Automated capability analysis in Wordpress plugins

Using static and dynamic analysis

SNE RP2

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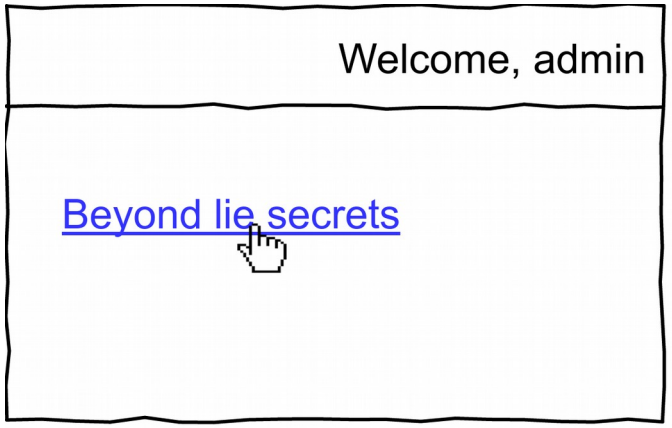
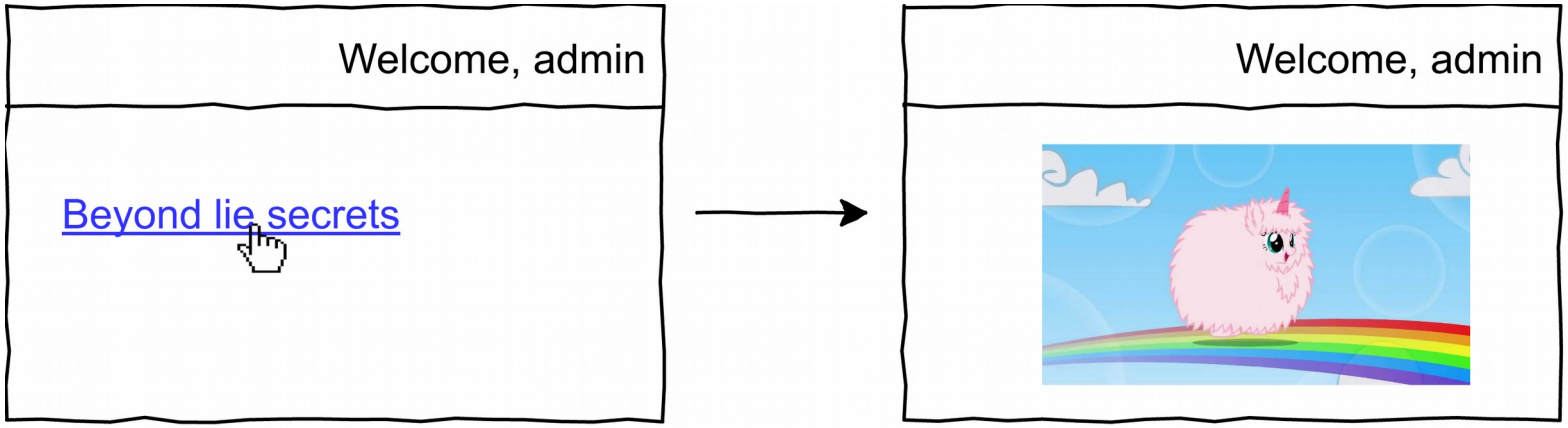
Initial project goal

- Find a new and interesting type of security analysis for web applications
- Static code analysis
- WordPress
- Plugins
- A7 Missing Function Level Access Control


Welcome, admin
Beyond lie secrets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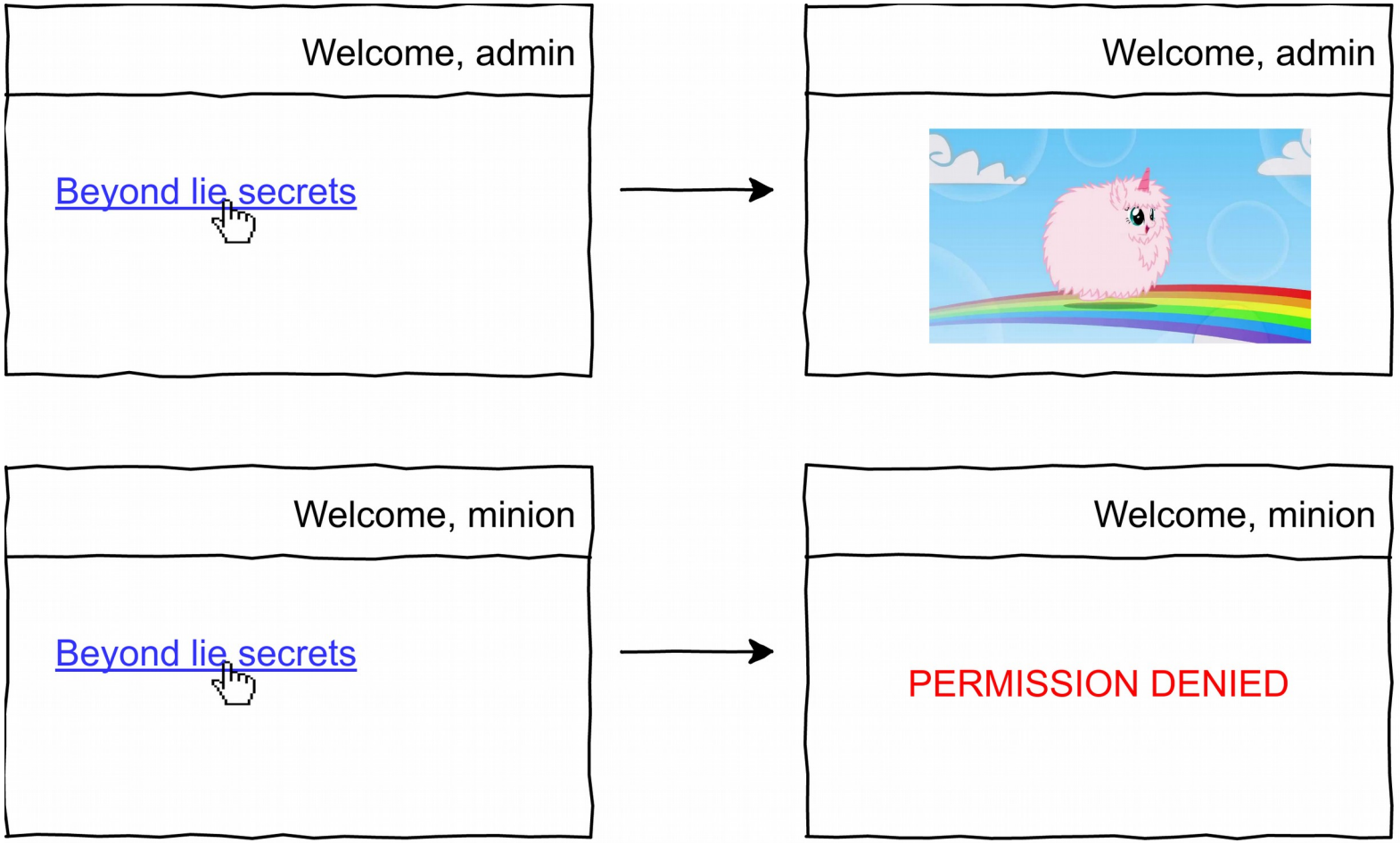
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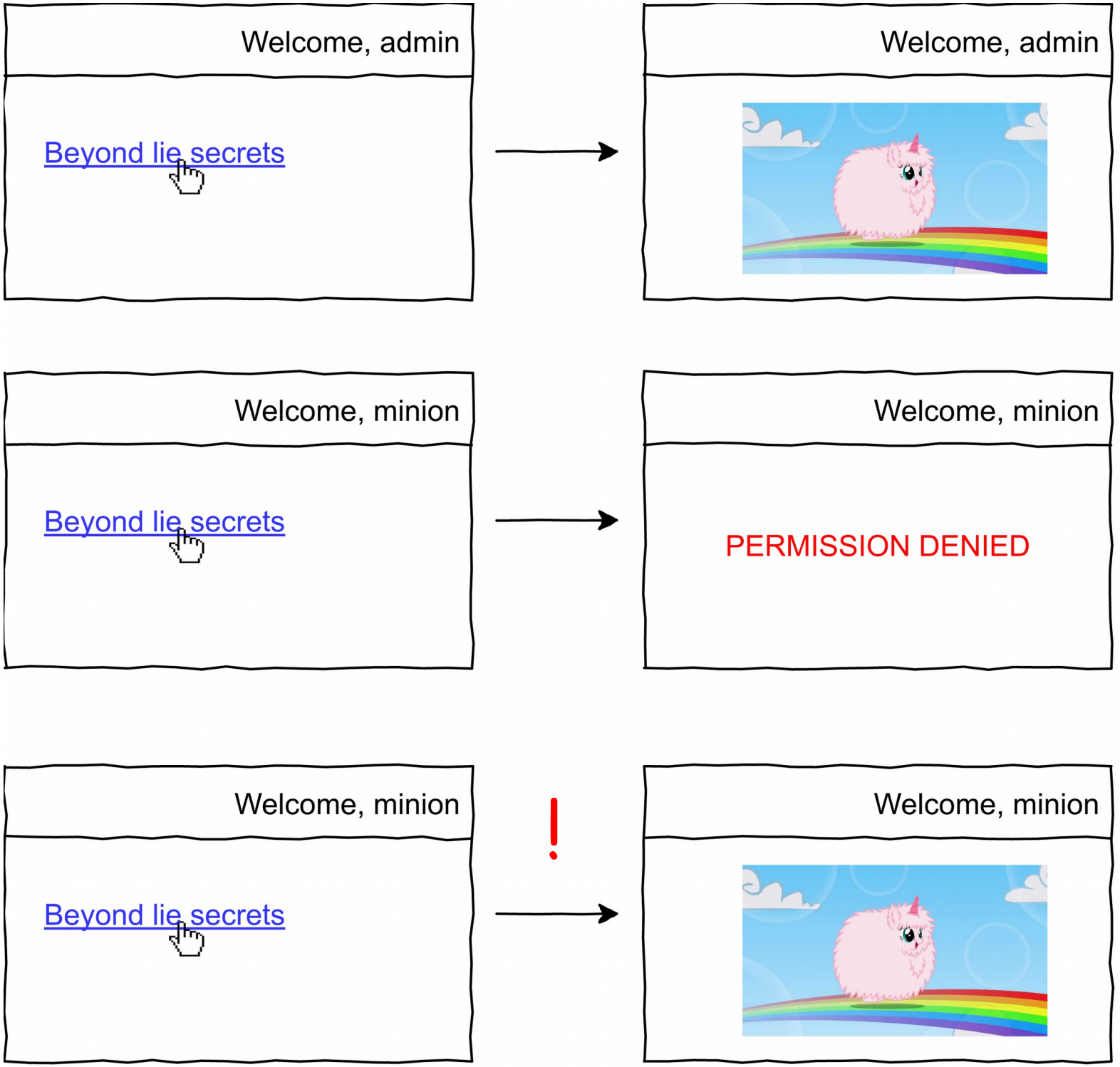
PERMISSION DENIED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!
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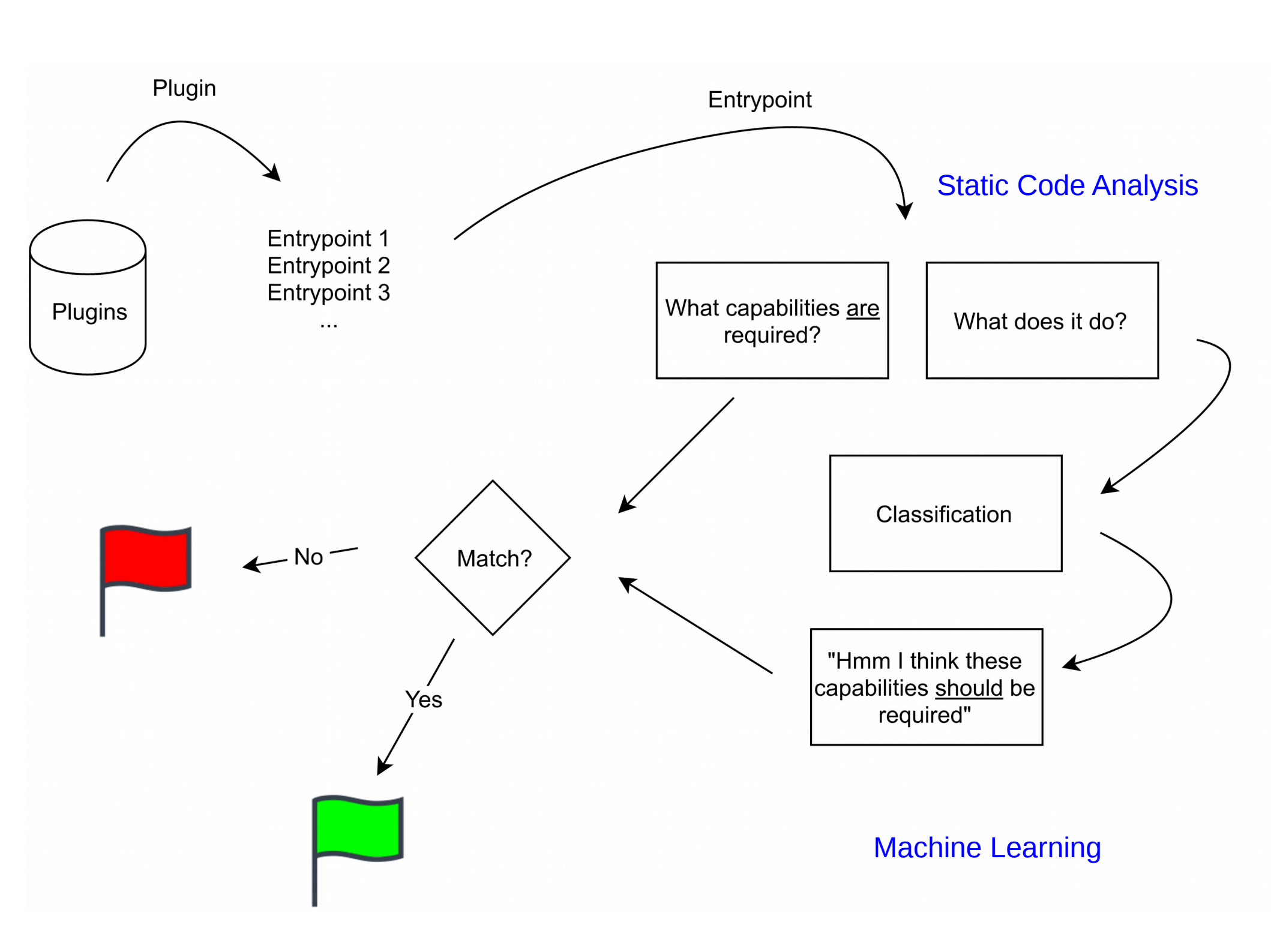
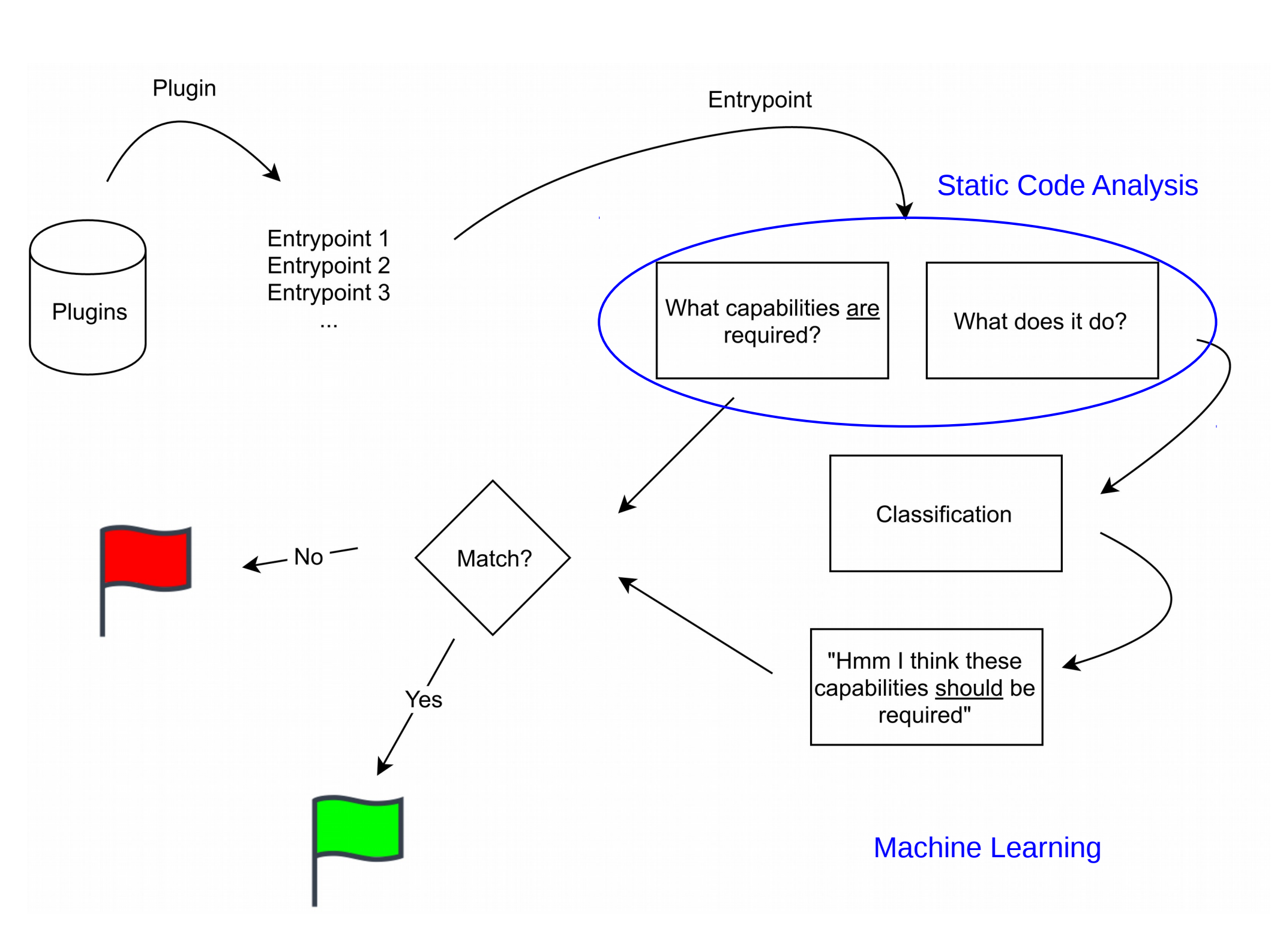

Plugin
Entrypoint
Static Code Analysis
Plugins
Entrypoint 1
Entrypoint 2
Entrypoint 3
...
What capabilities are required?
What does it do?
Classification
Match?
No
Yes
"Hmm I think these capabilities should be required"
Machine Learning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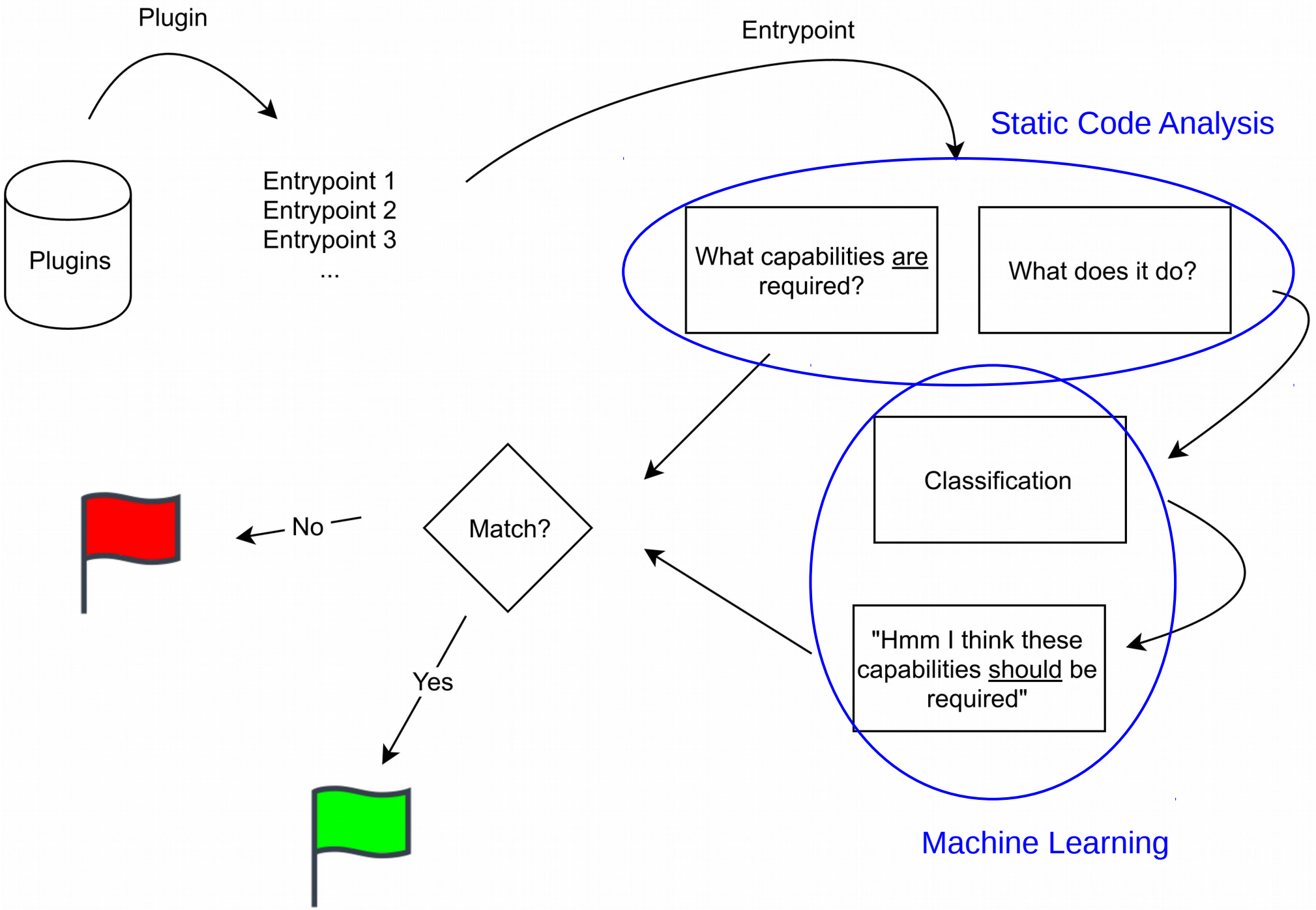
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Static Code Analysis part

Turns out

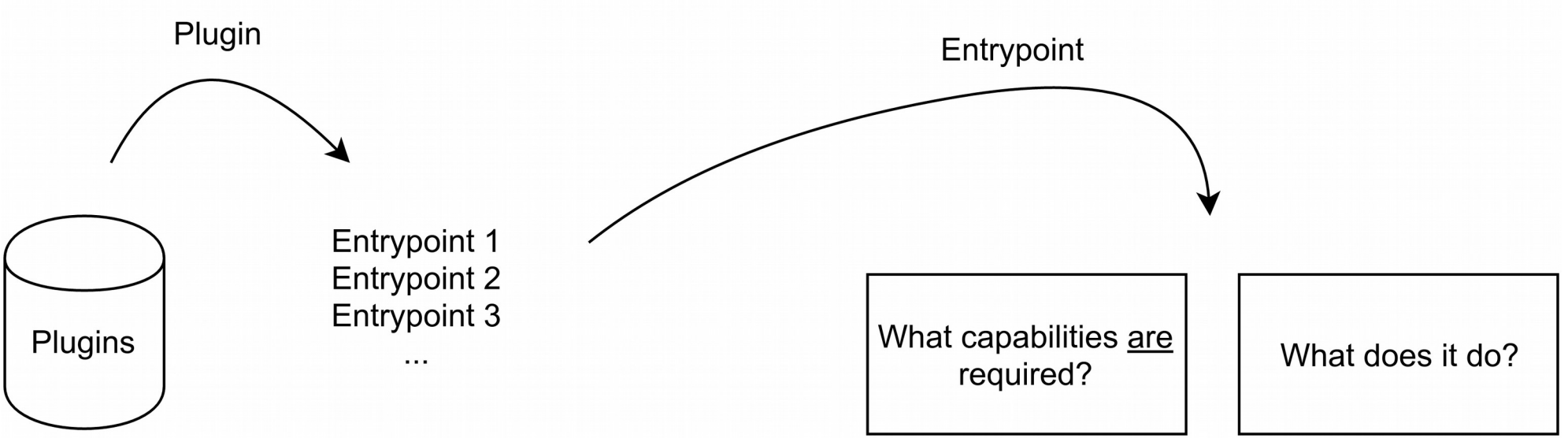
What capabilities are required?	What does it do?

Not so easy

No parsing & analysis tools available

Updated goal

- Static analyis
- Static & Dynamic analysis



Future work here

WordPress

- Capability checking
  - Functions *current_user_can*, *user_can*

```
if (!current_user_can('manage_options')) {
    wp_die(__("you don't have the clearance"));
}
```

- User roles
  - *Administrator*, *editor*, *author*, etc.
- URL handlers: events and callbacks
  - Functions *add_action*, *add_filter*

```
( string $tag, callable $function_to_add, ....)
```

Static analysis summary

- Simple, conformative code quite doable
- Lots of variation means stronger tools required
- Modeling and analysis tools a must to do this research
- *No such tools freely available*

Static analysis example

- Extract required capabilities

```
if (!current_user_can('manage_options')) {
    wp_die(__("you don't have the clearance"));
}
```

- Done!
  - Req capability == 'manage_options'
- Easy

Not always straightforward

```
if ( is_wp_error( $error = $this->validate_call( $blog_id, $this->needed_capabilities ) ) ) {
	return $error;
}
```

```
$must_pass = ( isset( $capability['must_pass'] ) && is_int( $capability['must_pass'] ) ?
$capability['must_pass'] : count( $capabilities ) );

$failed = array(); // store the failed capabilities
$passed = 0; //

foreach ( $capabilities as $cap ) {
	if ( current_user_can( $cap ) ) {
		$passed ++;
	} else {
		$failed[] = $cap;
	}
}
```

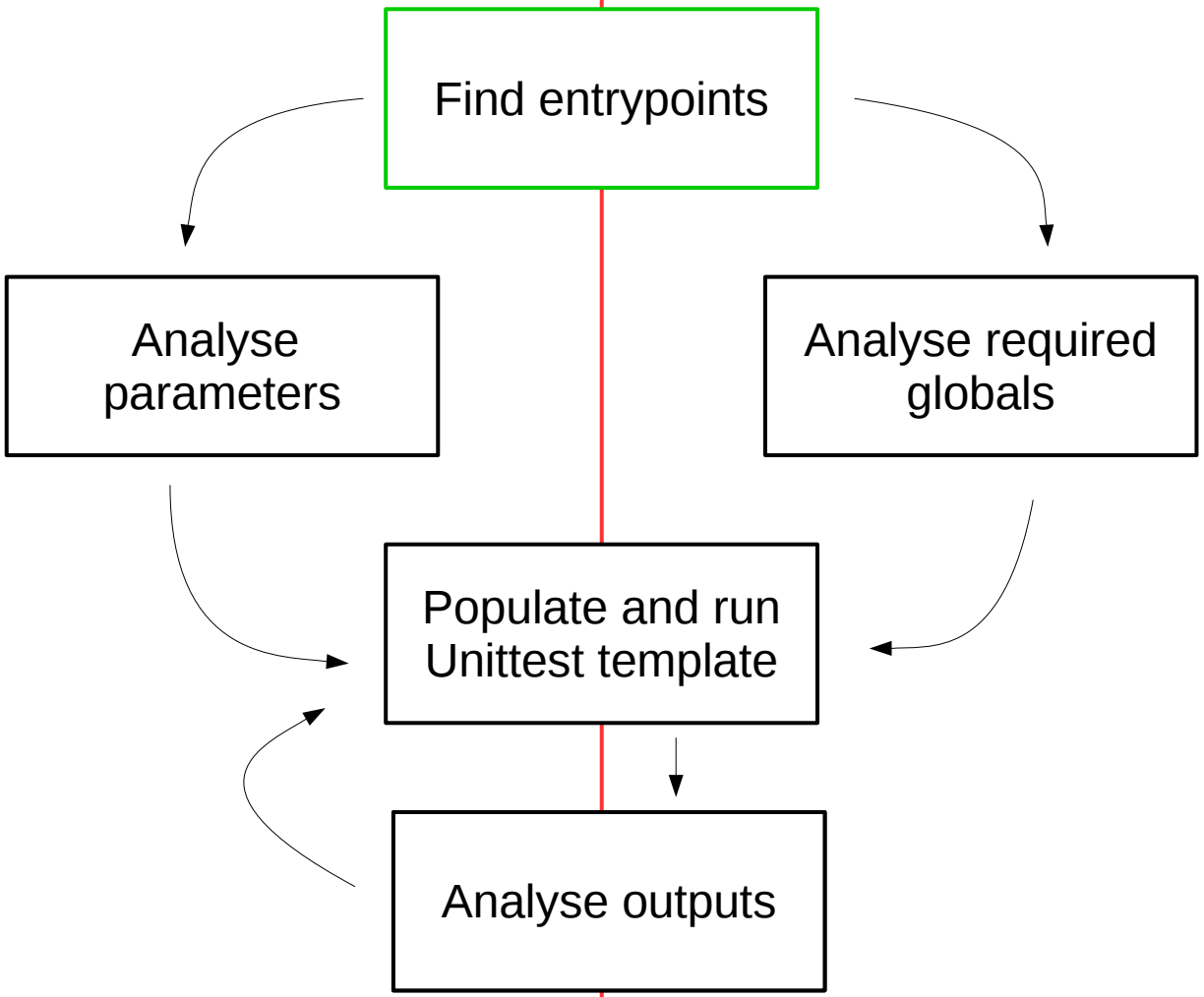
Static ... += dynamic

- No fancy tools
- Given current options, static = no go
- No time to create all tools necessary
- How far do we get without those “tools”, then?
- But... PHP interpreter?

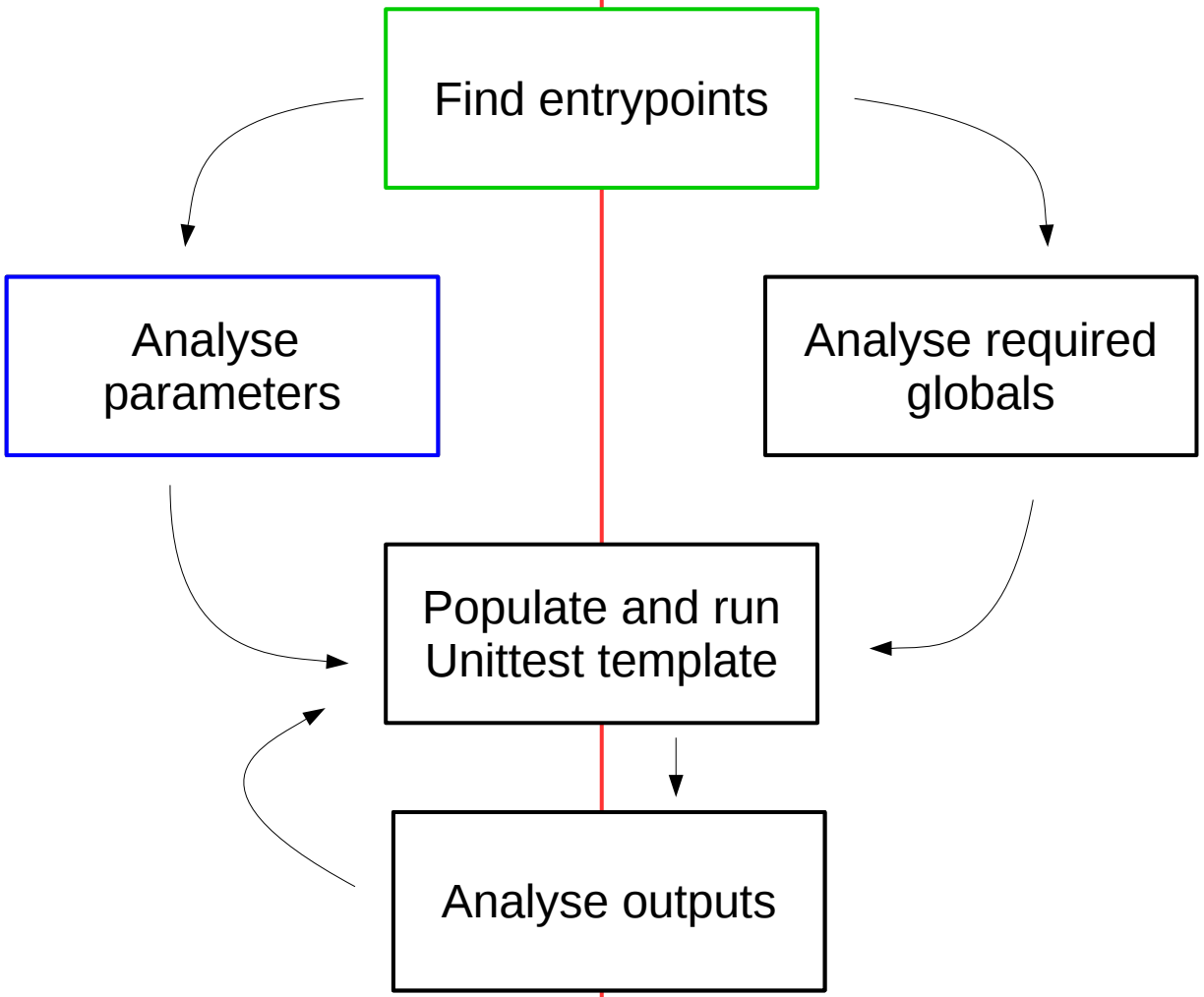
Static & dynamic, principles

- Gather as much data as possible statically
- Run URL handlers:
  - Directly: my_url_handler($arg1, $arg2, $arg3);
  - Not through webserver as is normally the case
  - Use gathered data to make a nice baby room
- Record as much data from run
  - Use data to repeat and finetune environment
  - Use data to analyse code paths & capabilities

Static & Dynamic approach



Static & Dynamic approach



Analyse parameters

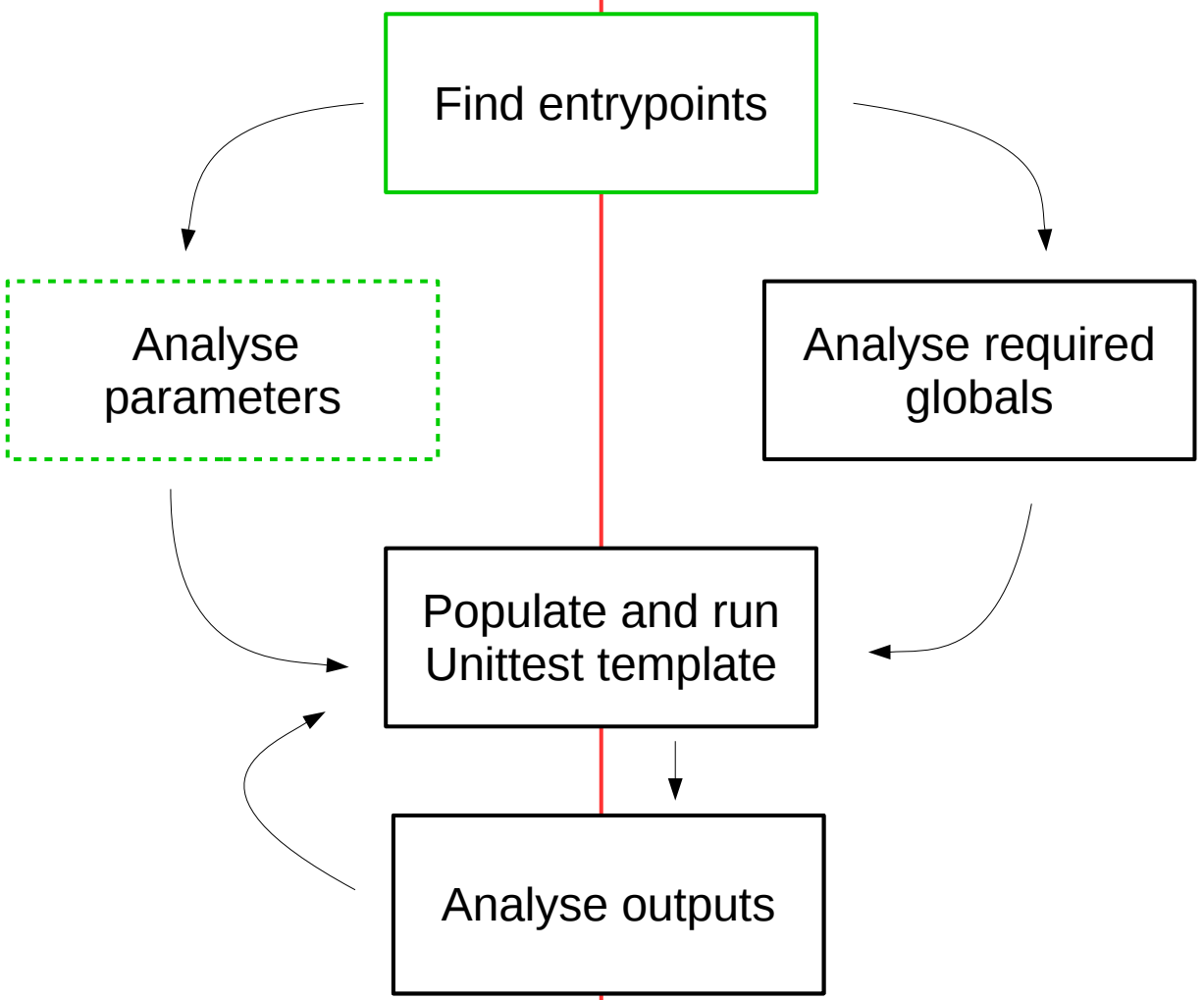
- Known hooks
- Custom hooks
- Trace parameters to known functions

```php
public function a_func($post_id) {}
```

- `add_ping ( int $post_id, string $uri )`
- `add_post_meta ( int $post_id, string $meta_key, mixed $meta_value, bool $unique = false )`
- `check_and_publish_future_post ( int|WP_Post $post_id )`

- Constraint analysis

Static & Dynamic approach



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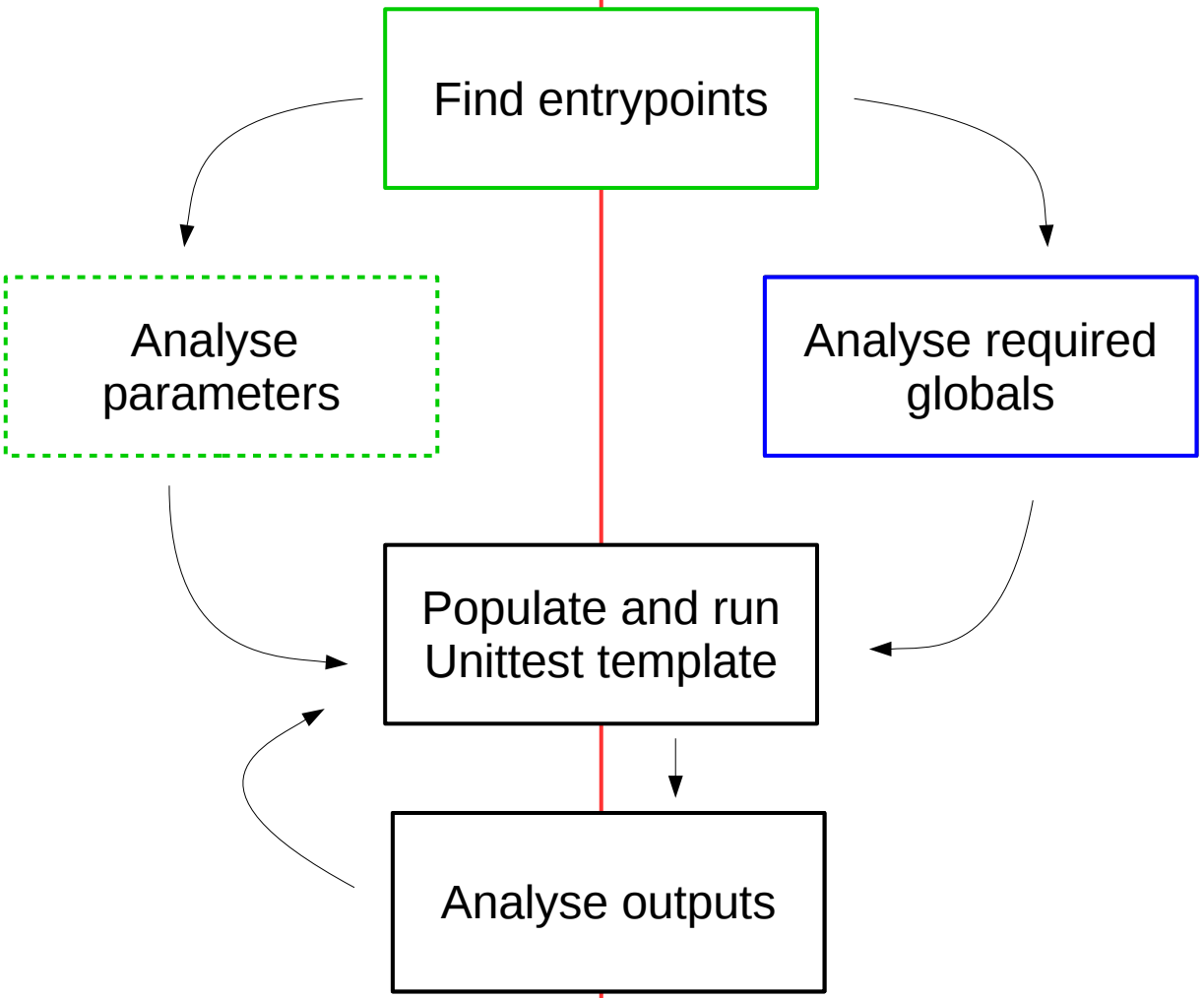

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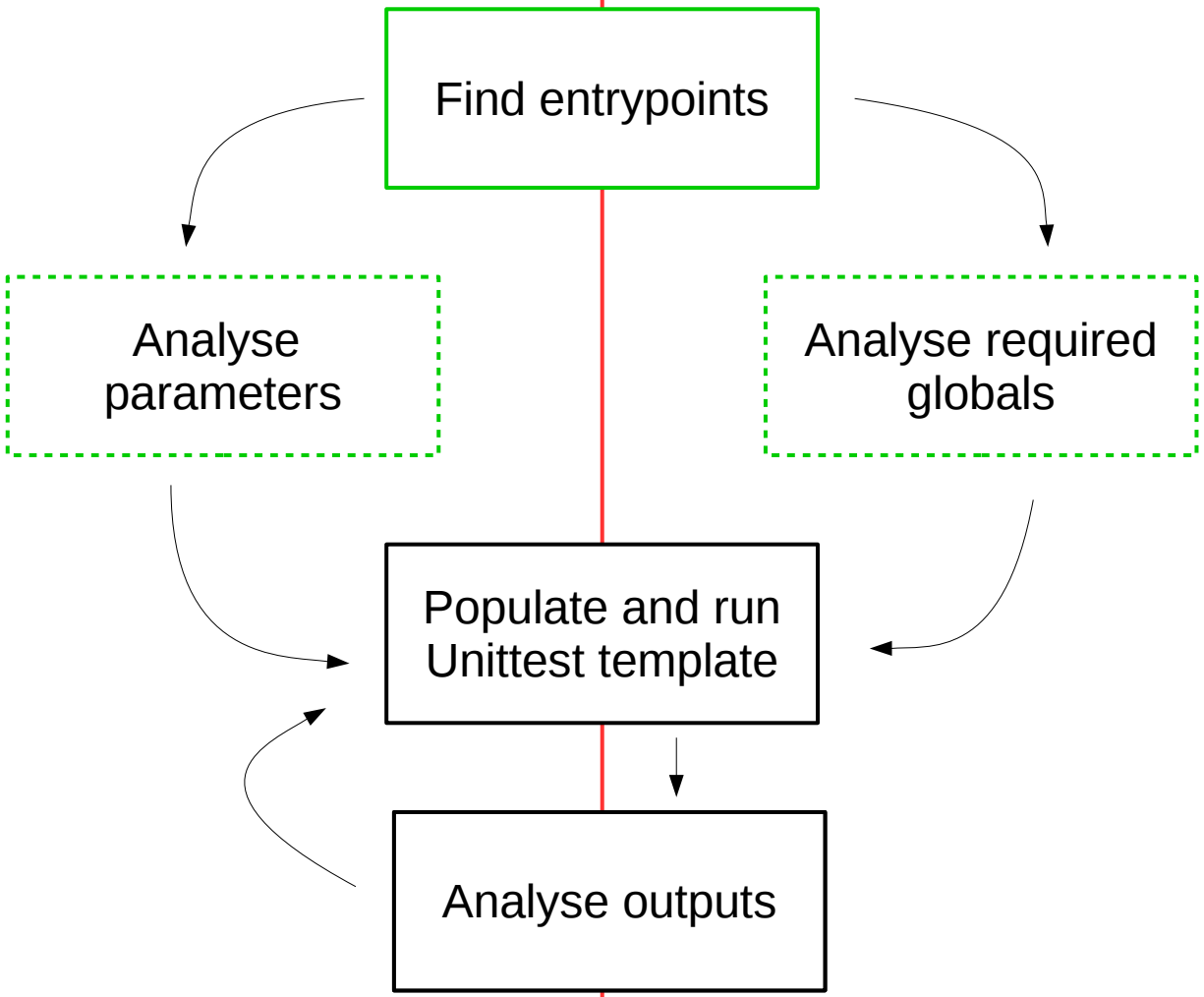

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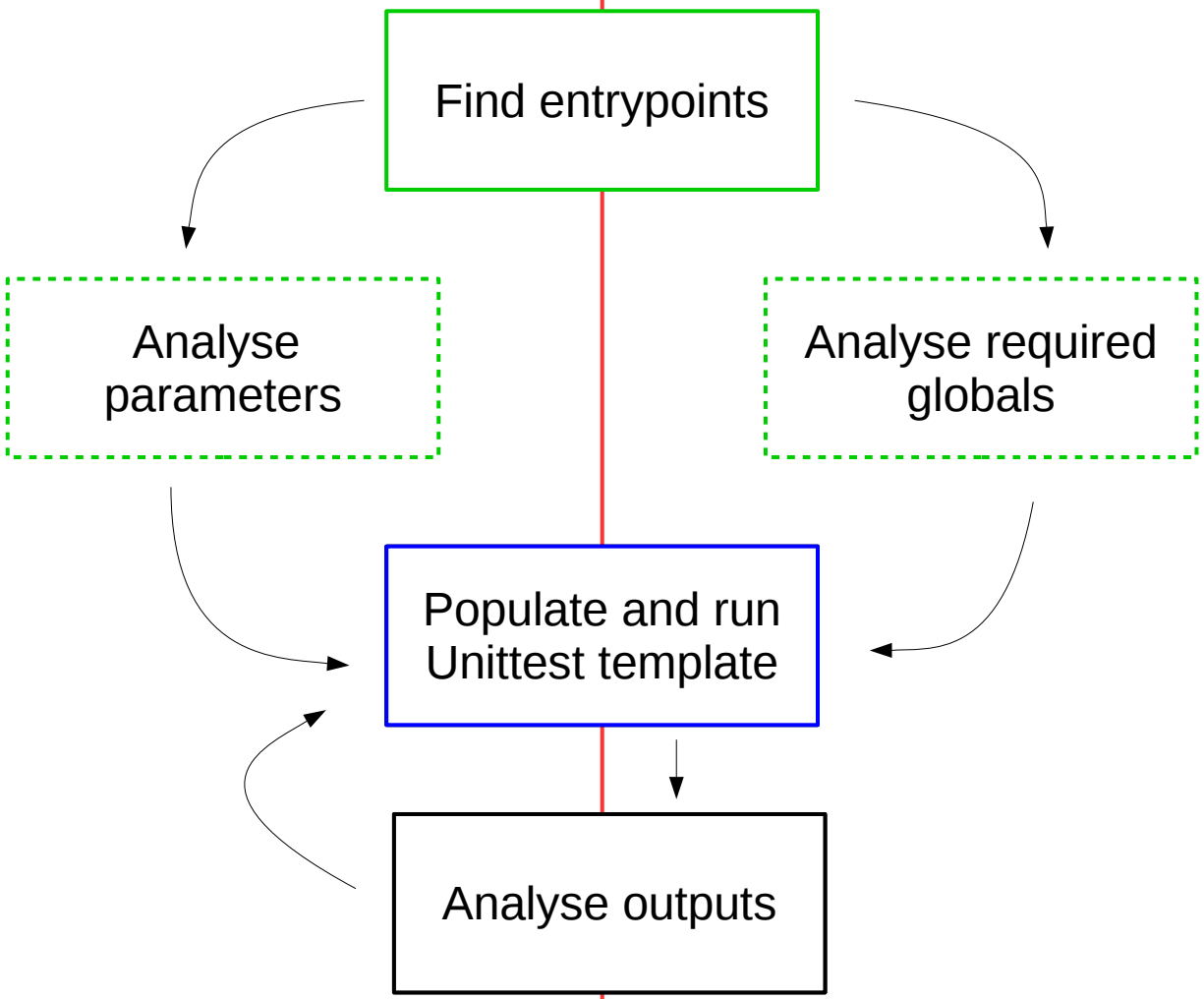
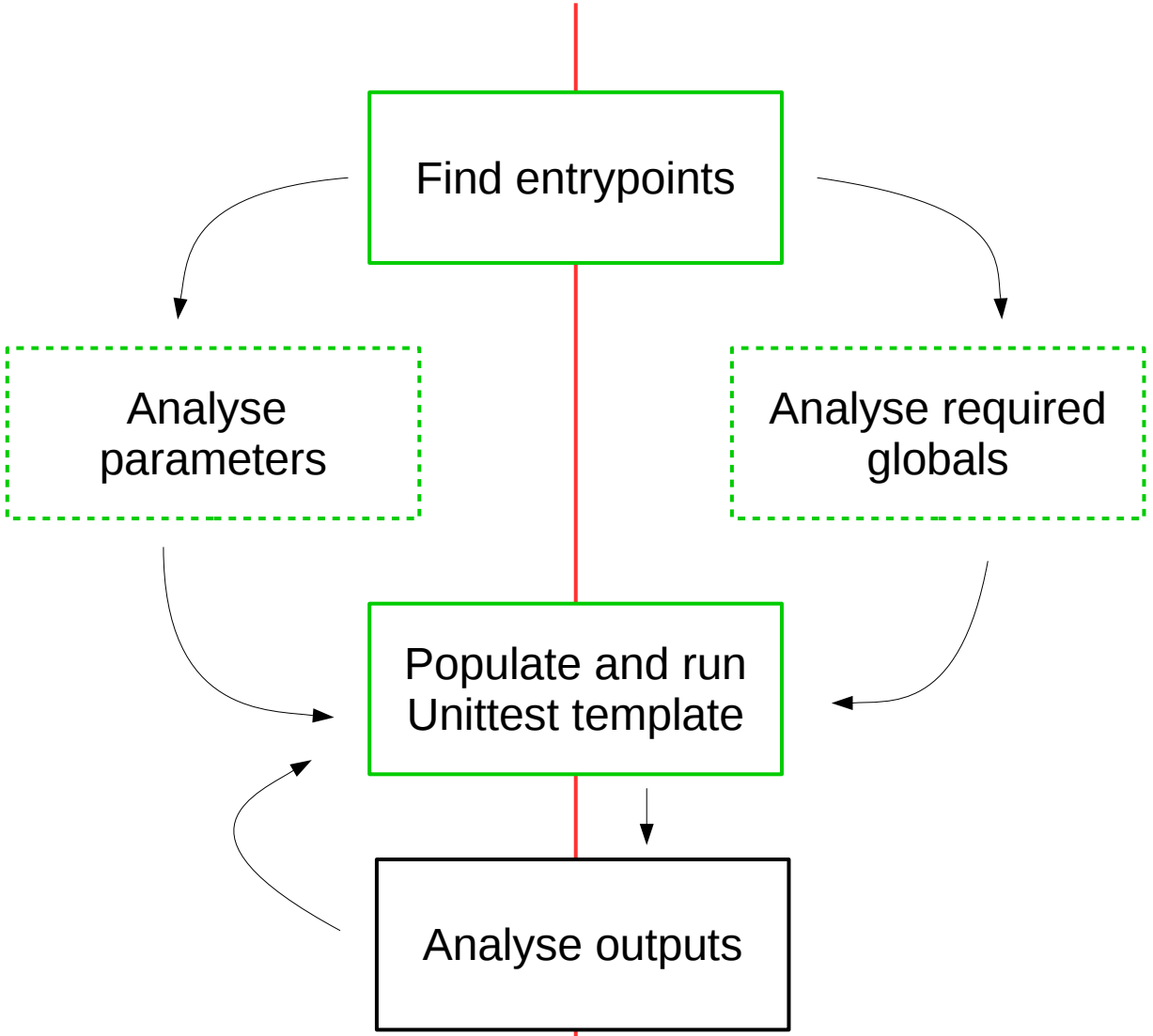


Unittest template

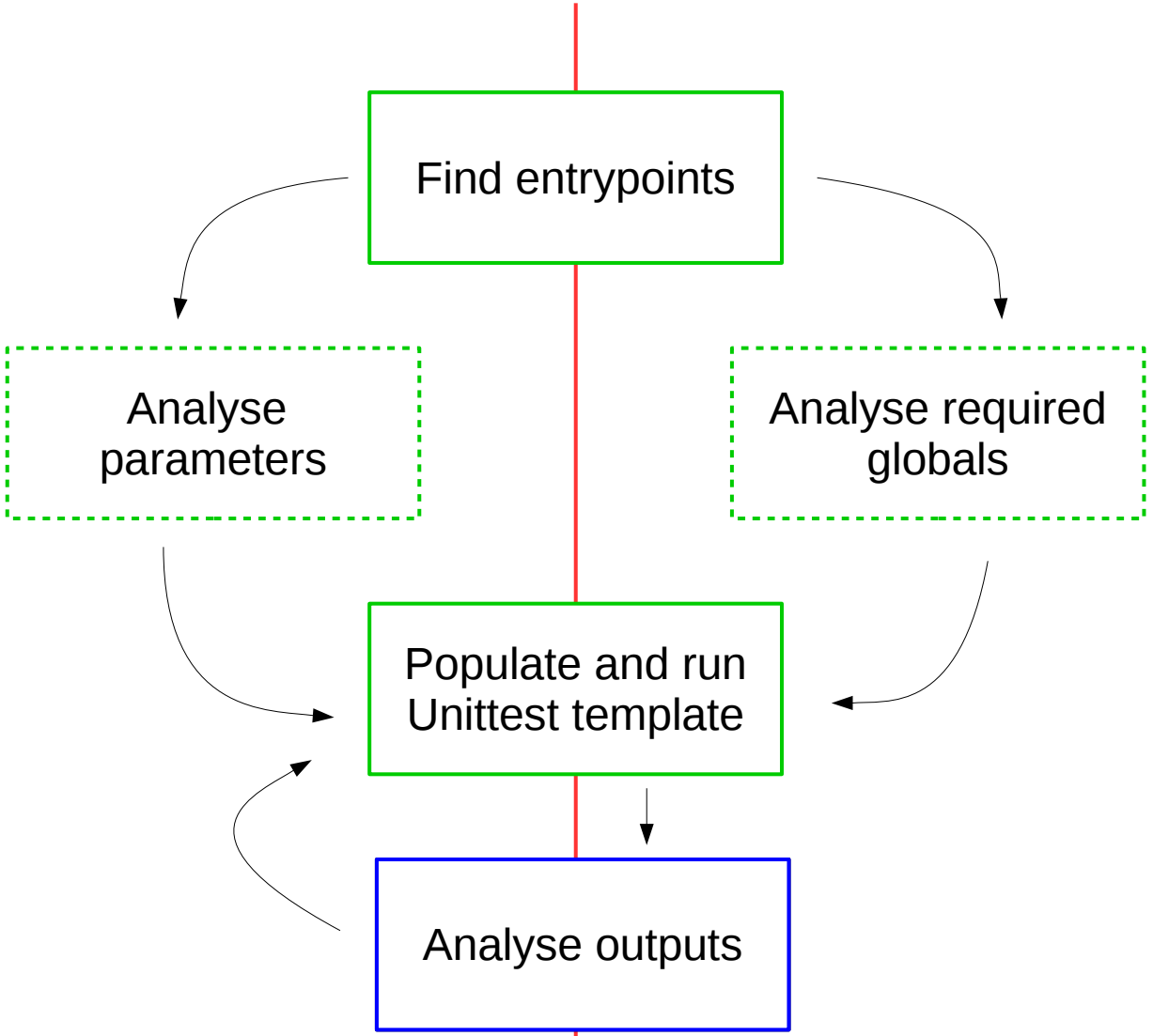
- Run callback:
  - WordPress has support for PHPunit
  - So, unittests
- WP_UnitTestCase
  - Sets up environment
  - Creates temporary tables
  - Offers nice functionality
- Xdebug for call traces and code coverage

```php
class TemplateTest extends WP_Ajax_UnitTestCase {
    private $roles = array();
    public function setUp() {
        parent::setUp();
        $this->role_names = array('subscriber', 'contributor',
            'author', 'editor', 'administrator');
    }

    public function test_do_handling()    {
        foreach ($this->role_names as $role_name) {
            // 1 {Setup per role}
            $this->_setRole($role_name);

            $filename = __DIR__ . "/traces/trace-{$role_name}";

            xdebug_start_code_coverage(XDEBUG_CC_UNUSED);
            xdebug_start_trace($filename);

            // 2 {Call to URL handler}

            xdebug_stop_trace();
            $coverage = xdebug_get_code_coverage();
            xdebug_stop_code_coverage();
            file_put_contents($filename . '.cov',
                    coverage_to_json($coverage));
            // 3 {Teardown for per-role setup}
        }
    }
}
```

Static & Dynamic approach



Static & Dynamic approach



Output 1: Traces

- Headers

Record type	1	6	10	11	12 - ...
Entry	level	function name	line number	no. of parameters	parameters
Exit	level	empty			
Return	level	return value	empty		

- Example output

0	19	wpdb->_real_escape	1209	1	$string = 'setting_b'
0	20	mysqli_real_escape_string	1127	2	class mysqli { ... }, 'setting_b'
1	20				
R	20	'setting_b'			
1	19				
R	19	'setting_b'			

```php
function plugin_settings_page() {
    if (!current_user_can('manage_options')) {
        wp_die(__("you don't have the clearance"));
    }
    include(sprintf("%s/settings.php", dirname(__FILE__)));
}
```

```
13 - E: MyPlugin->plugin_settings_page ([])
    14 - E: current_user_can (["$capability = 'manage_options'"])
    14 - R: FALSE
    14 - E: __ (["$text = 'you don\\'t have the clearance'", '$domain
           = ???'])
        15 - E: translate (["$text = 'you don\\'t have the clearance'",
               "$domain = 'default'"])
            16 - E: apply_filters (["$tag = 'gettext'", "$value = 'you
                  don\\'t have the clearance'", "'you don\\'t have the
                  clearance'", "'default'"])
            16 - R: 'you don\'t have the clearance'
        15 - R: 'you don\'t have the clearance'
    14 - R: 'you don\'t have the clearance'
    14 - E: wp_die (["$message = 'you don\\'t have the clearance'", '$title
= ???', '$args = ???'])
```

Output 2: Code coverage

```
18      public function __construct() {
19          // register actions
20          add_action('admin_init', array(&$this, 'admin_init'));
21          add_action('admin_menu', array(&$this, 'add_menu'));
22      }
```

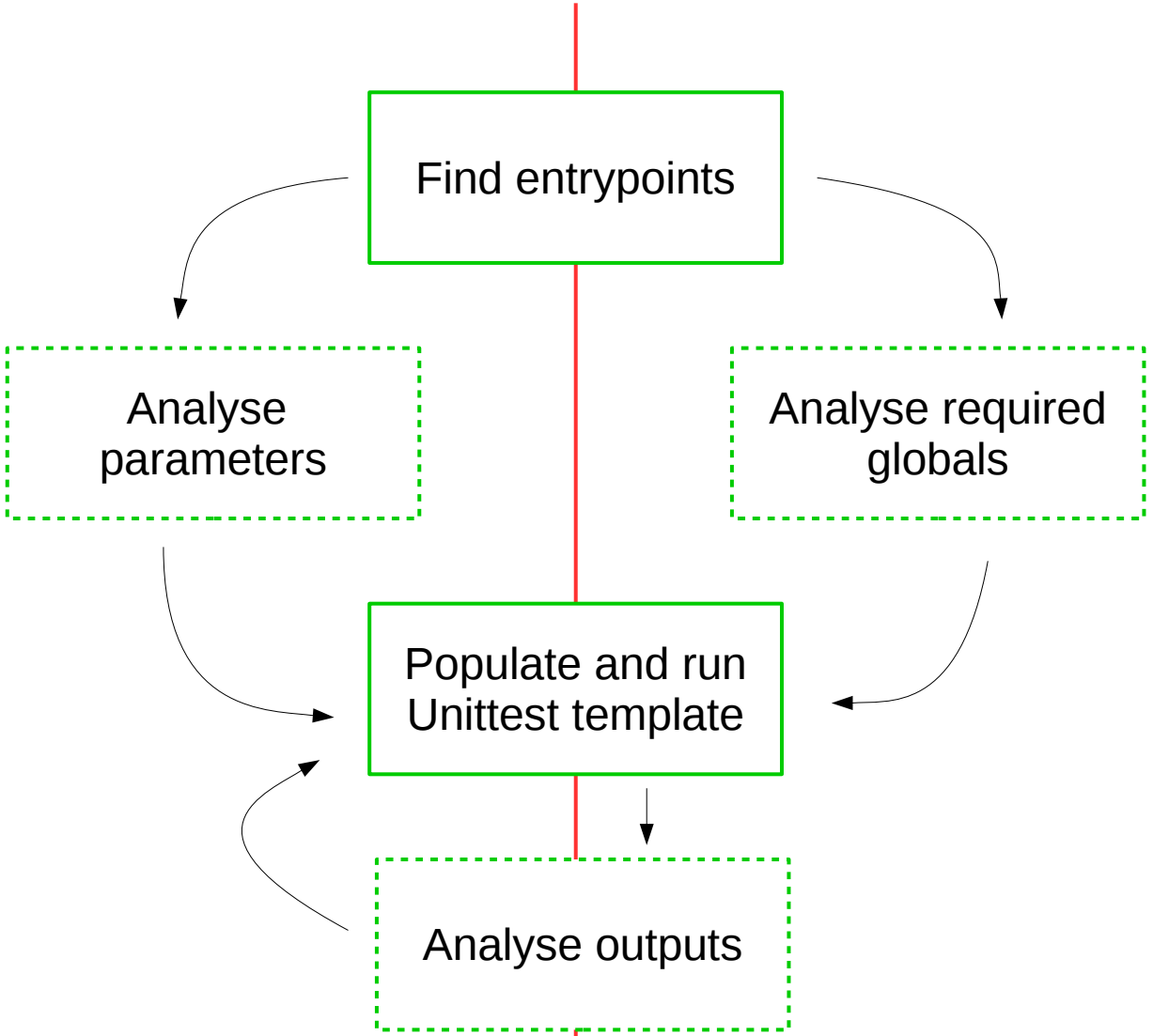
```
52      function plugin_settings_page() {
53          if (!current_user_can('manage_options')) {
54              wp_die(__("you don't have the clearance"));
55          }
56
57          include(sprintf("%s/templates/settings.php", dirname(__FILE__)));
58      }
```

Subscriber coverage	admin coverage	Admin noncoverage
20	20	54
21	21	
22	22	
53	53	
54	57	
	58	

Did the run/test succeed?

- Meaning:
  - Did we predict the correct arguments and globals?
- Metrics:
  - Full Code coverage?
  - Joined set should hit all return paths?
- If deemed not:
  - Rerun with different parameters/globals
  - Test's output may help here

Static & Dynamic approach



Conclusions

- Lack of good parsing & analysis tools inhibits research.
  - Exploring code, extracting features difficult
  - Testing hypotheses not possible on large scale

- If they *were* available:
  - Static & dynamic analysis may be quite fruitful here

Future work

- Design & build a good working modeling tool
  - Modular and extendible
  - Allows for queries to be done
    - What (symbolic) value does this variable have here?
    - What should x be to evaluate this to true? (constraint solving)
    - What is this variable used for?
  - Needs to build a very good representation of the code
- Next steps are Modeling & Predictions
  - WordPress knowledge needed for classification