Introduction into PHP Extensions

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https://derickrethans.nl/talks/phpext-confoo24

About Me

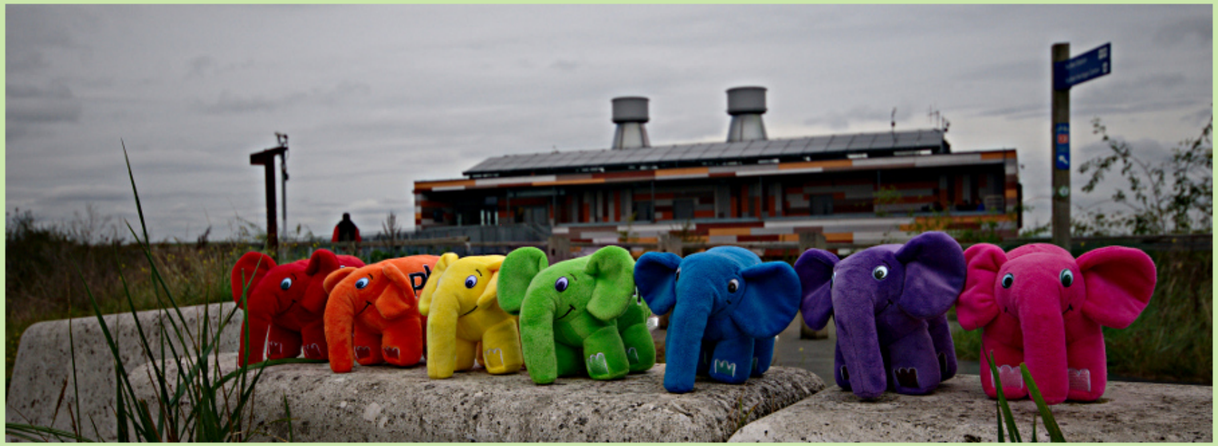
Derick Rethans

- I'm European, living in London
- ~~PHP 7.4 **Release Manager**~~
- **PHP Foundation**
- **Xdebug** & PHP's Date/Time support
- I ♥🌍 maps, I ♥🍺 beer, I ♥🥃 whisky
- mastodon: @derickr@phpc.social

Agenda

Questions

- What are extensions?
- Why would you write an extension?
- How do you write an extension?



What are extensions?

- Additional functions and classes
- Written in C
- Either compiled in, or a shared object
- Bundled with PHP, distributed through PECL, or distributed separately

Why write an extension?

- Wrap existing library
- Not everything can be done in userland
- Speed

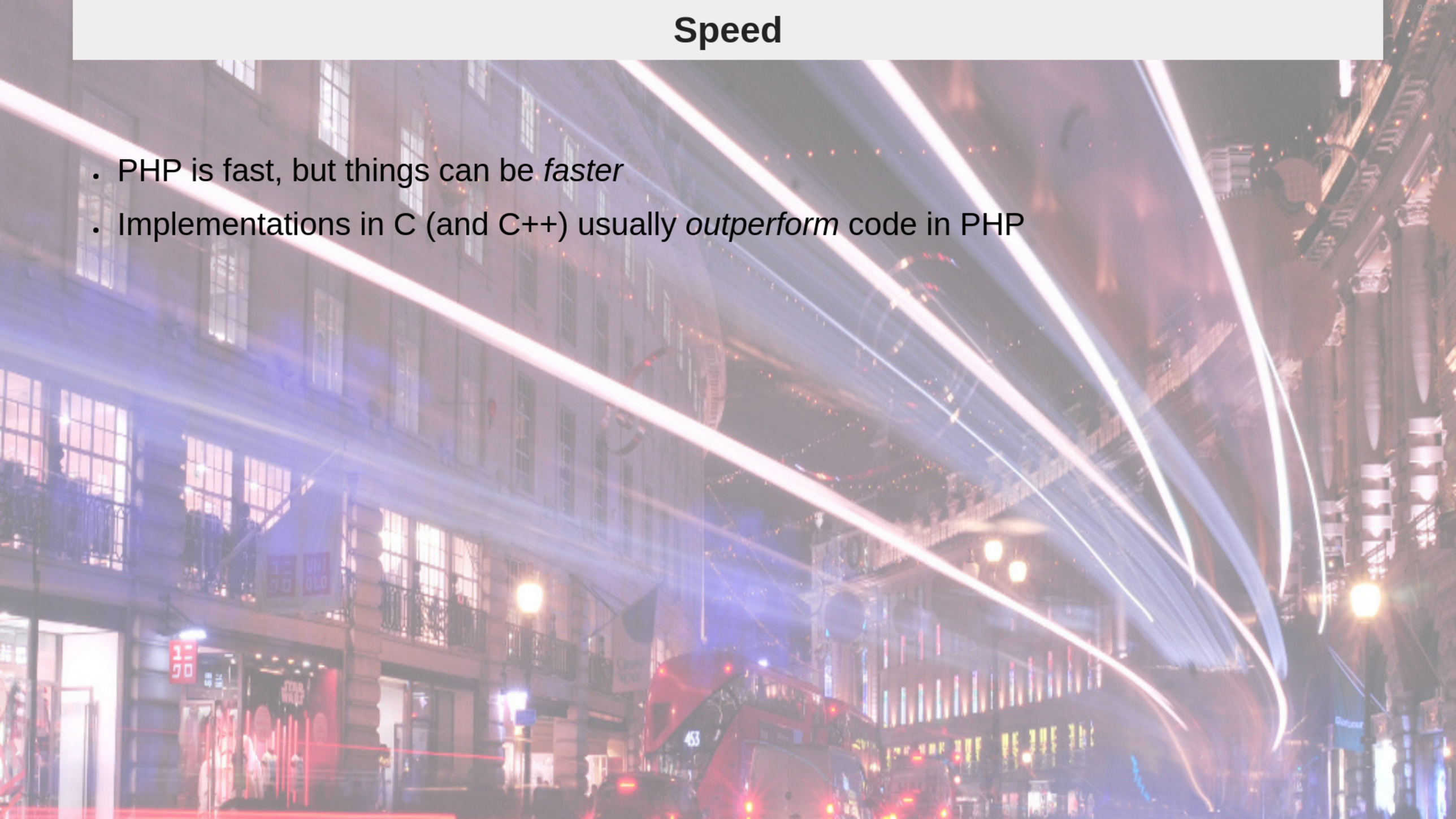
Wrapping Libraries

- Database drivers: **libmongoc**, **libmysql**, …
- Image processing: **GD**, **Cairo**, **ImageMagick**, …
- Image recognition: **OpenCV**, **Dlib**, …

Unpossible in userland

- Information or resources shared between requests: **persistent connections**, **PHP objects**
- Peeking into internals: **vld**, **Xdebug**, **opcache**

Speed



- PHP is fast, but things can be *faster*
- Implementations in C (and C++) usually *outperform* code in PHP

Why not implement something in an extension?

- It takes a lot more time to write
- It takes a lot more time to debug
- It takes a lot more time to maintain


Zeeland
Eindhoven
Venlo
Brugge
Antwerpen
Limburg
Gent
Vlaanderen
Bruxelles - Brussel
Leuven
Heerlen
Aachen
België - Belgique
Lille
Liège
Mons
Charleroi
Namur
Wallonie
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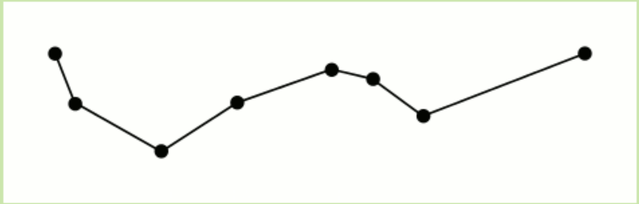
Oh, Belgium!

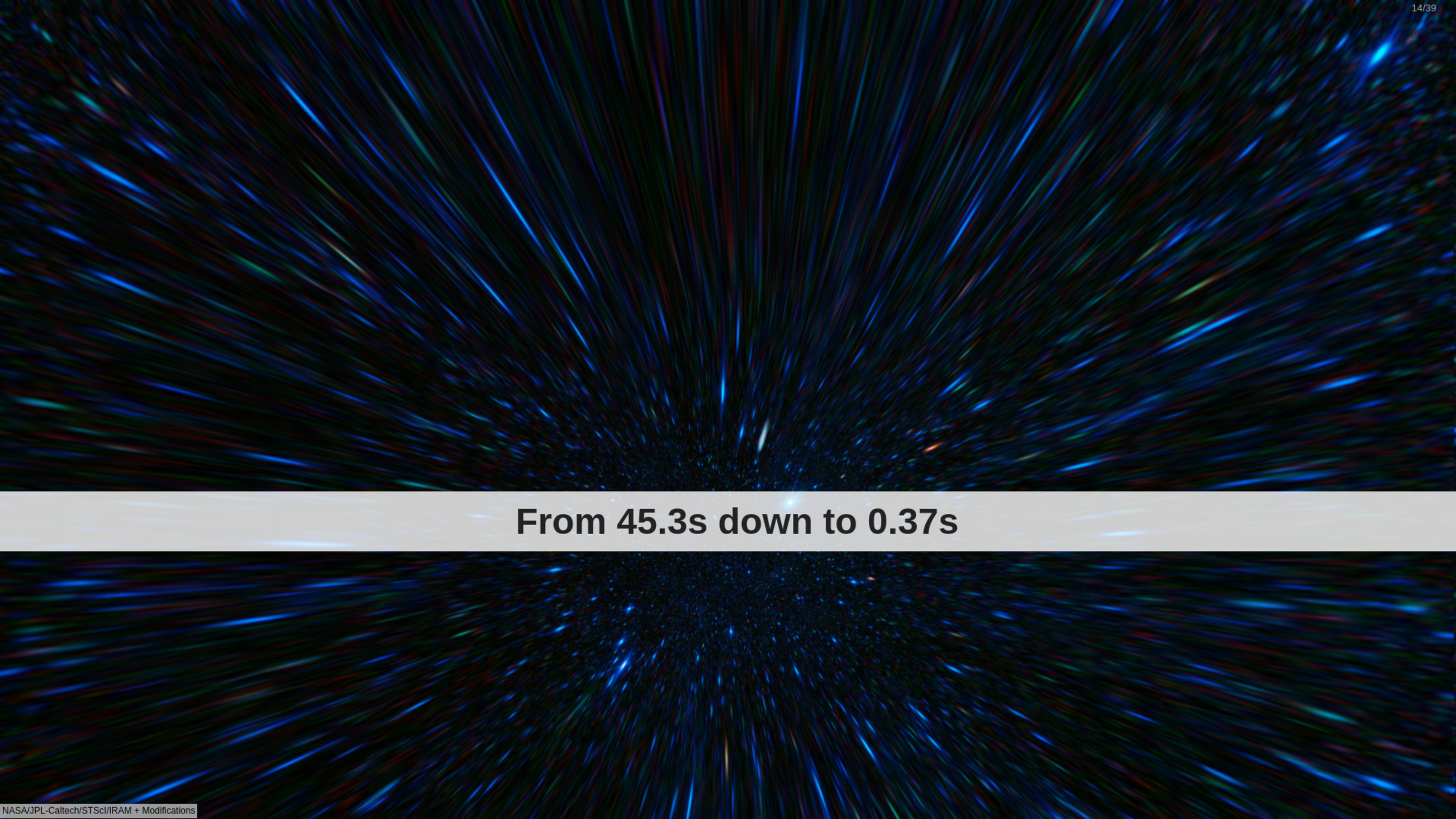
Polygon Simplification


```
[
    "geometry": {
        "type": "Polygon",
        "coordinates": [
            [
                [ 3.0275144577026, 50.770740509033 ],
                [ 3.0138611793518, 50.770278930664 ],
                [ 2.9991388320923, 50.763305664062 ],
                [ 2.9890556335449, 50.761665344238 ],
                [ 2.9853610992432, 50.756999969482 ],
                [ 2.9746110439301, 50.751445770264 ],
                [ 2.9703054428101, 50.751277923584 ],
                [ 2.9549167156219, 50.750751495361 ],
                [ 2.9511666297913, 50.750610351562 ],
                [ 2.9386110305786, 50.742416381836 ],
                [ 2.9403610229492, 50.73405456543 ],
                [ 2.936666727066, 50.729389190674 ],
                [ 2.9306666851044, 50.72785949707 ],
                [ 2.9279444217682, 50.723888397217 ],
                [ 2.9258055686951, 50.712223052979 ],
                [ 2.9244999885559, 50.704971313477 ],
                [ 2.9100832939148, 50.702026367188 ],
                [ 2.9036111831665, 50.700389862061 ],
                [ 2.9013612270355, 50.699806213379 ],
                [ 2.8941388130188, 50.701332092285 ],
```

Ramer–Douglas–Peucker algorithm

- Recursive algorithm for line/polygon simplification
- Computationally intensive
- 100 runs with episilon of 0.01:
  - PHP function: **45.3s**
  - C implementation in extension: **0.37s**





From 45.3s down to 0.37s

What makes up an Extension?

- `config.m4` / `config.w32`
  configure options and build instructions
- `php_extension.h`
  header files and glue
- `extension.c`
  extension definition and function implementation
- `algorithms.c`
  C implementation of algorithms
- `tests/*.phpt`
  Tests written in PHP

Build Instructions

config.m4

Comments:

```
dnl config.m4 for extension geospatial
```

Configure option definition:

```
PHP_ARG_ENABLE(geospatial, whether to enable geospatial support,
[  --enable-geospatial           Enable geospatial support])
```

Build instructions:

```
if test "$PHP_GEOSPATIAL" != "no"; then
  PHP_NEW_EXTENSION(geospatial, geospatial.c geo_array.c, $ext_shared)
fi
```

Build Instructions

config.w32

Comments:

```
// vim:ft=javascript
```

Configure option definition:

```
ARG_ENABLE("geospatial", "enable geospatial support", "no");
```

Build instructions:

```
if (PHP_GEOSPATIAL != "no") {
    EXTENSION("geospatial", "geospatial.c geo_array.c");
}
```

Building the Extension

- `phpize`
  Brings in headers and creates `configure` script
- `./configure`
  Runs system checks, and creates `Makefile`
- `make`
  Builds the extension

Header File

Guard:

```
#ifndef PHP_GEOSPATIAL_H
#define PHP_GEOSPATIAL_H
```

```
#define PHP_GEOSPATIAL_VERSION "0.1.1-dev"
```

Module definition:

```
extern zend_module_entry geospatial_module_entry;
#define phpext_geospatial_ptr &geospatial_module_entry
```

Module initialiser declarations:

```
PHP_MINIT_FUNCTION(geospatial);
PHP_MINFO_FUNCTION(geospatial);
```

Forward declarations:

```
PHP_FUNCTION(rdp_simplify);

#endif /* PHP_GEOSPATIAL_H */
```

Extension Set-Up

Headers and Function Definition

Header inclusions:

```
#include "php.h"
#include "php_ini.h"
#include "ext/standard/info.h"

#include "php_geospatial.h"
#include "php_geospatial_arginfo.h"

#include "Zend/zend_exceptions.h"
#include "ext/spl/spl_exceptions.h"
```

Extension Set-Up

Function Definitions

php_geospatial.stub.php

```
<?php
/** @generate-function-entries */
function rdp_simplify(array $points, float $epsilon): array {}
```

Generates php_geospatial_arginfo.h:

```
/* This is a generated file, edit the .stub.php file instead.
 * Stub hash: e128dccdbd9aa407d95c5b62e8000cb12d0bffa3 */

ZEND_BEGIN_ARG_WITH_RETURN_TYPE_INFO_EX(arginfo_rdp_simplify, 0, 2, IS_ARRAY, 0)
    ZEND_ARG_TYPE_INFO(0, points, IS_ARRAY, 0)
    ZEND_ARG_TYPE_INFO(0, epsilon, IS_DOUBLE, 0)
ZEND_END_ARG_INFO()

ZEND_FUNCTION(rdp_simplify);

static const zend_function_entry ext_functions[] = {
    ZEND_FE(rdp_simplify, arginfo_rdp_simplify)
    ZEND_FE_END
};
```

Extension Set-Up

Module Definition

Module (Extension) definition:

```
zend_module_entry geospatial_module_entry = {
#if ZEND_MODULE_API_NO >= 20010901
    STANDARD_MODULE_HEADER,
#endif
    "geospatial",
    ext_functions,
    PHP_MINIT(geospatial),
    NULL,
    NULL,
    NULL,
    PHP_MINFO(geospatial),
#if ZEND_MODULE_API_NO >= 20010901
    PHP_GEOSPATIAL_VERSION,
#endif
    STANDARD_MODULE_PROPERTIES
};
```

Handle Shared Object Loading:

```
#ifdef COMPILE_DL_GEOSPATIAL
ZEND_GET_MODULE(geospatial)
#endif
```

Extension Set-Up

Auxiliary Init and Info sections

Module INITialisation

```
PHP_MINIT_FUNCTION(geospatial)
{
    REGISTER_DOUBLE_CONSTANT("GEO_DIAMETER", GEO_DIAMETER, CONST_CS|CONST_PERSISTEI
    return SUCCESS;
}
```

Module INFO

```
PHP_MINFO_FUNCTION(geospatial)
{
    php_info_print_table_start();
    php_info_print_table_header(2, "Geospatial functions", "enabled");
    php_info_print_table_row(2, "Version", PHP_GEOSPATIAL_VERSION);
    php_info_print_table_end();
}
```

Implementing the function

- Parse Input Parameters
- Convert Data into Right Format
- Run Algorithm
- Return Result

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = 8\pi G T_{\mu\nu}$$

Parsing Input Parameters

```
PHP_FUNCTION(rdp_simplify)
{
    zval      *points_array;
    double     epsilon;

    ZEND_PARSE_PARAMETERS_START(2, 2)
        Z_PARAM_ARRAY(points_array)
        Z_PARAM_DOUBLE(epsilon)
    ZEND_PARSE_PARAMETERS_END();
```

- A different macro for each different data type
- Matched with a C data type
- Tests for type matches
- Can deal with optional arguments too

zval?

PHP's representation of a value

- Contains the type: `Z_TYPE_P(points_array)`
- Contains the value: `Z_ARRVAL_P(points_array)`

`IS_DOUBLE`, `IS_STRING`, `IS_ARRAY`, ...

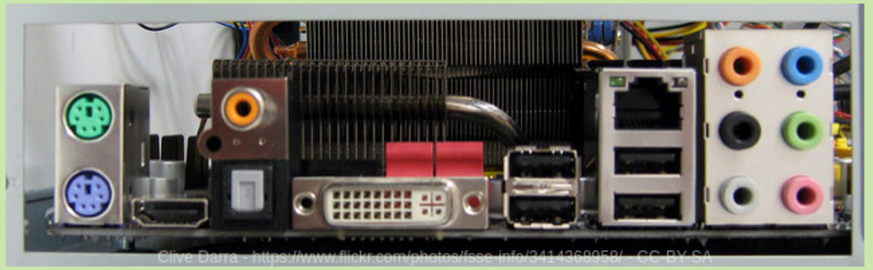
`Z_DVAL_P(lat)`, `Z_STRVAL_P(type)`, ...

```
    if (Z_TYPE_P(points_array) != IS_ARRAY) {
        return;
    }
```

Parsing Input Parameters

macro	variable	C data-type
Z_PARAM_ARRAY	array	`zval*`
Z_PARAM_ARRAY_HT	array	`HashTable`
Z_PARAM_BOOL	boolean	`zend_bool`
Z_PARAM_DOUBLE	double	`double`
Z_PARAM_LONG	long	`zend_long`
Z_PARAM_OBJECT_OF_CLASS	object of specific type	`zval*`, `zend_class_entry`
Z_PARAM_PATH	path	`zend_string*`
Z_PARAM_STRING	string	`char*`, `size_t`
Z_PARAM_STR	string	`zend_string*`

`docs/parameter-parsing-api.md`



Converting from PHP variables

```
    points = geo_hashtable_to_array(points_array TSRMLS_CC);
    if (!points) {
        return;
    }
```

Converting from PHP variables

```
geo_array *geo_hashtable_to_array(zval *array TSRMLS_DC)
{
    geo_array *tmp;
    int element_count, i = 0;
    zval *entry;
    double lon, lat;

    element_count = zend_hash_num_elements(Z_ARRVAL_P(array));
    tmp = geo_array_ctor(element_count);

    ZEND_HASH_FOREACH_VAL(Z_ARRVAL_P(array), entry) {
        if (!parse_point_pair(entry, &lon, &lat TSRMLS_CC)) {
            goto failure;
        }

        tmp->x[i] = lon;
        tmp->y[i] = lat;
        tmp->status[i] = 1;

        i++;
    } ZEND_HASH_FOREACH_END();

    return tmp;

failure:
    geo_array_dtor(tmp);
```

Run Algorithm

```
rdp_simplify(points, epsilon, 0, points->count - 1);
```

RDP (PHP)

```
static private function simplifyInternal( &$points, $epsilon, $start, $end )
{
    $firstPoint = $points[$start];
    $lastPoint = $points[$end];
    $index = -1;
    $dist  = 0;

    if ( $end - $start < 2 ) {
        return;
    }

    for ( $i = $start + 1; $i < $end; $i++ ) {
        if ( !isset( $points[$i] ) ) {
            continue;
        }

        $cDist = self::findPerpendicularDistance( $points[ $i ], $firstPoint, $las

        if ( $cDist > $dist ) {
            $dist = $cDist;
            $index = $i;
        }
    }

    if ( $dist > $epsilon ) {
```

RDP (C)

```
void rdp_simplify(geo_array *points, double epsilon, int start, int end)
{
    double firstX = points->x[start], firstY = points->y[start];
    double lastX = points->x[end], lastY = points->y[end];
    int    index = -1, i;
    double dist  = 0.0, current_dist;

    if (end - start < 2) {
        return;
    }

    for (i = start + 1; i < end; i++) {
        if (!points->status[i]) {
            continue;
        }

        current_dist = rdp_find_perpendicular_distable(points->x[i], points->y[i],

        if (current_dist > dist) {
            dist = current_dist;
            index = i;
        }
    }

    if (dist > epsilon) {
```

Return Result

```
PHP_FUNCTION(rdp_simplify)
{
…
    zval       pair;
…
    array_init(return_value);

    for (i = 0; i < points->count; i++) {
        if (points->status[i]) {
            array_init(&pair);
            add_next_index_double(&pair, points->x[i]);
            add_next_index_double(&pair, points->y[i]);
            add_next_index_zval(return_value, &pair);
        }
    }

    geo_array_dtor(points);
}
```

Returning Scalar Values

Set Return Value:

```
RETVAL_FALSE;
```

```
RETVAL_STRING(trace_fname);
```

Set Value and Return Immediately:

```
RETURN_BOOL(!mongoc_cursor_is_alive(intern->cursor));
```

```
RETURN_LONG(zend_memory_usage(0));
```

```
RETURN_STRING(i->function.function);
```

Memory Management

- If you allocate something, you need to free it
- PHP Memory Management helpers: `emalloc`, `efree`
- To prevent PHP from cleaning up input arguments:

```
Z_ADDREF(zval);
```

- But make sure to remove the reference later:

```
zval_ptr_dtor(&zval);
```

Tests

- Go into the `tests/` directory
- `phpt` format
- Run with `make test` in top source directory

Example Test File

`tests/rdp-belgium.phpt`

```
--TEST--
Test for rdp_simplify
--FILE--
<?php
$json = json_decode( file_get_contents( dirname( __FILE__ ) . '/rdp-belgium.json'
$points = $json[0]->geometry->coordinates[0];

$result = RDP_Simplify( $points, 0.001 );
var_dump( count( $result ) );

$result = RDP_Simplify( $points, 0.01 );
var_dump( count( $result ) );
?>
--EXPECT--
int(1029)
int(261)
```

- Sections: TEST, INI, FILE, EXPECT, EXPECTF
- Simple PHP script

Debugging Tools

`gdb`

→ allows the inspection of programs when they're running

→ `export USE_ZEND_ALLOC=0`

`valgrind`

→ tells you about memory corruption and allocation issues

→ `export ZEND_DONT_UNLOAD_MODULES=1`

Any Queries?

Slides & Resources

Contact

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