral evolution problem

- ▶ Libraries change.
 - ▶ These changes may affect the library interfaces.
 - ▶ Dependent code must be updated accordingly.
- Evolutions in generic library entails modifications, *i.e.* **collateral evolutions** in library clients.

Our target: Linux device drivers.

An example

Interface change: Drivers “proc_info” functions shouldn't use the functions `scsi_host_hn_get` and `scsi_host_put`.

```
static int usb_storage_proc_info (char *buffer, char **start, off_t offset,
                                int length, int hostno, int inout) {
    struct us_data *us;
    char *pos = buffer;
    struct Scsi_Host *hostptr;
    unsigned long f;

    if (inout) return length;
    hostptr = scsi_host_hn_get(hostno);
    if (!hostptr) { return -ESRCH; }
    us = (struct us_data*)hostptr->hostdata[0];
    if (!us) {
        scsi_host_put(hostptr);
        return -ESRCH;
    }
    <SOME CODE OMMITED>
    scsi_host_put(hostptr);
    <SOME CODE OMMITED>
}
```

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    }
    <SOME CODE OMMITED>
    scsi_host_put(hostptr);
    <SOME CODE OMMITED>
}
```

A corresponding patch file

```
--- a/drivers/usb/storage/scsiglue.c Sat Jun 14 12:18:55 2003
+++ b/drivers/usb/storage/scsiglue.c Sat Jun 14 12:18:55 2003
@@ -264,33 +300,21 @@
-static int usb_storage_proc_info (
+static int usb_storage_proc_info (struct Scsi_Host *hostptr,
+                                char *buffer, char **start, off_t offset,
-                                int length, int hostno, int inout) {
+                                int length, int inout) {
    struct us_data *us;
    char *pos = buffer;
-   struct Scsi_Host *hostptr;
    unsigned long f;
    if (inout) return length;

-   hostptr = scsi_host_hn_get(hostno);
-   if (!hostptr) {
-       return -ESRCH;
-   }
    us = (struct us_data*)hostptr->hostdata[0];
    if (!us) {
-       scsi_host_put(hostptr);
        return -ESRCH;
    }
@@ -318,9 +342,6 @@
-   scsi_host_put(hostptr);
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    char *pos = buffer;
-   struct Scsi_Host *hostptr;
    unsigned long f;
    if (inout) return length;

-   hostptr = scsi_host_hn_get(hostno);
-   if (!hostptr) {
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    us = (struct us_data*)hostptr->hostdata[0];
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```

Motivations

Collateral evolutions in Linux are mostly done manually (with a basic editor and the help of `grep`).

Some collateral evolutions can involve:

- ▶ hundreds of files
- ▶ thousands of code sites

Some collateral evolutions are quite complex.

→ Collateral evolutions in Linux is thus time consuming and error prone.

→ We propose a language to specify easily and automate such program transformations.

Proposal for a semantic patch language (SmPL)

```
proc_info_func (  
+   struct Scsi_Host *hostptr,  
   char *buffer, char **start, off_t offset, int length,  
-   int hostno,  
   int inout) {
```

Proposal for a semantic patch language (SmPL)

```
@@
identifier buffer, start, offset, length, inout, hostptr, hostno;
@@
proc_info_func (
+   struct Scsi_Host *hostptr,
   char *buffer, char **start, off_t offset, int length,
-   int hostno,
   int inout) {
```

Proposal for a semantic patch language (SmPL)

```
@@
struct SHT sht;
local function proc_info_func;
@@
    sht.proc_info = &proc_info_func;

@@
identifier buffer, start, offset, length, inout, hostptr, hostno;
@@
proc_info_func (
+   struct Scsi_Host *hostptr,
    char *buffer, char **start, off_t offset, int length,
-   int hostno,
    int inout) {
```

Proposal for a semantic patch language (SmPL)

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struct SHT sht;
local function proc_info_func;
@@
    sht.proc_info = &proc_info_func;

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identifier buffer, start, offset, length, inout, hostptr, hostno;
@@
proc_info_func (
+   struct Scsi_Host *hostptr,
    char *buffer, char **start, off_t offset, int length,
-   int hostno,
    int inout) {
    ...
-   struct Scsi_Host *hostptr;
    ...
-   hostptr = scsi_host_hn_get(hostno);
    ...
-   if (!hostptr) { ... }
    ...
-   scsi_host_put(hostptr);
    ...
}
```

Summary

A single small **semantic patch** can modify hundreds of files, at thousands of code sites.

This is because the features of SmPL make a semantic patch **generic** by abstracting away the specific details at each code site:

- ▶ differences in spacing, indentation, and comments.
- ▶ choice of the names given to variables (use of **metavariables**).
- ▶ different way to sequence instructions in C (**control-flow oriented** rather than AST oriented).
- ▶ other variations in coding style (use of **isomorphisms**).