ureadahead

Resurrection from the dead!

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- Traces files that are opened during boot up
- Calls `mincore()` system call to locate memory resident portions of the file
- Creates a “pack” file storing the files and information on what was read
- Subsequent boot ups will use this information to call `readahead()`

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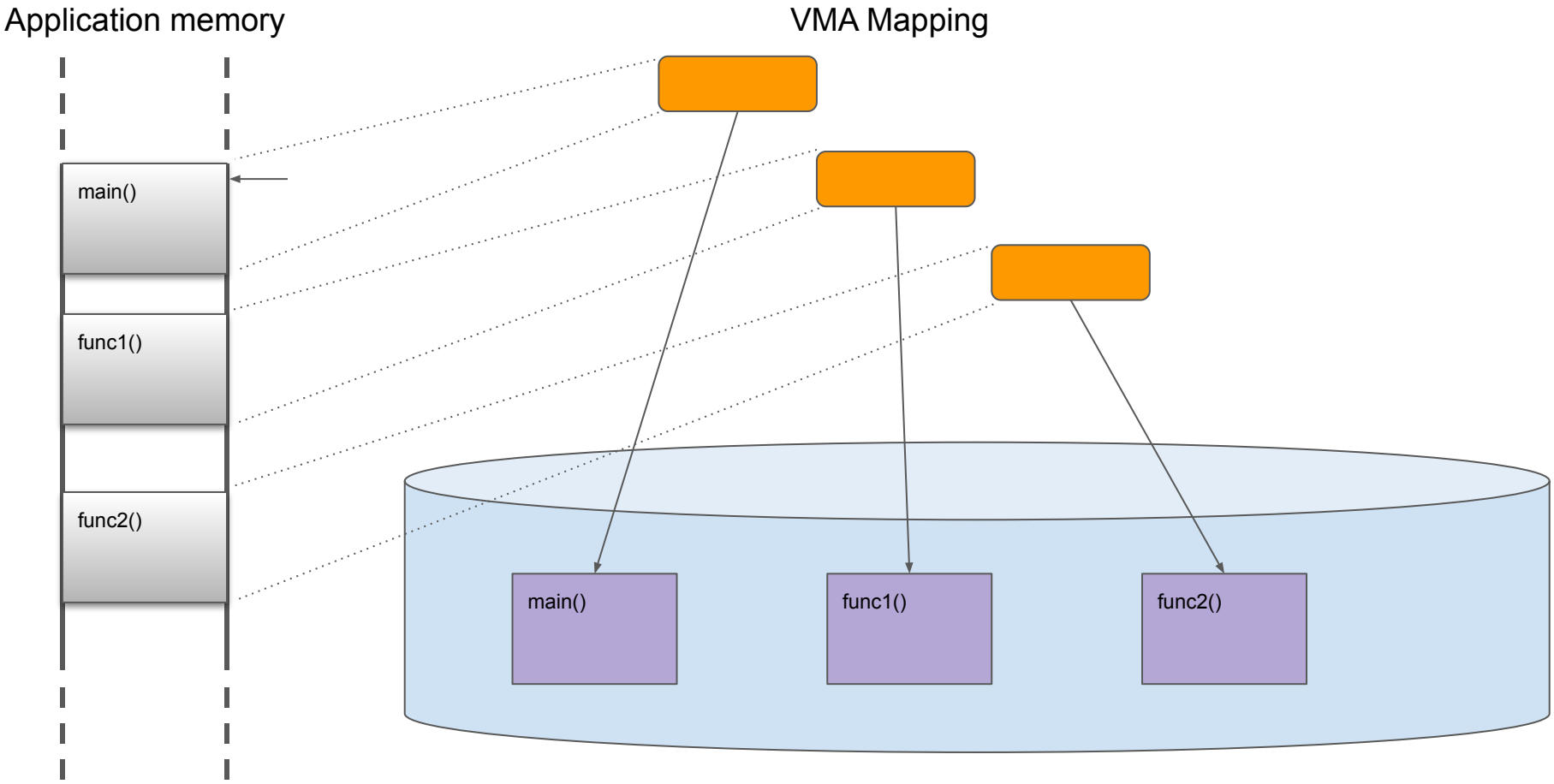
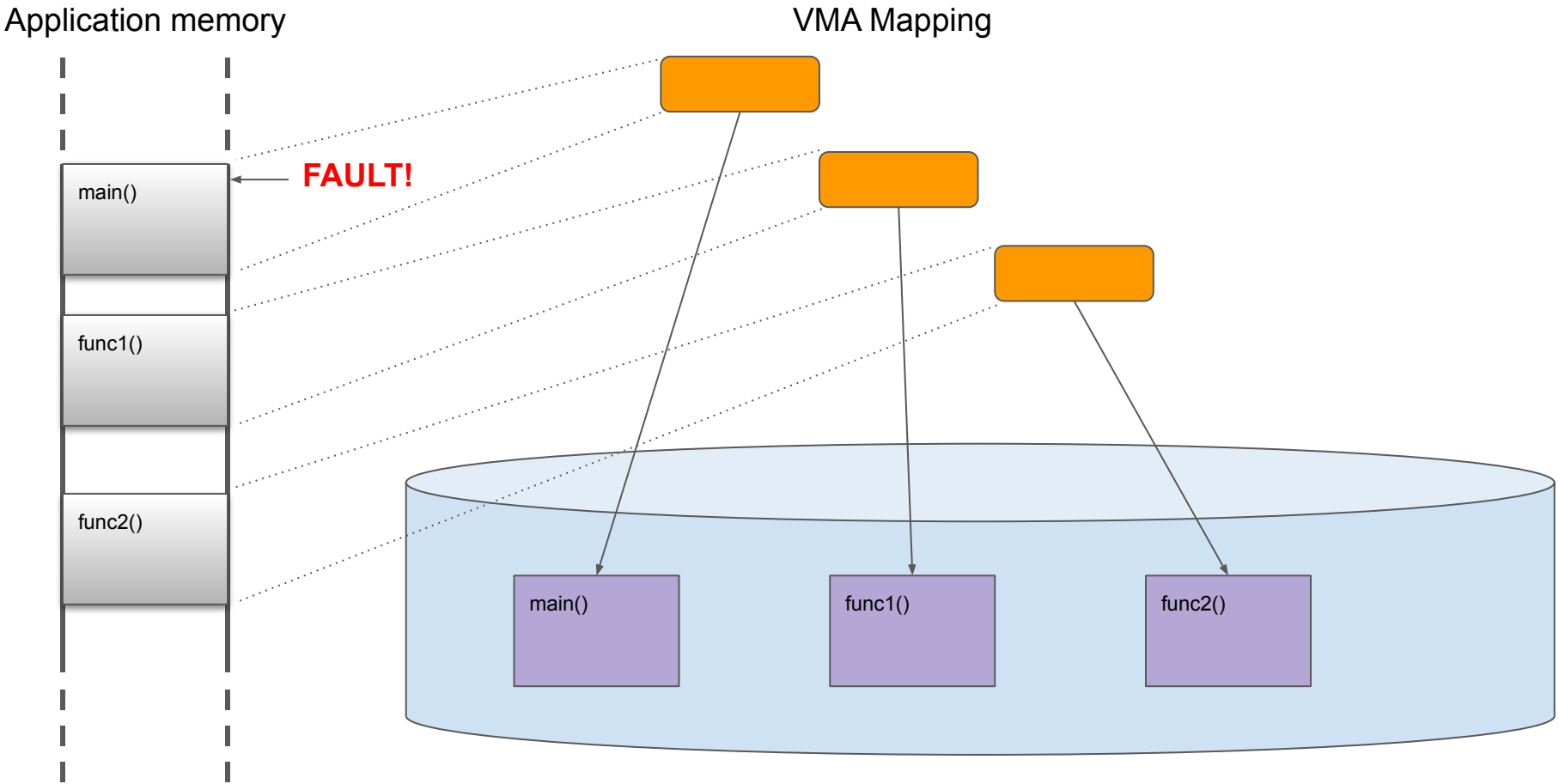
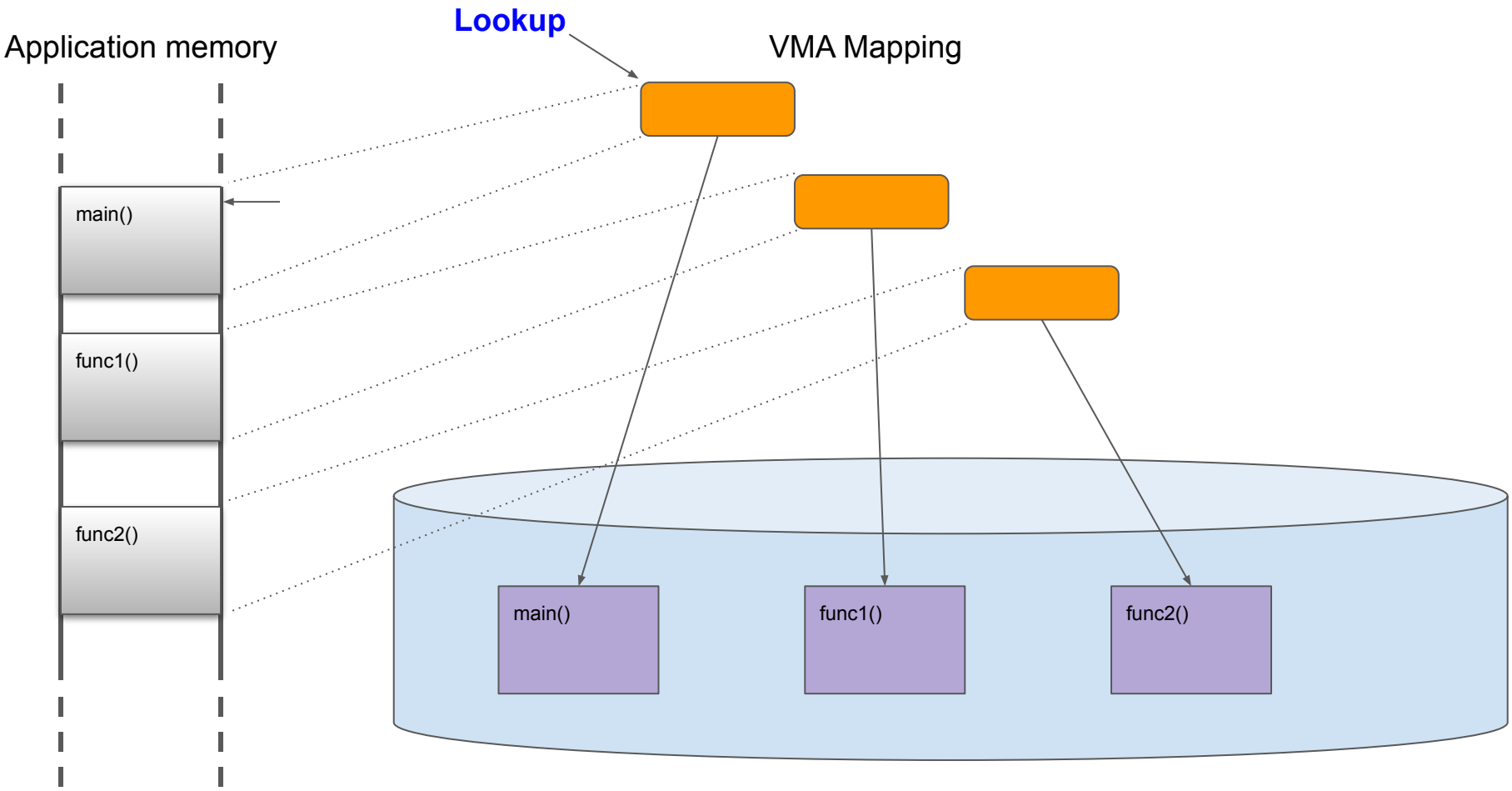
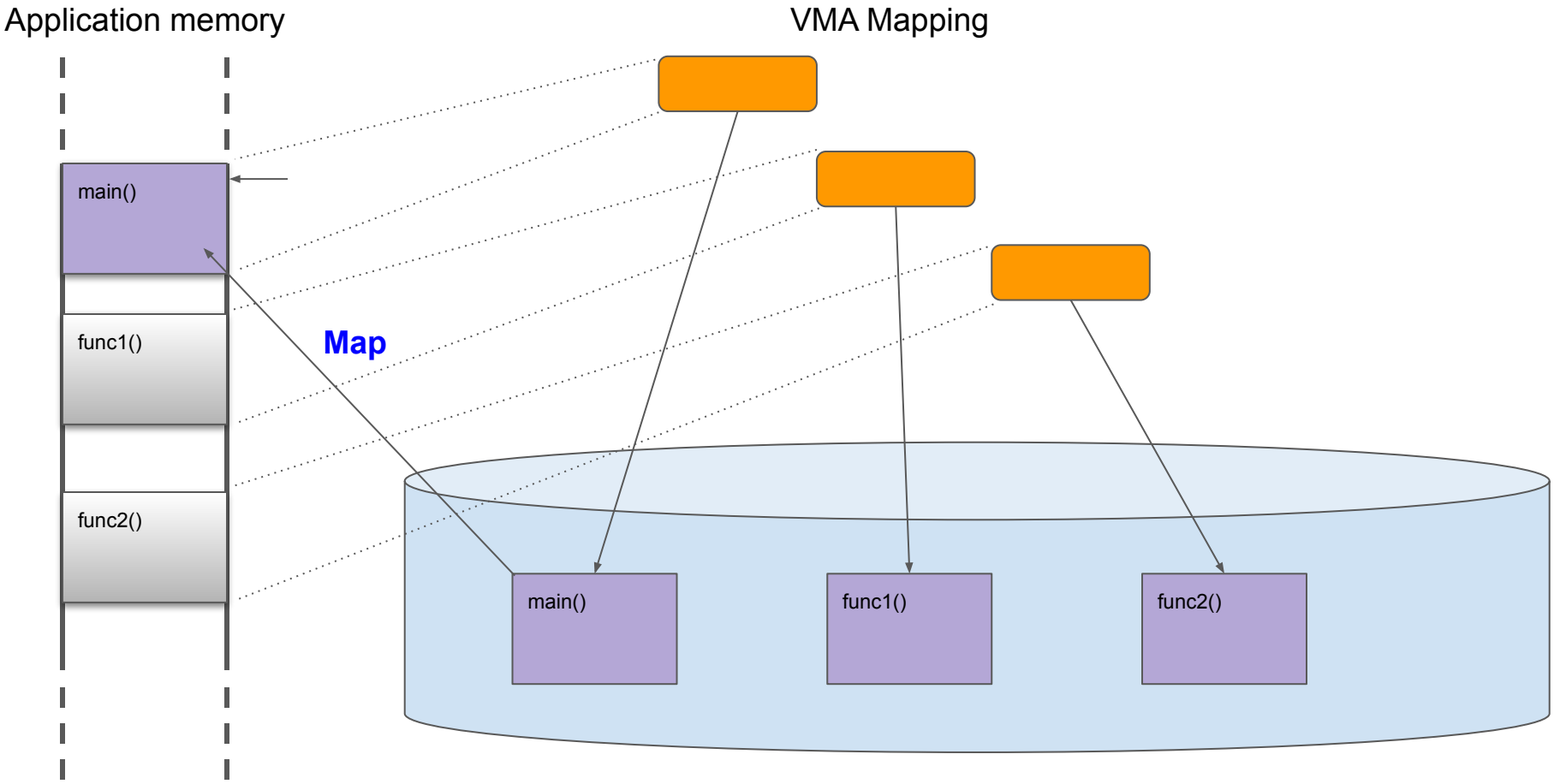
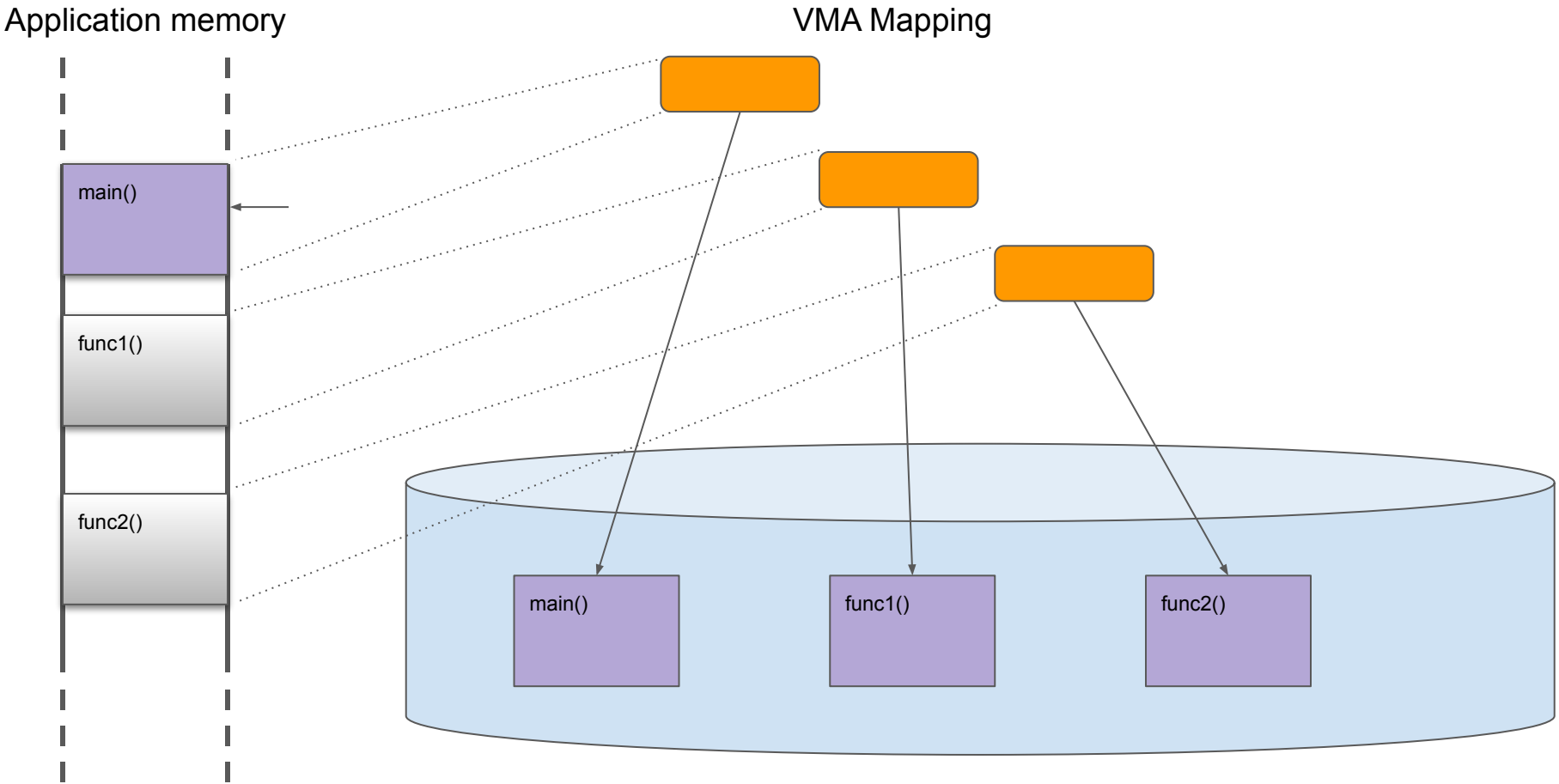
- Works for databases that access the same information in a database file


Application memory
VMA Mapping
main()
func1()
func2()
main()
func1()
func2()


Application memory
VMA Mapping
FAULT!
main()
func1()
func2()
main()
func1()
func2()


Application memory
Lookup
VMA Mapping
main()
func1()
func2()
main()
func1()
func2()


Application memory
VMA Mapping
main()
func1()
func2()
Map
main()
func1()
func2()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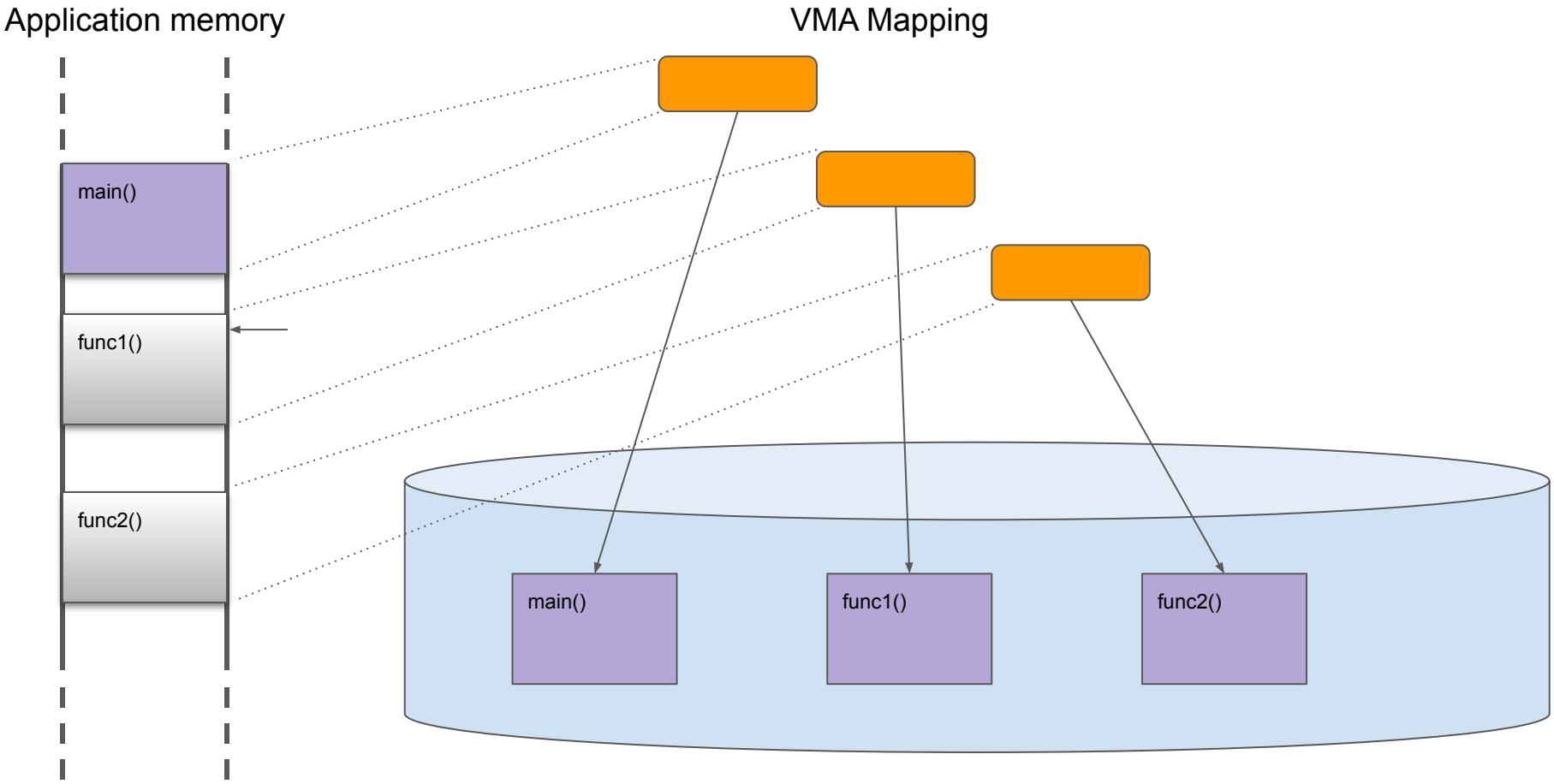
main()
func1()
func2()
main()
func1()
func2()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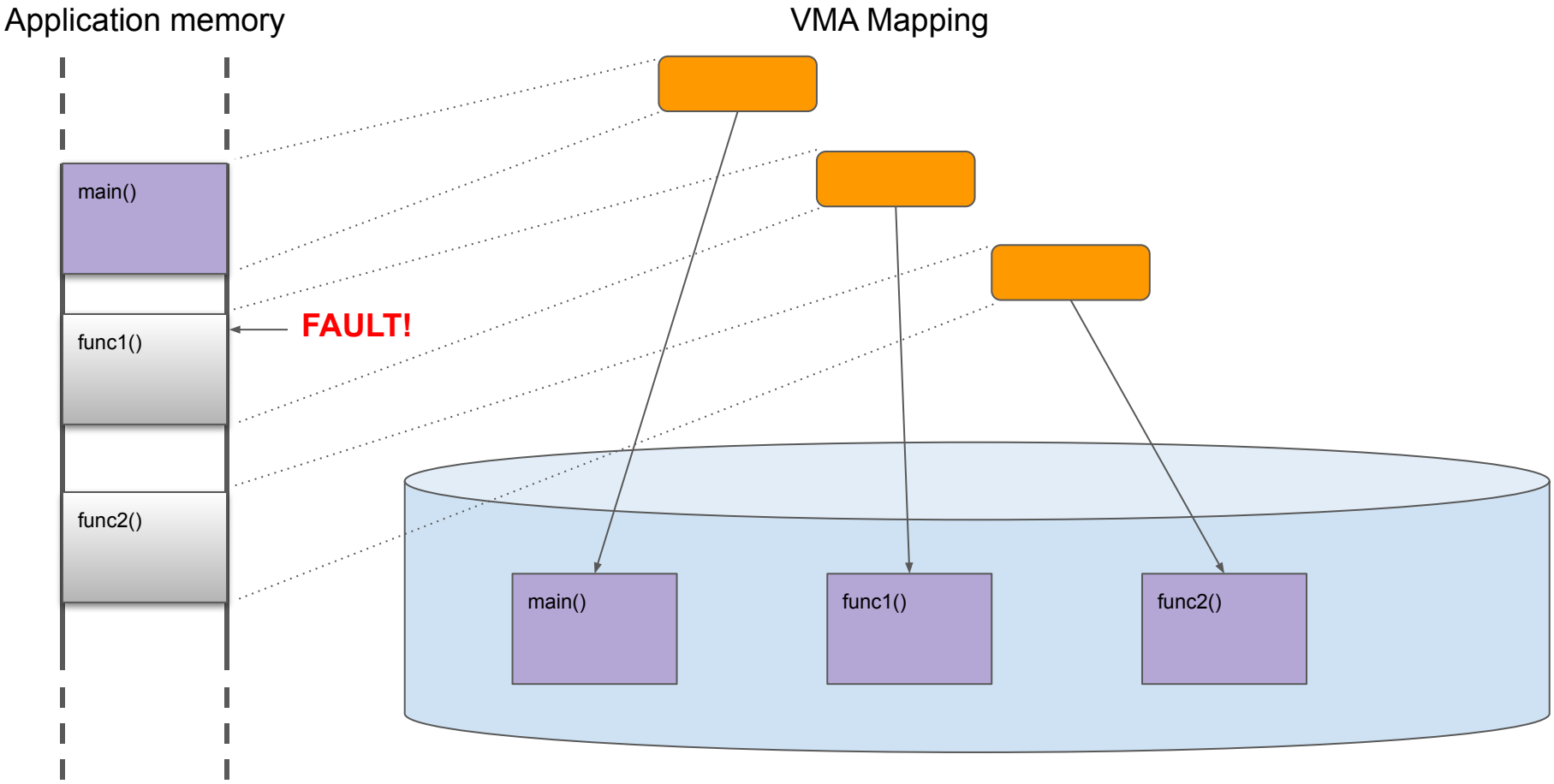
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FAULT!
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Trace Chrome’s page faulting

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cpus=8
          chrome-4098  [004] 154614.281855: funcgraph_entry:      + 53.556 us  |  handle_mm_fault();
          chrome-4098  [004] 154614.281982: mm_filemap_add_to_page_cache: dev 254:3 ino e0011 pfn=0x2708df ofs=0 order=0
          chrome-4098  [004] 154614.283043: funcgraph_entry:                   |  handle_mm_fault() {
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          chrome-4098  [004] 154614.283093: mm_filemap_add_to_page_cache: dev 254:3 ino 13f82f pfn=0x277a68 ofs=1204224 order=0
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          chrome-4098  [004] 154614.283102: mm_filemap_add_to_page_cache: dev 254:3 ino 13f82f pfn=0x270e0d ofs=1212416 order=0
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          chrome-4098  [004] 154614.283112: mm_filemap_add_to_page_cache: dev 254:3 ino 13f82f pfn=0x2709a7 ofs=1220608 order=0
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Major fault

Using: libtracecmd

```
int main (int argc, char **argv)
{
      struct tracecmd_input *handle;
      struct data data = {};

      handle = tracecmd_open(argv[1], 0);

      tracecmd_follow_event(handle, "ftrace", "funcgraph_exit",
                            func_graph_exit, &data);
      tracecmd_follow_event(handle, "filemap", "mm_filemap_add_to_page_cache",
                            mm_filemap, &data);
      tracecmd_iterate_events(handle, NULL, 0, NULL, NULL);
      tracecmd_close(handle);

      printf("Page faults:         %lld\n", data.nr_page_faults);
      printf("Page fault time:     ");
      print_time(data.page_fault_time);
      printf("file mapping count:  %lld\n", data.nr_filemaps);

      return 0;
}
```

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      return 0;
}
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```
static int func_graph_exit(struct tracecmd_input *handle, struct tep_event *event,
                           struct tep_record *record, int cpu, void *data)
{
      struct tep_handle *tep = tracecmd_get_tep(handle);
      static struct tep_format_field *func_field;
      static struct tep_format_field *call_field;
      static struct tep_format_field *ret_field;
      unsigned long long calltime, rettime, val;
      struct data *d = data;
      const char *func;

      if (!func_field) {
            func_field = tep_find_field(event, "func");
            call_field = tep_find_field(event, "calltime");
            ret_field = tep_find_field(event, "rettime");
      }

      tep_read_number_field(func_field, record->data, &val);
      func = tep_find_function(tep, val);

      tep_read_number_field(call_field, record->data, &calltime);
      tep_read_number_field(ret_field, record->data, &rettime);

      if (strcmp(func, "handle_mm_fault") == 0) {
            d->nr_page_faults++;
            d->page_fault_time += rettime - calltime;
      }
      return 0;
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      tep_read_number_field(func_field, record->data, &val);
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      if (strcmp(func, "handle_mm_fault") == 0) {
            d->nr_page_faults++;
            d->page_fault_time += rettime - calltime;
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static int func_graph_exit(struct tracecmd_input *handle, struct tep_event *event,
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      struct tep_handle *tep = tracecmd_get_tep(handle);
      static struct tep_format_field *func_field;
      static struct tep_format_field *call_field;
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      unsigned long long calltime, rettime, val;
      struct data *d = data;
      const char *func;

      if (!func_field) {
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      if (strcmp(func, "handle_mm_fault") == 0) {
            d->nr_page_faults++;
            d->page_fault_time += rettime - calltime;
      }
      return 0;
}
```

```
static int mm_filemap(struct tracecmd_input *handle, struct tep_event *event,
                      struct tep_record *record, int cpu, void *data)
{
      struct data *d = data;

      d->nr_filemaps++;
      return 0;
}
```

Using: libtracecmd

```
int main (int argc, char **argv)
{
      struct tracecmd_input *handle;
      struct data data = {};

      handle = tracecmd_open(argv[1], 0);

      tracecmd_follow_event(handle, "ftrace", "funcgraph_exit",
                            func_graph_exit, &data);
      tracecmd_follow_event(handle, "filemap", "mm_filemap_add_to_page_cache",
                            mm_filemap, &data);
      tracecmd_iterate_events(handle, NULL, 0, NULL, NULL);
      tracecmd_close(handle);

      printf("Page faults:         %lld\n", data.nr_page_faults);
      printf("Page fault time:     ");
      print_time(data.page_fault_time);
      printf("file mapping count:  %lld\n", data.nr_filemaps);

      return 0;
}
```

Using: libtracecmd

```
#define NS_PER_SEC 1000000000ULL

static void print_time(unsigned long long time)
{
	unsigned long long secs;
	unsigned long long usecs;

	secs = time / NS_PER_SEC;
	usecs = time - (secs * NS_PER_SEC);
	usecs /= 1000;
	printf("%lld.%06lld\n", secs, usecs);
}
```

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static void print_time(unsigned long long time)
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	unsigned long long secs;
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	secs = time / NS_PER_SEC;
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	usecs /= 1000;
	printf("%lld.%06lld\n", secs, usecs);
}
```

Code at: https://rostedt.org/code/cnt-page-faults.c

Compile with: `gcc -o cnt-page-faults cnt-page-faults.c `pkg-config --cflags --libs libtracecmd``

Using: libtracecmd

```
>$ ./cnt-page-faults trace-chrome-start.dat

Page faults:         100008
Page fault time:     1.984041
file mapping count:  74002

>$ ./cnt-page-faults trace-chrome-second.dat

Page faults:         90018
Page fault time:     0.777085
file mapping count:  183
```

ureadahead records what is read

- The first boot traces files opened

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  - After the trace it reads the memory that is mapped

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  - Races with the application as they start

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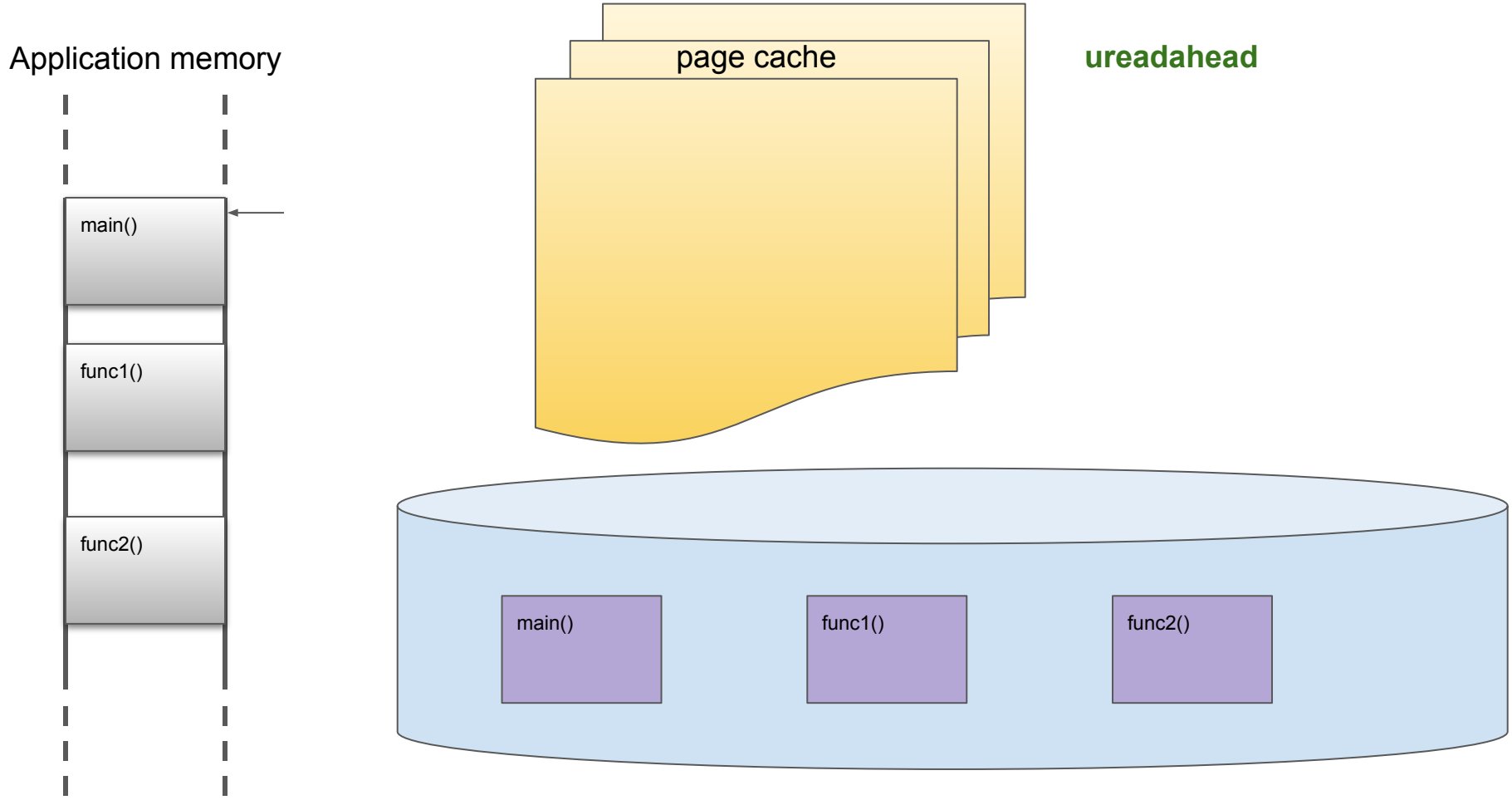
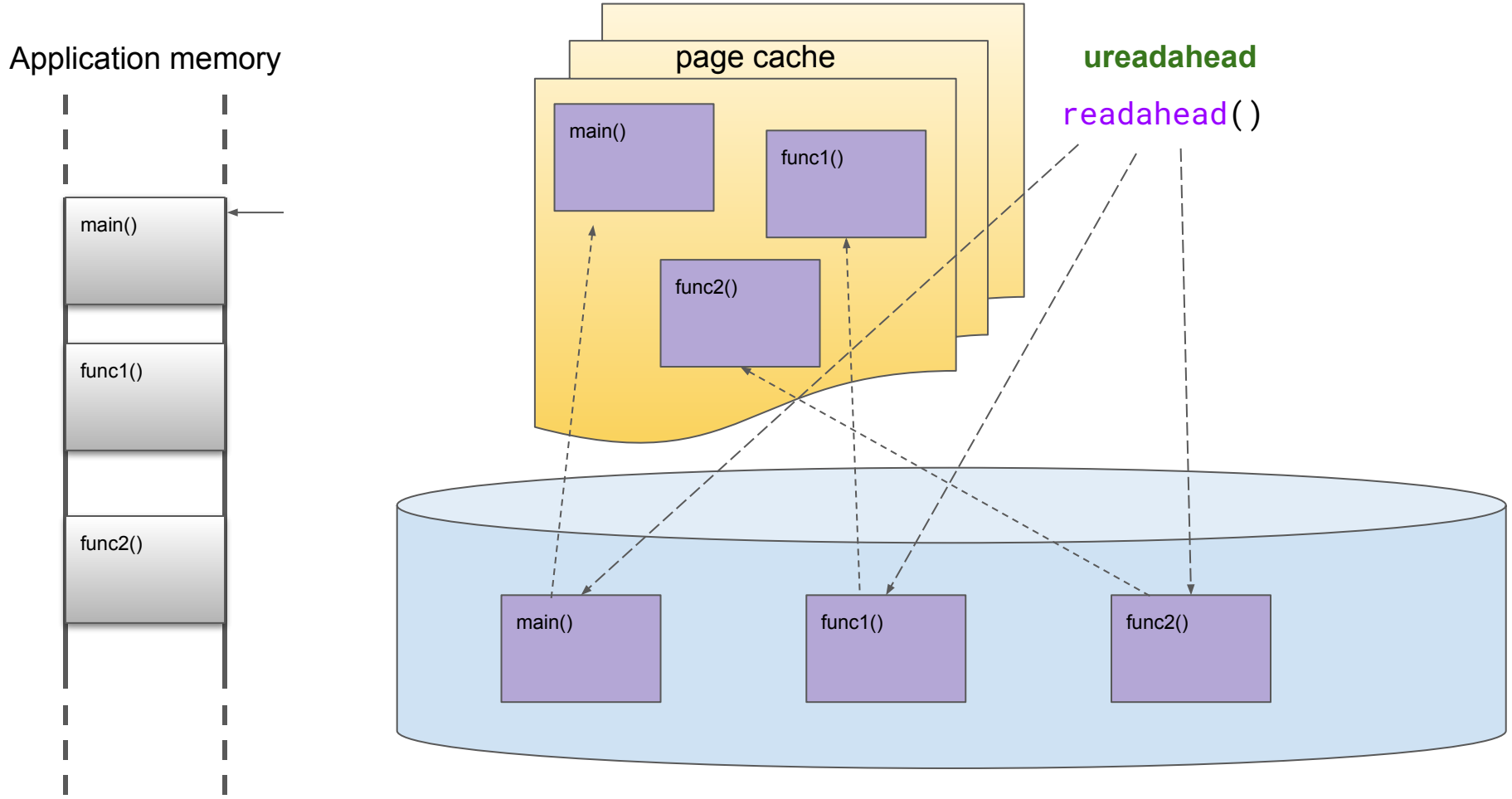
- The next boot reads the “pack” file
  - Calls `readahead()` system call to prefetch the data from disk
  - Races with the application as they start
  - But still has good results


Application memory
main()
func1()
func2()
page cache
ureadahead
main()
func1()
func2()


Application memory
main()
func1()
func2()
page cache
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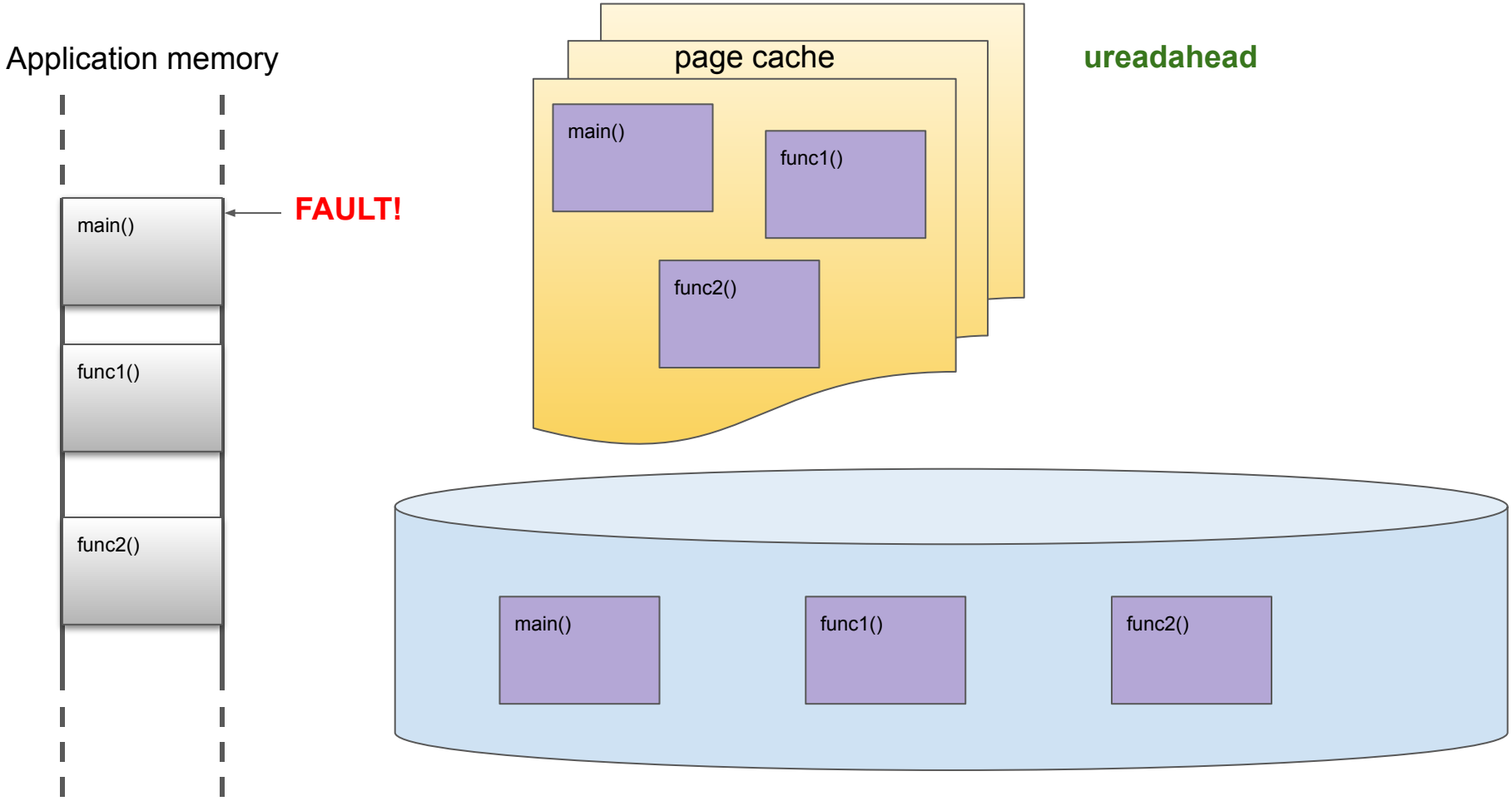
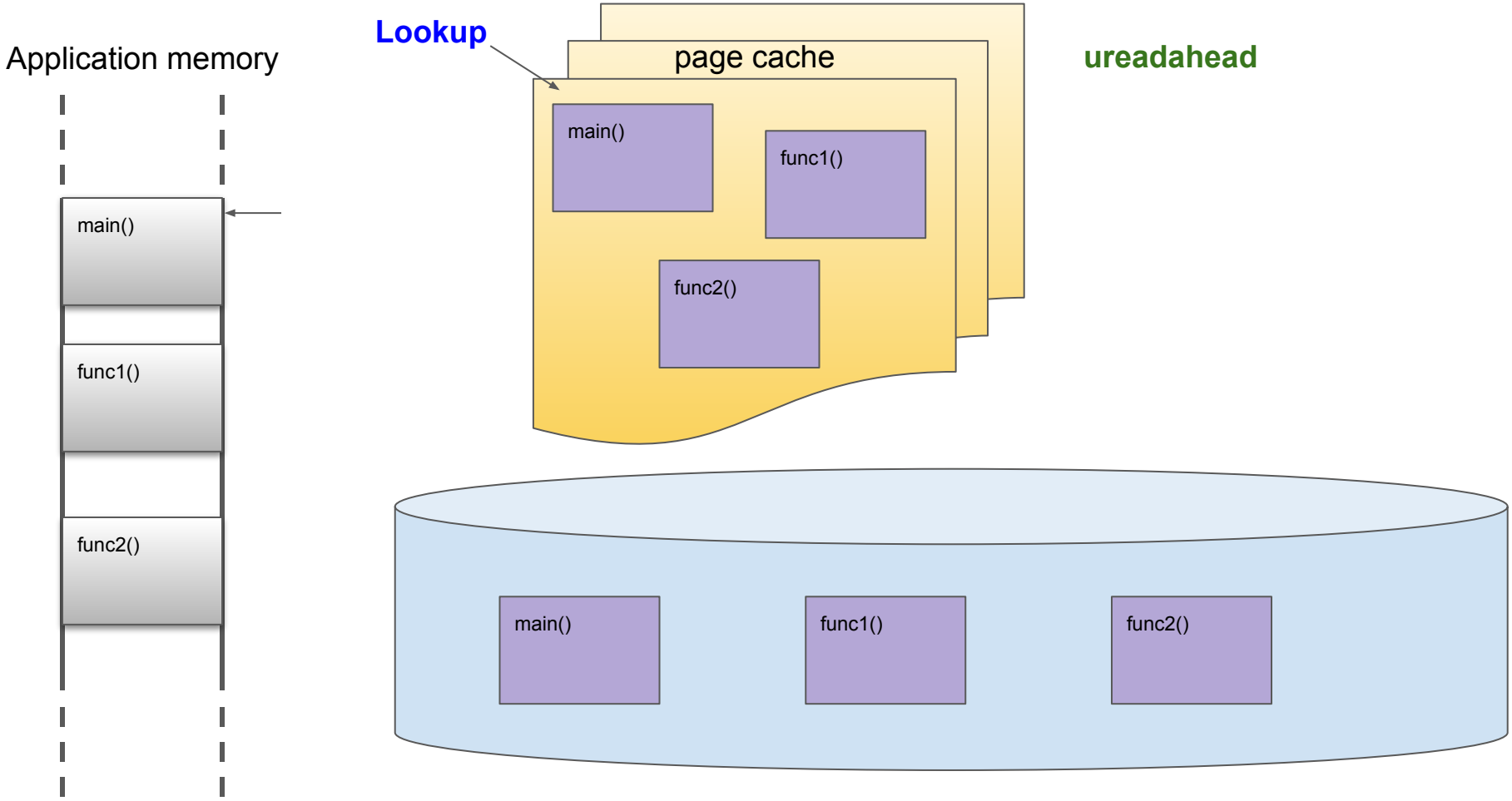
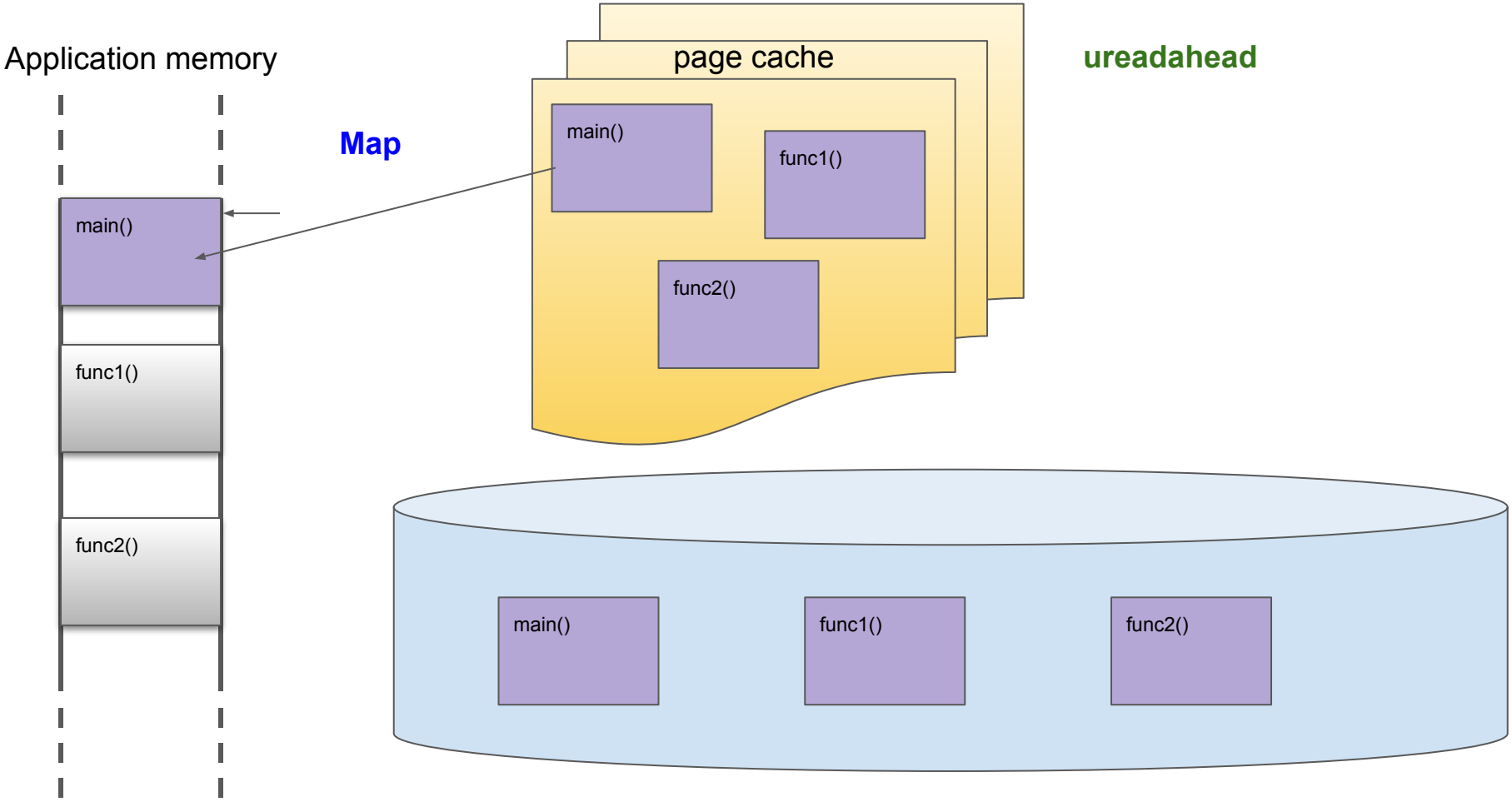
func1()
func2()
ureadahead
readahead()
main()
func1()
func2()


Application memory
main()
FAULT!
func1()
func2()
page cache
main()
func1()
func2()
ureadahead
main()
func1()
func2()


Application memory
main()
func1()
func2()
Lookup
page cache
main()
func1()
func2()
ureadahead
main()
func1()
func2()


Application memory
Map
page cache
ureadahead
main()
func1()
func2()
main()
func1()
func2()
main()
func1()
func2()

```
>#  ureadahead --dump

[..]
/usr/lib/x86_64-linux-gnu/libdb-5.3.so (1800 kB), 4 blocks (396 kB)
  [.................@.................@########################################]
  [#######.....................................................................]
  [.....................................................................@######]
  [###############.....................................................@##########]
  [#######                                                                     ]

        65536, 4096 bytes (at 18446744073709551615)
        135168, 196608 bytes (at 18446744073709551615)
        1445888, 131072 bytes (at 18446744073709551615)
        1773568, 73728 bytes (at 18446744073709551615)
[..]
```

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[..]
```

offset

length

physical address
of block device

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$ bootperf -o /tmp/test-${BOARD} ${DUT}
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```
$ bootperf -o /tmp/test-${BOARD} ${DUT}
[..]
$ less /tmp/test-${BOARD}/run.001/summary/results.json
[..]
    "seconds_kernel_to_login": {
        "summary": {
            "units": "seconds",
            "improvement_direction": "down",
            "type": "list_of_scalar_values",
            "values": [
                7.445,
                6.275,
                6.642,
                6.175,
                6.261,
                6.118,
                6.648,
                6.642,
                6.241,
                6.273
            ]
        }
    },
```

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```

First Boot (no pack file)

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Subsequent Boots (with pack file)

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            ]
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```

Subsequent Boots (with pack file)

14.5% savings!

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  - Last update was in 2017

ureadahead is dead; Long live ureadahead!

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  - We maintain it and patch our kernel for the two needed trace events

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- It is mostly held together with band-aid patches
- Breaks with certain updates to the kernel
- Needs a new rewrite
- I decided to start doing so

ureadahead rewrite

- Use libtracefs
  - Interface to access the tracefs file system

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  - Paths were hardcoded (tracefs is not guaranteed to be mounted at the default location)

ureadahead rewrite

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  - Interface to access the tracefs file system
  - Paths were hardcoded (tracefs is not guaranteed to be mounted at the default location)
  - libtracefs searches `/proc/mounts` to find it
  - libtracefs mounts it if not already mounted

ureadahead rewrite

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ureadahead rewrite

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https://github.com/rostedt/ureadahead/tree/devel

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- Rewrite in Rust?
- What other ideas do you have?

Questions?