

# Status of KUnit tests on DRM subsystem

Arthur Grillo

# About me

- Google Summer of Code 2023 participant for X.Org
- B.Sc. Computer Science - University of São Paulo/Brazil

# Thanks

- X.Org
- Google Summer of Code
- My Mentors:
  - André Almeida
  - Maíra Canal
  - Tales
- University Of São Paulo

# What is Unit Testing?

- Test individual units (functions)
- Assert behavior
- Fix bugs faster
- Prevent regressions

# KUnit

- Unit test framework inside the kernel since 2019
  - Maintained by Brendam Higgins and David Gow
- Inspired by other testing Frameworks
  - JUnit
  - Python's unittest.mock,
  - Googletest/Googlemock.
- Nice features
  - Expect and assert macros
  - Parameterized tests
  - Memory management
  - Try-catch

```
static void example_simple_test(struct kunit *test)
{
    KUNIT_EXPECT_EQ(test, 1 + 1, 2);
}
```

```
struct example_param {
    int value;
};

static const struct example_param example_params[] = {
    { .value = 2, },
    { .value = 1, },
    { .value = 0, },
};

static void example_param_get_desc(const struct example_param *p, char *desc)
{
    snprintf(desc, KUNIT_PARAM_DESC_SIZE, "example value %d", p->value);
}

KUNIT_ARRAY_PARAM(example, example_params, example_param_get_desc);

static void example_params_test(struct kunit *test)
{
    const struct example_param *param = test->param_value;

    KUNIT_EXPECT_EQ(test, param->value % param->value, 0);
}
```

```
struct example_param {
    int value;
};

static const struct example_param example_params[] = {
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    { .value = 0, },
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static void example_param_get_desc(const struct example_param *p, char *desc)
{
    snprintf(desc, KUNIT_PARAM_DESC_SIZE, "example value %d", p->value);
}

KUNIT_ARRAY_PARAM(example, example_params, example_param_get_desc);

static void example_params_test(struct kunit *test)
{
    const struct example_param *param = test->param_value;

    KUNIT_EXPECT_EQ(test, param->value % param->value, 0);
}
```

```
static struct kunit_case example_test_cases[] = {
    KUNIT_CASE(example_simple_test),
    KUNIT_CASE_PARAM(example_params_test, example_gen_params),
    {}
};

static struct kunit_suite example_test_suite = {
    .name = "example",
    .test_cases = example_test_cases,
};

kunit_test_suites(&example_test_suite);
```

# KUnit

- How to run it

- kunit tool

- ```
$ ./tools/testing/kunit.py run --kunitconfig=.kunitconfig
```

- Kernel configuration

- ```
CONFIG_KUNIT=y
```

- ```
CONFIG_KUNIT_EXAMPLE_TESTS=y
```

```
$ ./tools/testing/kunit/kunit.py run --kunitconfig=.kunitconfig
[09:35:31] Configuring KUnit Kernel ...
Regenerating .config ...
Populating config with:
$ make ARCH=um O=.kunit olddefconfig
[09:35:33] Building KUnit Kernel ...
Populating config with:
$ make ARCH=um O=.kunit olddefconfig
Building with:
$ make ARCH=um O=.kunit --jobs=8
/usr/bin/ld: warning: .tmp_vmlinux.kallsyms1 has a LOAD segment with RWX permissions
/usr/bin/ld: warning: .tmp_vmlinux.kallsyms2 has a LOAD segment with RWX permissions
/usr/bin/ld: warning: vmlinux has a LOAD segment with RWX permissions

[09:35:45] Starting KUnit Kernel (1/1)...
[09:35:45] =====
[09:35:45] ===== example (2 subtests) =====
[09:35:45] [PASSED] example_simple_test
[09:35:45] ===== example_params_test =====
[09:35:45] [PASSED] example value 2
[09:35:45] [PASSED] example value 1
[09:35:45] [PASSED] example value 0
[09:35:45] ===== [PASSED] example_params_test =====
[09:35:45] ===== [PASSED] example =====
[09:35:45] =====
[09:35:45] Testing complete. Ran 4 tests: passed: 4
[09:35:45] Elapsed time: 14.207s total, 2.553s configuring, 11.437s building, 0.163s running
```

# Gcov

- Coverage testing tool
- Useful for getting a sense of how much is tested
- Good coverage not always mean good tests

# Gcov + KUnit

```
$ ./tools/testing/kunit/kunit.py run --kunitconfig=$PWD/drivers/gpu/drm/tests/ \  
--make_options=CC=/usr/bin/gcc-6.5.0/bin/gcc \  
--kconfig_add CONFIG_DEBUG_KERNEL=y \  
--kconfig_add CONFIG_DEBUG_INFO=y \  
--kconfig_add CONFIG_DEBUG_INFO_DWARF_TOOLCHAIN_DEFAULT=y \  
--kconfig_add CONFIG_GCOV=y
```

```
$ lcov -t "kunit_tests" -o coverage.info -c -d .kunit/ \  
--gcov-tool=/usr/bin/gcc-6.5.0/bin/gcov
```

```
$ genhtml -o /tmp/coverage_html coverage.info
```

<https://flusp.ime.usp.br/kernel/generate-kunit-test-coverage/>

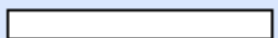










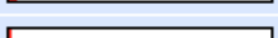

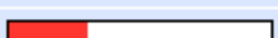



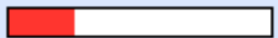





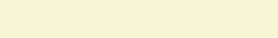
## LCOV - code coverage report

Current view: [top level](#) - drivers/gpu/drm

Test: coverage.info

Date: 2023-09-30 07:44:47

|            | Hit  | Total | Coverage |
|------------|------|-------|----------|
| Lines:     | 2685 | 17532 | 15.3 %   |
| Functions: | 243  | 1389  | 17.5 %   |

| Filename                                  | Line Coverage                                                                                          | Functions      |
|-------------------------------------------|--------------------------------------------------------------------------------------------------------|----------------|
| <a href="#">drm_aperture.c</a>            |  0.0 % 0 / 8        | 0.0 % 0 / 3    |
| <a href="#">drm_atomic.c</a>              |  0.0 % 0 / 592      | 0.0 % 0 / 41   |
| <a href="#">drm_atomic_helper.c</a>       |  2.5 % 30 / 1183    | 1.6 % 1 / 61   |
| <a href="#">drm_atomic_state_helper.c</a> |  0.0 % 0 / 246      | 0.0 % 0 / 30   |
| <a href="#">drm_atomic_uapi.c</a>         |  0.0 % 0 / 678      | 0.0 % 0 / 22   |
| <a href="#">drm_auth.c</a>                |  0.0 % 0 / 158      | 0.0 % 0 / 19   |
| <a href="#">drm_blend.c</a>               |  0.0 % 0 / 100      | 0.0 % 0 / 9    |
| <a href="#">drm_bridge.c</a>              |  0.0 % 0 / 270      | 0.0 % 0 / 28   |
| <a href="#">drm_bridge_connector.c</a>    |  0.0 % 0 / 120     | 0.0 % 0 / 9    |
| <a href="#">drm_buddy.c</a>               |  57.3 % 189 / 330 | 70.0 % 14 / 20 |
| <a href="#">drm_cache.c</a>               |  5.0 % 2 / 40     | 14.3 % 1 / 7   |
| <a href="#">drm_client.c</a>              |  3.1 % 5 / 162    | 5.9 % 1 / 17   |
| <a href="#">drm_client_modeset.c</a>      |  0.6 % 3 / 500    | 5.3 % 1 / 19   |
| <a href="#">drm_color_mgmt.c</a>          |  0.0 % 0 / 158    | 0.0 % 0 / 11   |
| <a href="#">drm_connector.c</a>           |  30.2 % 219 / 726 | 21.5 % 17 / 79 |
| <a href="#">drm_crtc.c</a>                |  2.0 % 6 / 297    | 9.1 % 2 / 22   |
| <a href="#">drm_crtc_helper.c</a>         |  0.0 % 0 / 382    | 0.0 % 0 / 16   |
| <a href="#">drm_crtc_internal.h</a>       |  0.0 % 0 / 1      | - 0 / 0        |
| <a href="#">drm_damage_helper.c</a>       |  25.3 % 24 / 95   | 40.0 % 2 / 5   |
| <a href="#">drm_displayid.c</a>           |  0.0 % 0 / 62     | 0.0 % 0 / 7    |
| <a href="#">drm_drv.c</a>                 |  65.6 % 202 / 308 | 63.3 % 19 / 30 |
| <a href="#">drm_dumb_buffers.c</a>        |  0.0 % 0 / 30     | 0.0 % 0 / 5    |
| <a href="#">drm_edid.c</a>                |  3.2 % 66 / 2081  | 3.1 % 5 / 160  |
| <a href="#">drm_encoder.c</a>             |  6.0 % 6 / 100    | 18.2 % 2 / 11  |

# What we have

- DRM core helpers
- TTM
- VC4
- /\* TODO \*/

|                                     |  |         |           |         |         |
|-------------------------------------|--|---------|-----------|---------|---------|
| <a href="#">drm_gem.c</a>           |  | 6.9 %   | 29 / 418  | 8.5 %   | 4 / 47  |
| <a href="#">drm_sysfs.c</a>         |  | 14.8 %  | 27 / 183  | 18.2 %  | 4 / 22  |
| <a href="#">drm_framebuffer.c</a>   |  | 18.1 %  | 69 / 382  | 8.0 %   | 2 / 25  |
| <a href="#">drm_mode_object.c</a>   |  | 24.1 %  | 42 / 174  | 30.0 %  | 6 / 20  |
| <a href="#">drm_damage_helper.c</a> |  | 25.3 %  | 24 / 95   | 40.0 %  | 2 / 5   |
| <a href="#">drm_property.c</a>      |  | 28.1 %  | 77 / 274  | 37.5 %  | 9 / 24  |
| <a href="#">drm_connector.c</a>     |  | 30.2 %  | 219 / 726 | 21.5 %  | 17 / 79 |
| <a href="#">drm_modeset_lock.c</a>  |  | 33.3 %  | 34 / 102  | 46.2 %  | 6 / 13  |
| <a href="#">drm_probe_helper.c</a>  |  | 34.8 %  | 142 / 408 | 32.1 %  | 9 / 28  |
| <a href="#">drm_fourcc.c</a>        |  | 46.9 %  | 30 / 64   | 77.8 %  | 7 / 9   |
| <a href="#">drm_mode_config.c</a>   |  | 55.5 %  | 147 / 265 | 63.6 %  | 7 / 11  |
| <a href="#">drm_buddy.c</a>         |  | 57.3 %  | 189 / 330 | 70.0 %  | 14 / 20 |
| <a href="#">drm_modes.c</a>         |  | 58.6 %  | 448 / 764 | 70.5 %  | 31 / 44 |
| <a href="#">drm_drv.c</a>           |  | 66.2 %  | 204 / 308 | 63.3 %  | 19 / 30 |
| <a href="#">drm_exec.c</a>          |  | 68.8 %  | 64 / 93   | 100.0 % | 10 / 10 |
| <a href="#">drm_managed.c</a>       |  | 70.0 %  | 56 / 80   | 70.0 %  | 7 / 10  |
| <a href="#">drm_format_helper.c</a> |  | 89.2 %  | 339 / 380 | 94.3 %  | 33 / 35 |
| <a href="#">drm_mm.c</a>            |  | 92.6 %  | 286 / 309 | 93.5 %  | 29 / 31 |
| <a href="#">drm_rect.c</a>          |  | 100.0 % | 119 / 119 | 100.0 % | 8 / 8   |

| Filename ↕                          | Line Coverage |        | Functions ↕ |        |         |
|-------------------------------------|---------------|--------|-------------|--------|---------|
| <a href="#">ttm_module.c</a>        |               | 0.0 %  | 0 / 4       | 0.0 %  | 0 / 1   |
| <a href="#">ttm_execbuf_util.c</a>  |               | 0.0 %  | 0 / 41      | 0.0 %  | 0 / 3   |
| <a href="#">ttm_range_manager.c</a> |               | 0.0 %  | 0 / 79      | 0.0 %  | 0 / 7   |
| <a href="#">ttm_bo_vm.c</a>         |               | 0.0 %  | 0 / 149     | 0.0 %  | 0 / 11  |
| <a href="#">ttm_bo_util.c</a>       |               | 0.0 %  | 0 / 256     | 0.0 %  | 0 / 19  |
| <a href="#">ttm_bo.c</a>            |               | 0.0 %  | 0 / 410     | 0.0 %  | 0 / 30  |
| <a href="#">ttm_resource.c</a>      |               | 3.8 %  | 9 / 240     | 3.4 %  | 1 / 29  |
| <a href="#">ttm_tt.c</a>            |               | 22.8 % | 36 / 158    | 33.3 % | 5 / 15  |
| <a href="#">ttm_sys_manager.c</a>   |               | 47.1 % | 8 / 17      | 33.3 % | 1 / 3   |
| <a href="#">ttm_device.c</a>        |               | 55.8 % | 67 / 120    | 50.0 % | 4 / 8   |
| <a href="#">ttm_pool.c</a>          |               | 81.6 % | 169 / 207   | 81.2 % | 13 / 16 |



## LCOV - code coverage report

Current view: [top level - drivers/gpu/drm - drm\\_rect.c](#) (source / [functions](#))

Test: [coverage.info](#)

Date: 2023-09-30 07:44:47

|            | Hit | Total | Coverage |
|------------|-----|-------|----------|
| Lines:     | 119 | 119   | 100.0 %  |
| Functions: | 8   | 8     | 100.0 %  |

Line data    Source code

```
1 : /*
2 :  * Copyright (C) 2011-2013 Intel Corporation
3 :  *
```

## LCOV - code coverage report

Current view: [top level - drivers/gpu/drm - drm\\_format\\_helper.c](#) (source / [functions](#))

Test: [coverage.info](#)

Date: 2023-09-30 07:44:47

|            | Hit | Total | Coverage |
|------------|-----|-------|----------|
| Lines:     | 339 | 380   | 89.2 %   |
| Functions: | 33  | 35    | 94.3 %   |

Line data    Source code

```
1 : // SPDX-License-Identifier: GPL-2.0 or MIT
2 : /*
3 :  * Copyright (C) 2016 Noralf Trønnes
4 :  *
5 :  * This program is free software; you can redistribute it and/or modify
6 :  * it under the terms of the GNU General Public License as published by
7 :  * the Free Software Foundation; either version 2 of the License, or
8 :  * (at your option) any later version.
9 :  */
10 :
11 : #include <linux/io.h>
12 : #include <linux/iosys-map.h>
```

# KUnit Tests as an introduction to kernel development

- Large number of functions to test
- Already a small task
- Great for gaining knowledge of the subsystem

# Case of Study

```
struct fb_memcpy_case {
    const char *name;
    u32 format;
    struct drm_rect clip;
    unsigned int src_pitches[DRM_FORMAT_MAX_PLANES];
    const u32 src[DRM_FORMAT_MAX_PLANES][TEST_BUF_SIZE];
    unsigned int dst_pitches[DRM_FORMAT_MAX_PLANES];
    const u32 expected[DRM_FORMAT_MAX_PLANES][TEST_BUF_SIZE];
};
```

```
static struct fb_build_fourcc_list_case fb_build_fourcc_list_cases[] = {
    /* ... */
    {
        .name = "single_pixel_clip_rectangle",
        .format = DRM_FORMAT_YUV444,
        .clip = DRM_RECT_INIT(1, 1, 1, 1),
        .src_pitches = { 2 * 1, 2 * 1, 2 * 1 },
        .src = {
            { 0x01000000 },
            { 0x01000000 },
            { 0x01000000 },
        },
        .dst_pitches = { TEST_USE_DEFAULT_PITCH },
        .expected = {
            { 0x00000001 },
            { 0x00000001 },
            { 0x00000001 },
        },
    },
    /* ... */
}
```

```
$ ./tools/testing/kunit/kunit.py run --kunitconfig=drivers/gpu/drm/tests/ 'drm_format_helper_test.drm_test_fb_memcpy'
[18:40:53] Configuring KUnit Kernel ...
[18:40:53] Building KUnit Kernel ...
Populating config with:
$ make ARCH=um O=.kunit olddefconfig
Building with:
$ make ARCH=um O=.kunit --jobs=8
[18:40:59] Starting KUnit Kernel (1/1)...
[18:40:59] =====
[18:40:59] ===== drm_format_helper_test (1 subtest) =====
[18:40:59] ===== drm_test_fb_memcpy =====
[18:40:59] [PASSED] single_pixel_source_buffer: XR24 little-endian (0x34325258)
[18:40:59] [PASSED] single_pixel_source_buffer: XRA8 little-endian (0x38415258)
[18:40:59] [PASSED] single_pixel_source_buffer: YU24 little-endian (0x34325559)
[18:40:59] [PASSED] single_pixel_clip_rectangle: XB24 little-endian (0x34324258)
[18:40:59] [PASSED] single_pixel_clip_rectangle: XRA8 little-endian (0x38415258)
[18:40:59] [PASSED] single_pixel_clip_rectangle: YU24 little-endian (0x34325559)
[18:40:59] [PASSED] well_known_colors: XB24 little-endian (0x34324258)
[18:40:59] [PASSED] well_known_colors: XRA8 little-endian (0x38415258)
[18:40:59] [PASSED] well_known_colors: YU24 little-endian (0x34325559)
[18:40:59] [PASSED] destination_pitch: XB24 little-endian (0x34324258)
[18:40:59] [PASSED] destination_pitch: XRA8 little-endian (0x38415258)
[18:40:59] [PASSED] destination_pitch: YU24 little-endian (0x34325559)
[18:40:59] ===== [PASSED] drm_test_fb_memcpy =====
[18:40:59] ===== [PASSED] drm_format_helper_test =====
[18:40:59] =====
[18:40:59] Testing complete. Ran 12 tests: passed: 12
[18:40:59] Elapsed time: 5.872s total, 0.002s configuring, 5.754s building, 0.096s running
```

Questions?