使用C++11开发PHP7扩展

@hantianfeng　Rango-韩天峰

01

PHP原生扩展

PHP的扩展加载过程

1. Zend引擎的 php_load_extension 函数
2. 加载并执行so中 get_module 函数，返回 zend_module_entry
3. struct中设置了M(R)INIT、M(R)SHUTDOWN 4个函数指针
4. 执行 zend_startup_module_ex 函数启动扩展
5. PHP扩展加载依赖 glibc 的 dl 库，是标准的 Linux 动态链接库

```
if (type == MODULE_PERSISTENT) {
    extension_dir = INI_STR("extension_dir");
} else {
    extension_dir = PG(extension_dir);
}

if (type == MODULE_TEMPORARY) {
    error_type = E_WARNING;
} else {
    error_type = E_CORE_WARNING;
}

/* Check if passed filename contains directory separators */
if (strchr(filename, '/') != NULL || strchr(filename, DEFAULT_SLASH) != NULL) {
    /* Passing modules with full path is not supported for dynamically loaded extensions */
    if (type == MODULE_TEMPORARY) {
        php_error_docref(NULL, E_WARNING, "Temporary module name should contain only filename");
        return FAILURE;
    }
    libpath = estrdup(filename);
} else if (extension_dir && extension_dir[0]) {
    int extension_dir_len = (int)strlen(extension_dir);

    if (IS_SLASH(extension_dir[extension_dir_len-1])) {
        spprintf(&libpath, 0, "%s%s", extension_dir, filename); /* SAFE */
    } else {
        spprintf(&libpath, 0, "%s%c%s", extension_dir, DEFAULT_SLASH, filename); /* SAFE */
    }
```

```
    /* load dynamic symbol */
    handle = DL_LOAD(libpath);
    if (!handle) {
#ifdef PHP_WIN32
        char *err = GET_DL_ERROR();
        if (err && (*err != '\0')) {
            php_error_docref(NULL, error_type, "Unable to load dynamic library '%s' - %s", libpath, err);
            LocalFree(err);
        } else {
            php_error_docref(NULL, error_type, "Unable to load dynamic library '%s' - %s", libpath, "Unknown reason");
        }
#else
        php_error_docref(NULL, error_type, "Unable to load dynamic library '%s' - %s", libpath, GET_DL_ERROR());
        GET_DL_ERROR(); /* free the buffer storing the error */
#endif
        efree(libpath);
        return FAILURE;
    }
    efree(libpath);
```

```
get_module = (zend_module_entry *(*)(void)) DL_FETCH_SYMBOL(handle, "get_module");

/* Some OS prepend _ to symbol names while their dynamic linker
 * does not do that automatically. Thus we check manually for
 * _get_module. */

if (!get_module) {
    get_module = (zend_module_entry *(*)(void)) DL_FETCH_SYMBOL(handle, "_get_module");
}

if (!get_module) {
    if (DL_FETCH_SYMBOL(handle, "zend_extension_entry") || DL_FETCH_SYMBOL(handle, "_zend_extension_entry")) {
        DL_UNLOAD(handle);
        php_error_docref(NULL, error_type, "Invalid library (appears to be a Zend Extension, try loading using z
        return FAILURE;
    }
    DL_UNLOAD(handle);
    php_error_docref(NULL, error_type, "Invalid library (maybe not a PHP library) '%s'", filename);
    return FAILURE;
}
module_entry = get_module();
```

```
if ((module_entry = zend_register_module_ex(module_entry)) == NULL) {
    DL_UNLOAD(handle);
    return FAILURE;
}

if ((type == MODULE_TEMPORARY || start_now) && zend_startup_module_ex(module_entry) == FAILURE) {
    DL_UNLOAD(handle);
    return FAILURE;
}

if ((type == MODULE_TEMPORARY || start_now) && module_entry->request_startup_func) {
    if (module_entry->request_startup_func(type, module_entry->module_number) == FAILURE) {
        php_error_docref(NULL, error_type, "Unable to initialize module '%s'", module_entry->name);
        DL_UNLOAD(handle);
        return FAILURE;
    }
}
return SUCCESS;
```

创建 PHP 的扩展工程

1. 扩展骨架生成工具：ext_skel
2. 编辑 config.m4
3. 修改 extension.h 头文件定义扩展的函数
4. 修改 extension.c 源文件，实现函数的逻辑
5. phpize、configure、make、make install
6. 建议：参考其他扩展的源码

编写 PHP 扩展 - 基本类型

```
zval a;
ZVAL_LONG(&a, 1234);

zval b;
ZVAL_DOUBLE(&b, 1234.56);

zval c;
ZVAL_STRING(&c, "hello world");

zval d;
array_init(&d);

zval e;
ZVAL_BOOL(&e, 0);
```

```
$a = 1234;

$b = 1234.56;

$c = "hello world";

$d = array();

$e = false;
```

编写 PHP 扩展 - 类型推断

```
zval *value;
Z_TYPE_P(value) == IS_LONG;
Z_TYPE_P(value) == IS_STRING;
Z_TYPE_P(value) == IS_ARRAY;
Z_TYPE_P(value) == IS_DOUBLE;
Z_TYPE_P(value) == IS_TRUE;
Z_TYPE_P(value) == IS_FALSE;
Z_TYPE_P(value) == IS_OBJECT;
```

```
is_int($value);
is_float($value);
is_string($value);
is_array($value);
is_bool($value);
is_object($value);
```

编写 PHP 扩展 - 类型转换

```
convert_to_long(value);
convert_to_string(value);
convert_to_double(value);
convert_to_boolean(value);
```

```
$value = intval($value);
$value = strval($value);
$value = floatval($value);
$value = boolval($value);
```

编写 PHP 扩展 - 参数输入

```
PHP_FUNCTION(swoole_event_add)
{
    zval *cb_read = NULL;
    zval *cb_write = NULL;
    zval *zfd;
    char *func_name = NULL;
    long event_flag = 0;

    if (zend_parse_parameters(ZEND_NUM_ARGS() TSRMLS_CC, "z|zzl", &zfd, &cb_read, &cb_write, &event_flag) == FAILURE)
    {
        return;
    }
```

编写 PHP 扩展 - 参数输入

b：布尔值，l ：整型(long)，d：浮点型(double)

s：字符串(char **, long *)，a：数组，z：任意PHP变量

|：可选参数，&：引用

坑：1. 字符串长度PHP7必须为long，PHP5为int

2. 整型必须为long，不能是int

3. 浮点型必须为double，不能是float

编写 PHP 扩展 - 输出返回值

1. 修改 return_value 实现返回值
2. 使用 RETURN_* 宏

```
RETURN_LONG(1234);
RETURN_BOOL(0);
RETURN_STRING("hello world");
RETURN_DOUBLE(1234.56);
```

编写 PHP 扩展 - 数组操作

```
zval d;
array_init(&d);
add_assoc_long_ex(&d, "key", sizeof("key")-1, 1234);
add_next_index_long(&d, 1234);
```

编写 PHP 扩展 - 数组添加

```
#define add_assoc_long(__arg, __key, __n) add_assoc_long_ex(__arg, __key, strlen(__key), __n)
#define add_assoc_null(__arg, __key) add_assoc_null_ex(__arg, __key, strlen(__key))
#define add_assoc_bool(__arg, __key, __b) add_assoc_bool_ex(__arg, __key, strlen(__key), __b)
#define add_assoc_resource(__arg, __key, __r) add_assoc_resource_ex(__arg, __key, strlen(__key), __r)
#define add_assoc_double(__arg, __key, __d) add_assoc_double_ex(__arg, __key, strlen(__key), __d)
#define add_assoc_str(__arg, __key, __str) add_assoc_str_ex(__arg, __key, strlen(__key), __str)
#define add_assoc_string(__arg, __key, __str) add_assoc_string_ex(__arg, __key, strlen(__key), __str)
#define add_assoc_stringl(__arg, __key, __str, __length) add_assoc_stringl_ex(__arg, __key, strlen(__key),
#define add_assoc_zval(__arg, __key, __value) add_assoc_zval_ex(__arg, __key, strlen(__key), __value)
```

```
ZEND_API int add_next_index_long(zval *arg, zend_long n);
ZEND_API int add_next_index_null(zval *arg);
ZEND_API int add_next_index_bool(zval *arg, int b);
ZEND_API int add_next_index_resource(zval *arg, zend_resource *r);
ZEND_API int add_next_index_double(zval *arg, double d);
ZEND_API int add_next_index_str(zval *arg, zend_string *str);
ZEND_API int add_next_index_string(zval *arg, const char *str);
ZEND_API int add_next_index_stringl(zval *arg, const char *str, size_t length);
ZEND_API int add_next_index_zval(zval *arg, zval *value);
```

编写 PHP 扩展 - 数组操作

```
ZEND_API zend_bool ZEND_FASTCALL zend_hash_exists(const HashTable *ht, zend_string *key);
ZEND_API zend_bool ZEND_FASTCALL zend_hash_str_exists(const HashTable *ht, const char *str, size_t len);
ZEND_API zend_bool ZEND_FASTCALL zend_hash_index_exists(const HashTable *ht, zend_ulong h);
```

```
ZEND_API zval* ZEND_FASTCALL zend_hash_find(const HashTable *ht, zend_string *key);
ZEND_API zval* ZEND_FASTCALL zend_hash_str_find(const HashTable *ht, const char *key, size_t len);
ZEND_API zval* ZEND_FASTCALL zend_hash_index_find(const HashTable *ht, zend_ulong h);
ZEND_API zval* ZEND_FASTCALL _zend_hash_index_find(const HashTable *ht, zend_ulong h);
```

```
ZEND_API int ZEND_FASTCALL zend_hash_del(HashTable *ht, zend_string *key);
ZEND_API int ZEND_FASTCALL zend_hash_del_ind(HashTable *ht, zend_string *key);
ZEND_API int ZEND_FASTCALL zend_hash_str_del(HashTable *ht, const char *key, size_t len);
ZEND_API int ZEND_FASTCALL zend_hash_str_del_ind(HashTable *ht, const char *key, size_t len);
ZEND_API int ZEND_FASTCALL zend_hash_index_del(HashTable *ht, zend_ulong h);
```

编写 PHP 扩展 - 对象操作

```
zval object;
object_init_ex(&object, my_class_entry);
char *message = "hello world";
zend_update_property_string(my_class_entry, &object, "message", sizeof("message") - 1, message);
zval rv;
zval *res = zend_read_property(my_class_entry, &object, "message", sizeof("message") - 1, 1, &rv);
```

```
zval args[4];
zval func_name;
zval *retval = NULL;
ZVAL_STRINGL(&func_name, "test", sizeof("test")-1);
zval *result = call_user_function_ex(NULL, &object, &func_name, &retval, 4, args, 0, NULL);
```

编写 PHP 扩展 - 更多

1. 遍历数组
2. 使用资源类型
3. 实现一个扩展类
4. 引用计数管理
5. ……

编写 PHP 扩展 - 坑

1. zend_update_property 是否要对zval增加引用计数
2. Immutable 数组修改导致崩溃
3. API函数风格不统一，有的是SUCCESS，有的是False

Zend API 的问题

1. 大量使用宏
2. API 名称太长，参数太多，无法记住
3. API 分散在众多 .h 和 .c 文件中
4. C语言开发，大量使用指针，容易出错
5. 没有任何教程或手册

C or C++

C语言

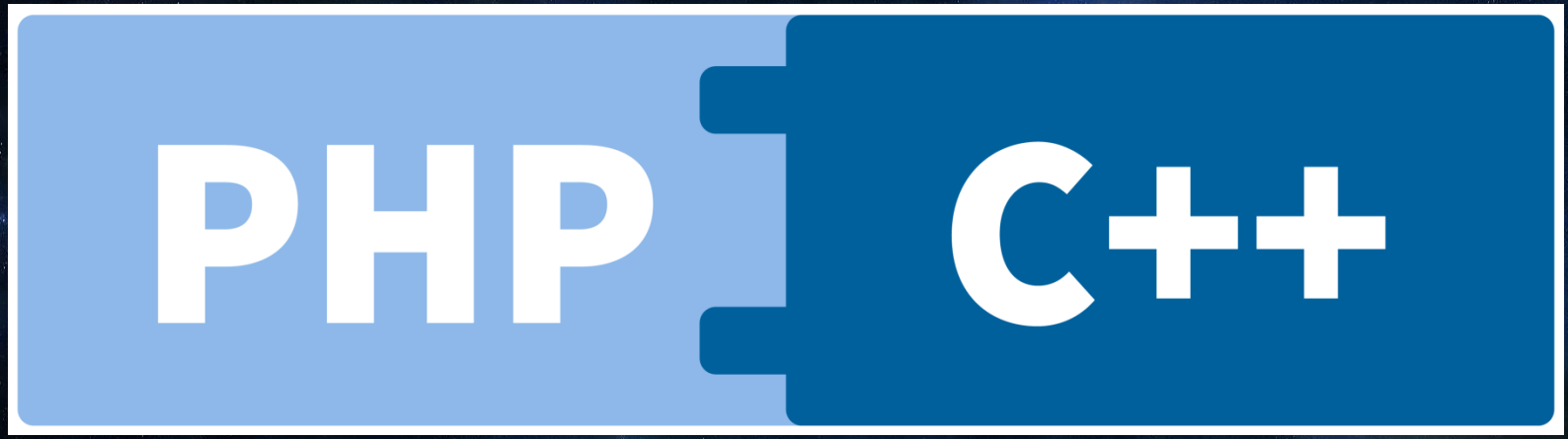
- 50年历史的古老编程语言
- 面向过程风格，函数夹杂着宏，封装性差
- 使用宏和万能指针
- 未提供数据结构
- 仅适合编写底层软件

C++11

- 现代编程语言
- 面向对象风格，对象属性和方法，封装性好
- 模版泛型编程
- STL容器
- 通用编程

PHP 与 C++

	PHP	C++
语言类型	动态，弱类型	静态，强类型
计算性能	差	强
执行方式	编译生成中间码，解释执行	编译为机器指令，直接执行
开发效率	高	低
扩展能力	弱（必须依赖扩展）	强


PHP
C++

PHP 与 C++

1. PHP与C++互补性强，可实现动静结合
2. C/C++**唯一**与PHP直接在内存堆栈上实现互调用的语言
3. 其他编程语言与PHP互调用需要通过 RPC（远程调用）实现

最大的障碍：Zend API 太难用了

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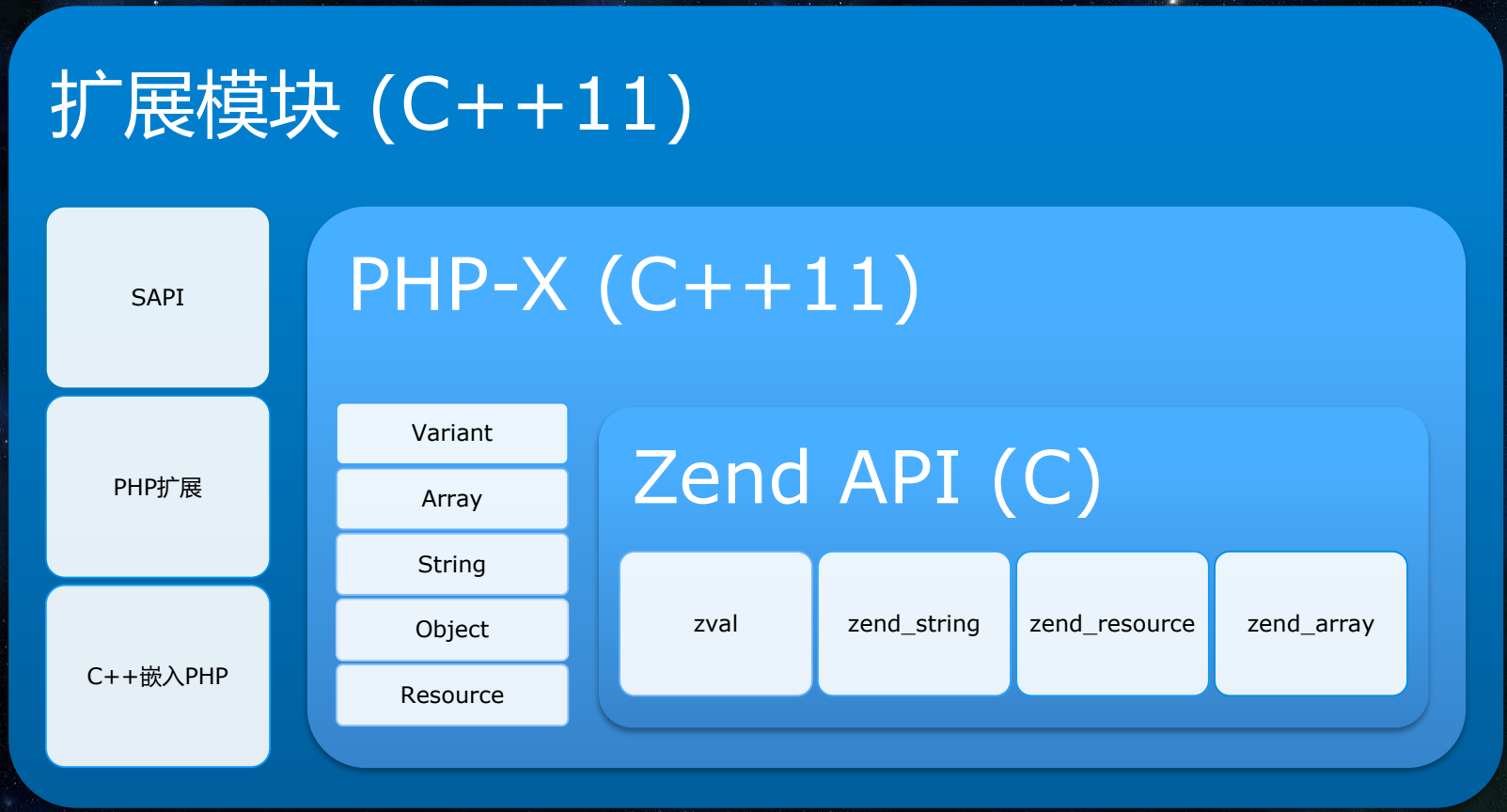
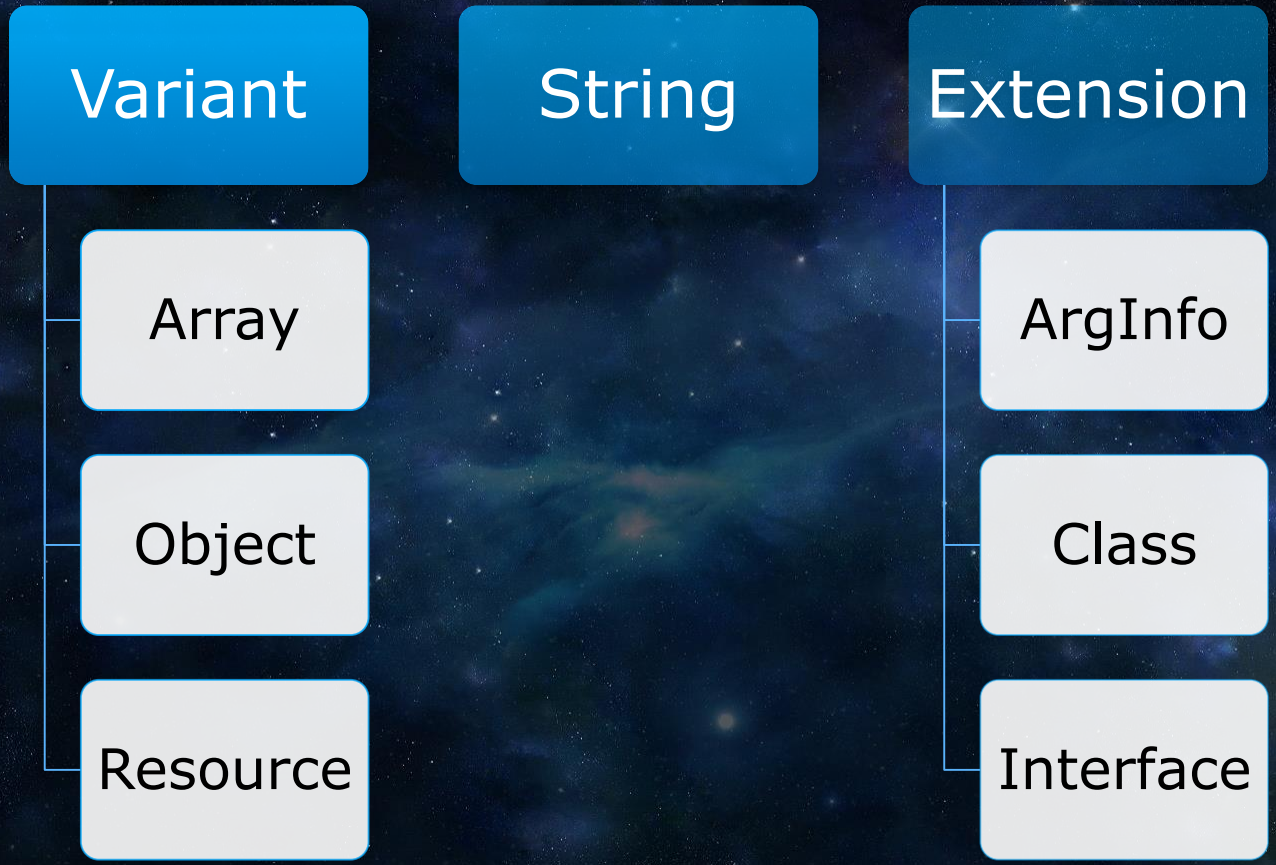
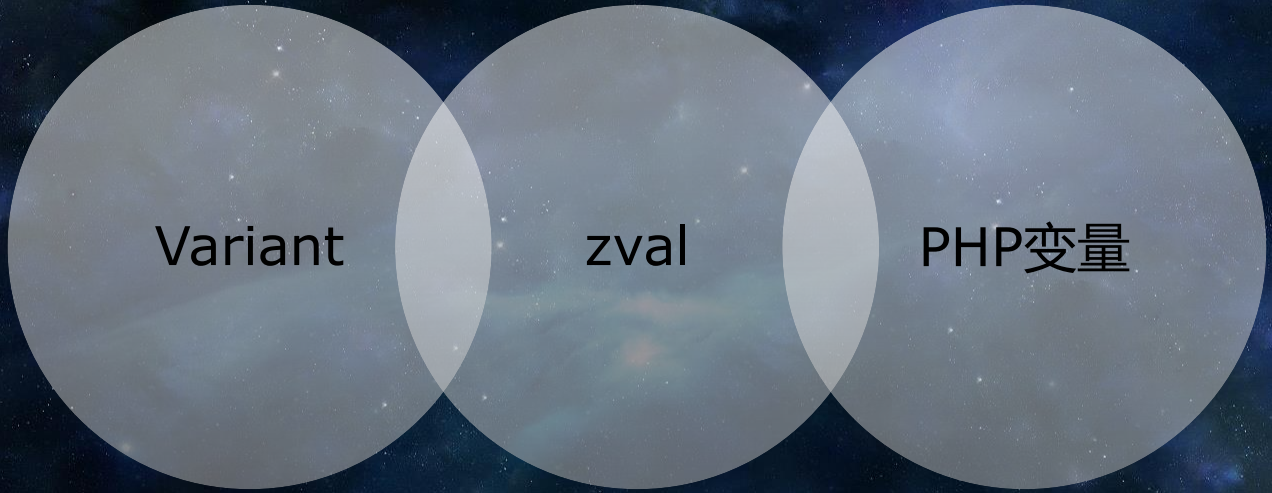
使用C++11
编写PHP扩展

PHP-X

https://github.com/swoole/PHP-X


扩展模块 (C++11)
SAPI
PHP扩展
C++嵌入PHP
PHP-X (C++11)
Variant
Array
String
Object
Resource
Zend API (C)
zval
zend_string
zend_resource
zend_array


Variant
String
Extension
Array
Object
Resource
ArgInfo
Class
Interface


Variant
zval
PHP变量

Variant：赋值

```
Variant a = 1234;
Variant b = 1234.56;
Variant c = "hello world";
Variant d = true;
```

Variant：Scalar类型转换

```
long v1 = value.toInt();
double v2 = value.toFloat();
bool v3 = value.toBool();
string v4 = value.toString();
CURL *v5 = value.toResouce<CURL>();
```

Variant：非Scalar类型转换

```
Array arr(var);
Object obj(var);
String str(var);
```

Variant：类型推断

```
bool ret1 = value.isString();
bool ret2 = value.isArray();
bool ret3 = value.isObject();
bool ret4 = value.isInt();
bool ret5 = value.isFloat();
bool ret6 = value.isBool();
bool ret7 = value.isResource();
```

Variant：更多API

```
value.type() == IS_STRING;
value.addRef();
value.length();
value.equals(var2);
Variant *v = value.dup();
value.getRefCount();
```

Variant：生命周期

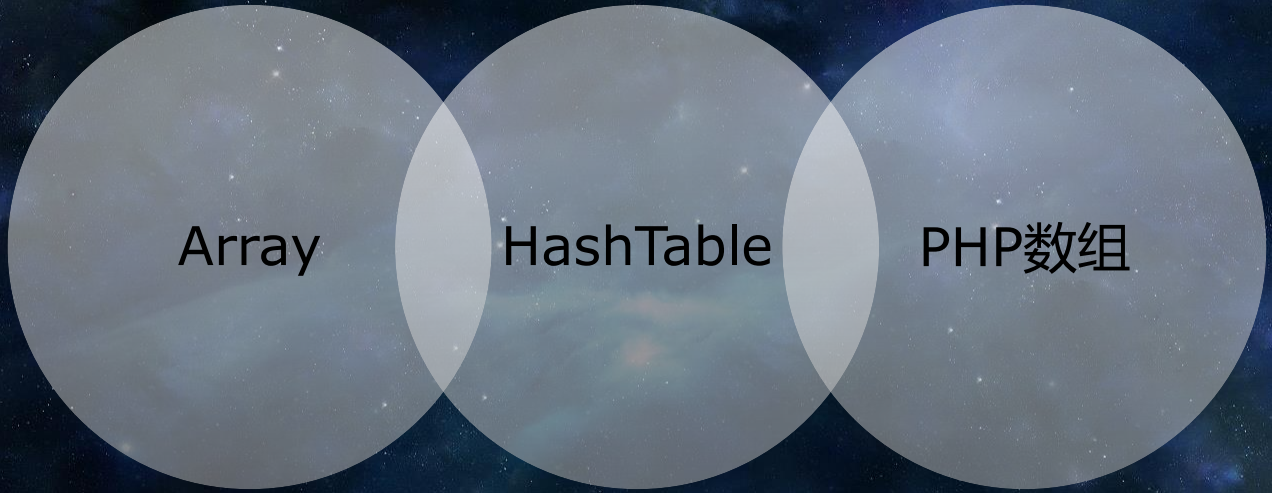
```
function test()
{
    $a = "hello world";
}
```

```
void test()
{
    Variant a("hello world");
}
```

Variant：堆内存

```
void test()
{
    Variant *a = new Variant("hello world");
}
```

```
void test2(Variant *a)
{
    delete a;
}
```


Array
HashTable
PHP数组

Array : List

```
Array arr;
arr.append(1234);
arr.append(1234.56);
arr.append(true);
arr.append("hello");
```

Array : Map

```
Array arr;
arr.set("key1", 1234);
arr.set("key2", 1234.56);
arr.set("key3", false);
arr.set("key4", "world");
```

Array：遍历

```
for (int i = 0; i < arr.count(); i++)
{
    cout << "key: " << i;
    cout << "value: " << arr[i].toString() << endl;
}

for (auto i = map.begin(); i != map.end(); i++)
{
    Variant key = i.key();
    Variant value = i.value();
    cout << "key: " << key.toString();
    cout << "value: " << arr[i].toString() << endl;
}
```

Array：合并

```
Array arr1;
Array arr2;
arr2.append(123);
arr2.append("hello world");
arr2.append(123.05);
arr1.merge(arr2);
```

Array：排序与查找

```
Array arr;
arr.append(123);
arr.append(456);
arr.append(150);
arr.sort();
var_dump(arr);
```

Array：更多API

```
arr.remove("key4");
Variant v1 = arr["key1"];
Variant v2 = arr[0];
int c = arr.count();
bool e = arr.empty();
bool f = arr.exists(1234);
bool g = arr.exists("key5");
```


C++指针
zend_resource
PHP资源

Resource：打通 PHP 与 C++

1. 将 C++ 指针可保存到 PHP 变量中
2. 在 PHP 的函数中互相传递资源变量
3. PHP 中调用 C++ 扩展函数，将资源变量传给 C++

Resource：定义

```
void defineResource()
{
    PHP::registerResource("String", String_dtor);
}

static void String_dtor(zend_resource *res)
{
    String *str = static_cast<String*>(res->ptr);
    delete str;
}
```

Resource：创建/获取

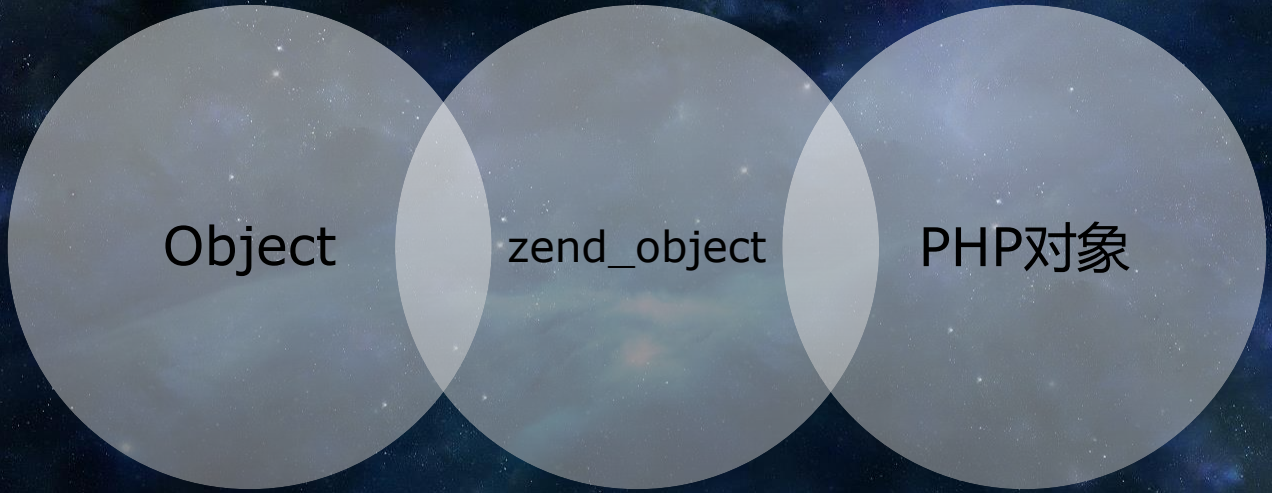
```
void setResource(Object object)
{
    String *str = new String("hello world")
    Variant var = PHP::newResource("String", str);
    object.set("resource", var);
}

void getResource(Object object)
{
    Variant var = object.get("resource");
    String *str = var.toResource<String>("String");
}
```

常用 API

```
php::global("_GET");
php::constant("PHP_VERSION");
php::echo("hello world");
php::error(E_NOTICE, "notice");
php::var_dump(var);
php::exec("json_encode", arr);
```

调用 PHP 函数

```
Variant ret = php::exec("test");
if (ret.isArray()) {
    Array arr(ret);
} else if (ret.isObject()) {
    Object obj(obj);
}
```


Object
zend_object
PHP对象

Object：创建对象/执行方法

```
Object redis = php::newObject("redis");
Variant ret1 = redis.exec("connect", "127.0.0.1");
if (ret1.toBool())
{
    auto ret2 = redis.exec("get", "key");
    cout << "value=" << ret2.toString() << endl;
}
```

Object：读写对象属性

```
Object object = php::newObject("stdClass");
object.set("name", "Rango");
Varaint name = object.get("name");
```

Object：读写C++指针

```
object.oSet("str", "String", new String("php"));
String *str = object.oGet<CppObject>("str", "String");
```

Object：更多API

```
uint32_t id = object.getId();
string name = object.getClassName();
bool ret1 = object.methodExists("methodName");
bool ret2 = object.propertyExists("propertyName");
```

```
Variant value = Class::get("MyClass", "name");
Class::set("MyClass", "name", Array());
```

编写 PHP7 扩展

```
PHPX_EXTENSION()
{
    Extension *extension = new Extension("cpp_ext", "0.0.1");
    extension->onStart = [extension]()
    {
        extension->registerConstant("CPP_EXT_VERSION", "0.0.1");
        extension->registerClass(c);
    };
    extension->registerFunction(PHPX_FN(cpp_ext_test));
    return extension;
}
```

实现扩展函数

```
PHPX_FUNCTION(cpp_ext_test)
{
    for (int i = 0; i < args.count(); i++) {
        php::echo("arg[%d] type is %d\n", i, args[i].type());
    }

    Variant v1 = args[0];
    Array arr(v1);
    arr.set(1, "efg");

    retval = arr;
}
```

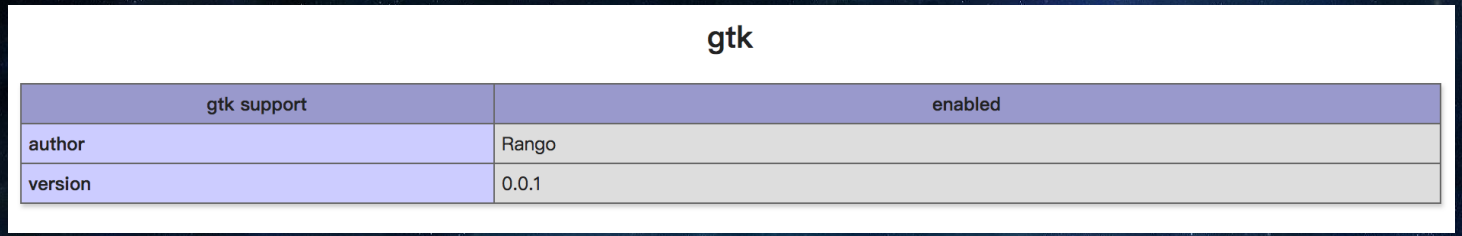
实现扩展类

```
Class *c = new Class("myClass");
c->addMethod(PHPX_ME(myClass, test), STATIC);
c->addMethod(PHPX_ME(myClass, test2));
c->addMethod(PHPX_ME(myClass, construct), CONSTRUCT);
c->addProperty("name", "Rango");
c->addConstant("VERSION", 1002);
extension->registerClass(c);
```

实现类方法

```
PHPX_METHOD(myClass, test2)
{
    Variant res = newResource("String", new String("hello"));
    _this.set("resource", res);
    php::error(E_WARNING, "error message.");
}
```

注入phpinfo



gtk

gtk support	enabled
author	Rango
version	0.0.1

```
extension->info({"gtk support", "enabled"}, {
    { "author", "Rango" },
    { "version", ext->version },
});
```

PHP-X 宏

```
PHPX_FUNCTION(cpp_ext_test)
void cpp_ext_test(Args &args, Variant &retval);

PHPX_METHOD(MyClass, test)
void MyClass_test(Object &_this, Args &args, Variant &retval);
```

```
PHPX_EXTENSION()
Extension* get_module()

PHPX_FN(cpp_ext_test)
"cpp_ext_test", cpp_ext_test

PHPX_ME(myClass, test)
"test", MyClass_test
```

PHP-X 宏

```
PHPX_EXTENSION()
Extension* get_module()

PHPX_FN(cpp_ext_test)
"cpp_ext_test", cpp_ext_test

PHPX_ME(myClass, test)
"test", MyClass_test
```

Makefile编写

```
PHP_INCLUDE = `php-config --includes`
PHP_LIBS = `php-config --libs`
PHP_LDFLAGS = `php-config --ldflags`
PHP_INCLUDE_DIR = `php-config --include-dir`
PHP_EXTENSION_DIR = `php-config --extension-dir`
PHP_INCLUDE_DIR = "/home/htf/workspace/php-x/include"

cpp_ext.so: cpp_ext.cpp
    c++ -g -o cpp_ext.so -O0 -fPIC -shared cpp_ext.cpp -std=c++11 \
    ${PHP_INCLUDE} -I${PHP_INCLUDE_DIR} -I${PHPX_INCLUDE_DIR} ${PHP_LDFLAGS}
install: cpp_ext.so
    cp cpp_ext.so ${PHP_EXTENSION_DIR}/
clean:
    rm *.so
```

编译安装

```
make
sudo make install
echo "extension=cpp_ext.so" >> /path/to/php.ini
php -m
php --ri cpp_ext
php --re cpp_ext
php -r "MyClass::test();"
```

03

在C++程序中嵌入PHP ZendVM

C++嵌入动态语言

1. Python（boost）
2. Lua（游戏）
3. JS（Qt）
4. PHP Embed（没人用）

C++嵌入PHP

```
#include "sapi/embed/php_embed.h"

int main(int argc, char * argv[])
{
    PHP_EMBED_START_BLOCK(argc, argv);
    char * script = " print 'Hello World!';";
    zend_eval_string(script, NULL, "Simple Hello\
        World App" TSRMLS_CC);
    PHP_EMBED_END_BLOCK();
    return 0;
}
```

C++嵌入PHP会带来什么

1. C++程序调用ZendVM提供的功能
2. C++程序调用各类PHP扩展提供的功能
3. C++程序调用PHP类库、框架

C++嵌入PHP

```
#include "embed.h"
```

```
VM vm(argc, argv);
vm.eval("echo 'Hello World!';");
vm.include("embed.php");
```

```
auto obj = php::newObject("Redis");
auto ret = obj.exec("connect", '127.0.0.1');
```

C++使用Composer包

```
//composer
vm.include("vendor/autoload.php");
auto c = "Illuminate\\Foundation\\Application";
auto app = php::newObject(c);
```

04

PHP-X实践

建议使用Eclipse

Eclipse

- 自动提示
- 自动补齐
- 语法搜索
- 自动跳转
- 代码即文档

PHP-X

1. rocksdb：Facebook开源KV数据库RocksDB的客户端
2. Gtk：Gtk图形界面库，用于开发跨平台的桌面软件
3. Stdext：标准库扩展，补充 Standard 和 SPL 的不足

PHP-X Gtk

```php
$app = new Gtk\Application("test.glade", "window1");
$app->setTitle("Power by PHP-X.");
$app->find("button1")->on("clicked", function () use ($app) {
    $app->quit();
});
$app->find('button3')->on('clicked', function() use ($app) {
    $input = $app->find("entry1");
    $text = $input->getText();
    $app->find('label1')->setText("Value=$text");
});
$app->find('button4')->on('clicked', function() use ($app) {
    $input = $app->find("entry1");
    $input->setText('hello world');
});
$app->run();
```

PHP-X Gtk

PHP-X 想象力

1. PHP 可以用 C++ 扩展实现多线程
2. PHP-X 支持 Windows 平台，可以开发Windows的PHP扩展
3. 程序中大量运算的逻辑可以改为 C++ 扩展实现
4. 使用 PHP-X 开发商业软件，避免源码泄漏
5. 利用 Facebook/Google/Microsoft/Inter/Tencent 等巨头开源的C++库来扩展 PHP

THANK YOU

- 2018年再见 -

Q & A