References in PHP:

An In-Depth Look

by Derick Rethans

*PHP’s handling of variables can be non-obvious, at times.*

*Have you ever wondered what happens at the engine level*

*when a variable is copied to another? How about when a*

*function returns a variable “by reference?” If so, read on.*

Every computer language needs some form of container

to hold data—variables. In some languages,

those variables have a specific type attached to

them. They can be a string, a number, an array, an

object or something else. Examples of such staticallytyped

languages are C and pascal. Variables in PHP do

not have this specific restraint. They can be a string in

one line, but a number in the next line. Converting

between types is also easy to do, and often, even automatic.

These loosely-typed variables are one of the

properties that make PHP such an easy and powerful

language, although they can sometimes also cause

interesting problems.

Internally, in PHP, those variables are all stored in a

similar container, called a zval container (also called

“variable container”). This container keeps track of several

things that are related to a specific value. The most

important things that a variable container contains are

the value of the “variable”, but also the type of the variable.

Python is similar to PHP in this regard as it also

labels each variable with a type. The variable container

contains a few more fields that the PHP engine uses to

keep track of whether a value is a reference or not. It

also keeps reference count of its value.

Variables are stored in a symbol table, which is quite

analogous to an associative array. This array has keys

that represent the name of the variable, and those keys

point to variable containers that contain the value (and

type) of the variables. See Figure 1 for an example of

this.

Reference Counting

PHP tries to be smart when it deals with copying variables

like in $a = $b. Using the = operator is also called

an “assign-by-value” operation. While assigning by

value, the PHP engine will not actually create a copy of

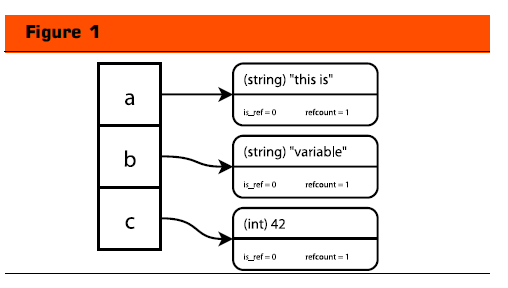
the variable container, but it will merely increase the

refcount field in the variable container. As you can

imagine this saves a lot of memory in case you have a

large string of text, or a large array. Figure 2 shows how

this “looks”. In Step 1 there is one variable, a,



contains the text this is and it has (by default) a reference

count of 1. In step 2, we assign variable $a to

variable $b and $c. Here, no copy of the variable container

is made, only the *refcount* value gets updated

with 1 for each variable that is assigned to the container.

Because we assign two more variables here, the

refcount gets updated to 2 and ends up being 3 after

the two assignment statements.

Now, you might wonder what would happen if the

variable $c gets changed. Two things might happen,

depending on the value of the refcount. If the value is

1, then the container simply gets updated with its new

value (and possibly its type, too). In case the refcount

value is larger than 1, a new variable container gets created

containing the new value (and type). You can see

this in step 3 of Figure 2. The refcount value for the

variable container that is linked to the variable $a is

decreased by one so that the variable container that

belongs to variable $a and $b now has a refcount of 2,

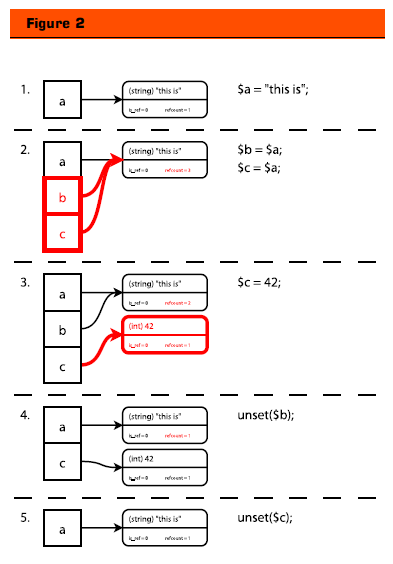
and the newly created container has a refcount of 1.

When unset() is called on a variable the refcount

value of the variable container that is linked to the variable

that is unset will be decreased by one. This happens

when we call unset($b) in step 4. If the refcount



value drops below 1, the PHP Engine will free the variable

container. The variable container is then

destroyed, as you can see in step 5.

Passing Variables to Functions

Besides the global symbol table that every script has,

every call to a user defined function creates a symbol

table where a function locally stores its variables. Every

time a function is called, such a symbol table is created,

and every time a function returns, this symbol table is

destroyed. A function returns by either using the return

statement, or by implicitly returning because the end of

the function has been reached.

In Figure 3, I illustrate exactly how variables are

passed to functions. In step 1, we assign a value to the

variable $a, again—“this is”. We pass this variable to the

do\_something() function, where it is received in the

variable $s. In step 2, you can see that it is practically

the same operation as assigning a variable to another

one (like we did in the previous section with $b = $a),

except that the variable is stored in a different symbol

table—the one that belongs to the called function—

and that the reference count is increased twice, instead

the normal once. The reason for this is that the function’s

stack also contains a reference to the variable

container.

When we assign a new value to the variable $s in step

3, the refcount of the original variable container is

decreased by one and a new variable container is created,

containing the new variable. In step 4, we return

the variable with the return statement. The returned

variable gets an entry in the global symbol table and

the refcount value is increased by 1. When the function

ends, the function’s symbol table will be destroyed.

During the destruction, the engine will go over all variables

in the symbol table and decrease the refcount of

each variable container. When a refcount of a variable

container reaches 0, the variable container is destroyed.

As you see, the variable container is again not copied

when returning it from the function due to PHP’s reference

counting mechanism.

If the variable $s would not have been modified in

step 3 then variable $a and $b would still point to the

same variable container which would have a refcount

value of 2. In this situation, a copy of the variable container

that was created with the statement $a = “this

is” would not have been made.

Introducing References

References are a method of having two names for the

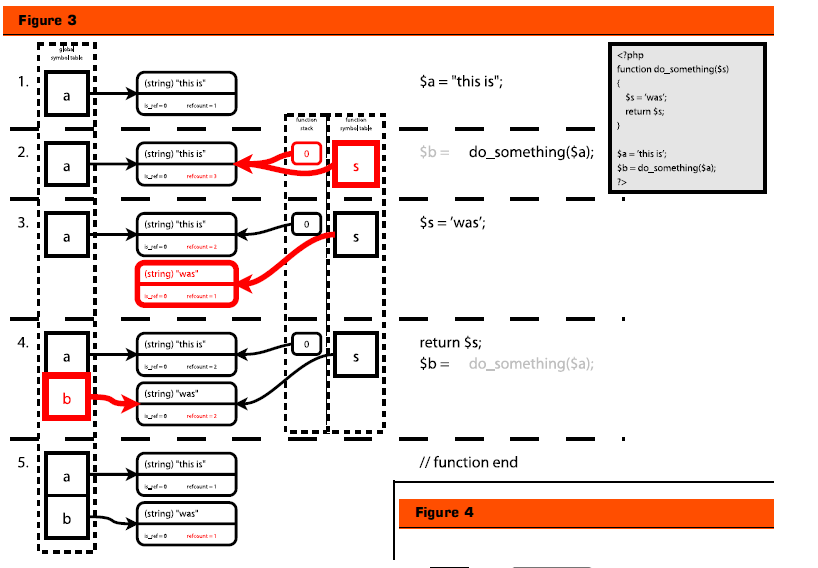
same variable. A more technical description would be:

references are a method of having two keys in a symbol

table pointing to the same zval container. References

can be created with the *reference assignment* operator

&=.



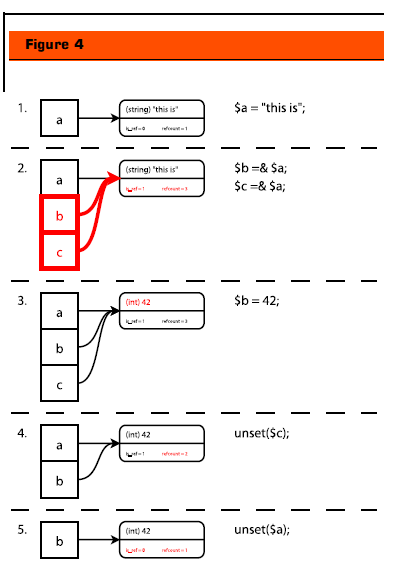


Figure 4 gives a schematic overview of how references

work in combination with reference counting. In

step 1, we create a variable $a that contains the string

“this is”. Then in step two we create two references ($b

and $c) to the same variable container. The refcount

increases normally for each assignment making the

final refcount 3, after both assignments by reference

*(*$b =& $a and $c =& $a)*,* but because the *reference*

*assignment* operator is used, the other value is\_ref is

now set to 1. This value is important for two reasons.

The second one I will divulge a little bit later in this article,

and the first reason that makes this value important

is when we are reassigning a new value to one of the

three variables that all point to the same variable container.

If the is\_ref value is set to 0 when a new value is set

for a specific variable, the PHP engine will create a new

variable container as you could see in step 3 of Figure

2. But if the is\_ref value is set to 1, then the PHP

engine will not create a new variable container and simply

only update the value to which one of the variable

names point as you can see in step 2 of Figure 4. The

exact same result would be reached when the statement

$a = 42 was used instead of $b = 42. After the

variable container is modified, all three variables $a, $b

and $c will contain the value 42.

In step 4, we use the unset() language construct to

remove a variable—in this case variable $c. Using

unset() on a variable means that the refcount value of

the variable container that the variable points to gets

decreased by 1. This works exactly the same for referenced

variables. There is one difference, though, that

shows in step 5. When the reference count of a variable

container reaches 1 and the is\_ref value is set to 1, the

is\_ref value is reset to 0. The reason for this is that a

variable container can only be marked as a referenced

variable container when there is more than one variable

pointing to the variable container.

Mixing Assign-by-Value and Assign-by-

Reference

Something interesting—and perhaps unexpected—

happens if you mix an assign-by-value call and an

assign-by-reference call. This shows in Figure 5. In the

first step we create two variables $a and $b, where the

latter is assigned-by-value to the former. This creates a

situation where there is one variable container with

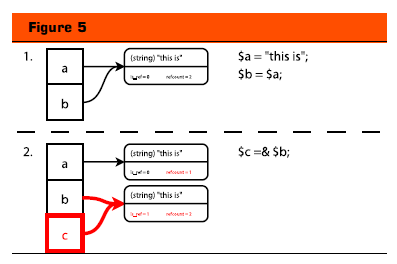
is\_ref set to 0 and refcount set to 2. This should be

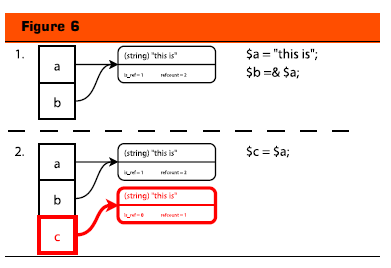
familiar by now.

In step 2 we proceed by assigning variable $c by reference

to variable $b. Here, the PHP engine will create

a copy of the variable container. The variable $a keeps





pointing to the original variable container but the

refcount is, of course, decreased to 1 as there is only

one variable pointing the this variable container now.

The variables $b and $c point to the copied container

which has now a refcount of 2 and the is\_ref value is

set to 1.

You can see that in this case, using a reference does

*not* save you any memory, it actually uses more memory,

as it had to duplicate the original variable container.

The container had to be copied, otherwise the PHP

engine would have no way of knowing how to deal

with the reassignment of one of the three variables as

two of them were references to the same container $b

and $c, while the other was not supposed to be a reference.

If there is only one container with refcount set to

3, and is\_ref set to 1, then it is impossible to figure

that out. That is the reason why the PHP engine needs

to create a copy of the container when you do an

assignment-by-reference.

If we switch the order of assignments—first we assign

$a by reference to $b and then we assign $a by value to

$c—then something similar happens. Figure 6 shows

how this is handled. In the first step we assign the variable

$a to the string “this is” and then we proceed to

assign $a by reference to variable $b. We now have one

variable container where is\_ref is 1 and refcount is 2.

In step 2, we assign variable $a by value to variable $c,

now a copy of the variable container is made in order

for the PHP engine to be able to handle modifications

to the variables, correctly, with the same reasons as

stated in the previous paragraph.

But if you go back to step 2 of Figure 2, where we

assign the variable $a to both $b and $c, you see that

no copy is made here.

Passing References to Functions

Variables can also be passed-by-reference to functions.

This is useful when a function needs to modify the value

of a specific variable when it is called. The script in

Figure 7 is a slightly modified version of the script that

you have already seen in Figure 3. The only difference

is the ampersand (&) in front of the $s variable in the

declaration of the function do\_something(). This ampersand

instructs the PHP engine that the variable to

which the ampersand is applied is going to be passed

by reference and not by value. A different name for a

passed-by-reference variable is an “out variable”.

When a variable is passed by reference to a function

the new variable in the function’s symbol table is pointed

to the old container and the refcount value is

increased by 2 (one for the symbol table, and one for

the stack). Just as in a normal assignment-by-reference

the is\_ref value inside the variable container is also set

to 1 as you can see in step 2. From here on, the same

things happen as with a normal reference like in step 3,

where no copy of the variable container is made if we

assign a new value to the variable $s.

The return $s; statement is basically the same as the

$c = $a statement in step 2 of Figure 6. The global variable

$a and the local variable $s are both references to

the same variable container and the logic dictates that

if is\_ref is set to 1 for a specific container and this container

is assigned to another variable by-value, the container

does not need to be duplicated. This is exactly

what happens here, except that the newly created variable

is created in the global symbol table by the assignment

of the return value of the function with the statement

$b = do\_something($s).

Returning by Reference

Another feature in PHP is the ability to “return by reference”.

This is useful, for example, if you want to select

a variable for modification with a function, such as

selecting an array element or a node in a tree structure.

In Figure 8 we show how returning by references work

by means of an example. In this example (step 1), we

define a $tree variable (which is actually not a tree, but

a simple array) that contains three elements. The three

elements have key values of 1, 2 and 3, and all of them

point to a string describing the English word that

matches with the key’s value (ie. one, two and three).

This array gets passed to the find\_node() function by

reference, along with the key of the element that the

find\_node() function should look for and return. We

need to pass by reference here, otherwise we can not

return a reference to one of the elements, as we will be

returning a reference to a copy of the $tree. When

$tree is passed to the function it has a refcount of 3

and is\_ref is set to 1. Nothing new here.

The first statement in the function, $item =&

$node[$key], causes a new variable to be created in the

symbol table of the function, which points to the array

element where the key is “3” (because the variable $key

is set to 3). In this step 3 you see that the creation of

the $item by assigning it by reference to the array element

causes the refcount value of the variable container

that belongs to the array element to be increased by

1. The is\_ref value of that variable container is now 1,

too, of course.

The interesting things happen in step 4 where we

return $item (by reference) back to the calling scope

and assign it (by reference) to $node. This causes the

refcount of the variable container to which the 3rd

array key points to be set to 3. At this point $tree[3],

$item (from the function’s scope) and $node (global

scope) all point to this variable container. When the

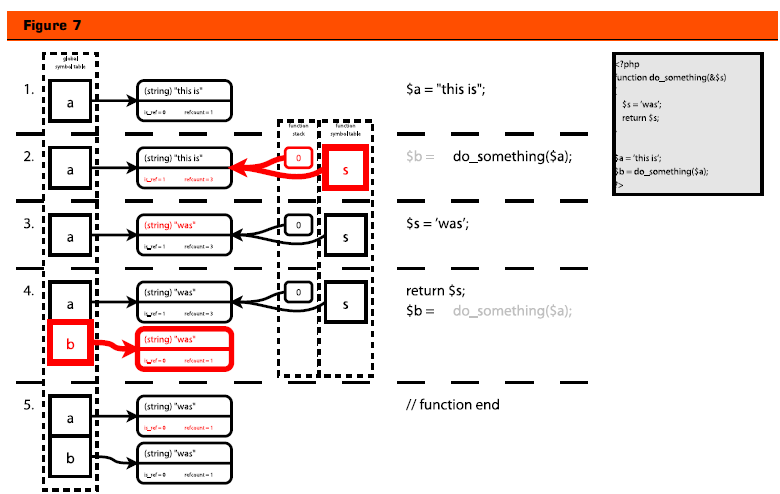
symbol table of the function is destroyed (in step 5),

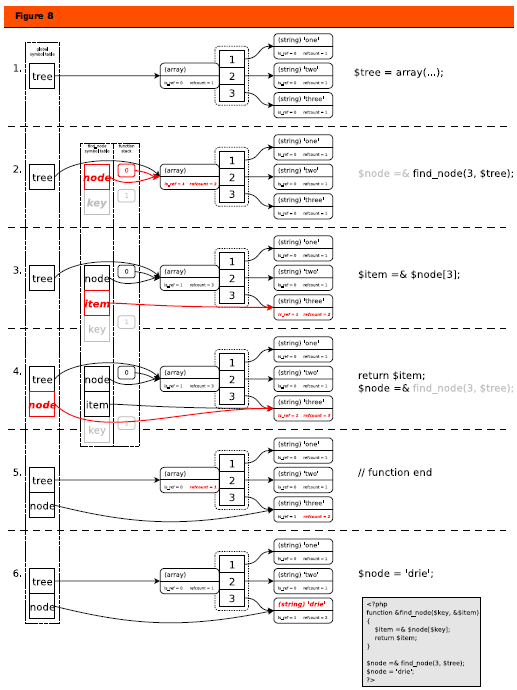
the refcount value decreases from 1 to 2. $node is now

a reference to the third element in the array.

If the variable $item would not have been assigned by

reference to the return value of the do\_something()





function, but instead would have been assigned by

value, then $node would not have been a reference to

$tree[3]. In this case, the refcount value of the variable

container to which $tree[3] points is then 1 after the

function ends, but for some strange reason the is\_ref

value is not reset to 0 as you might expect. My tests did

not find any problems with this, though, in this simple

example. If the function do\_something() would not

have been a “return-by-reference function”, then again

the $node variable would not be a reference to

$tree[3]. In this case, the is\_ref value of the variable

container would have been reset to 0.

Finally, in step 6, we modify the value in the variable

container to which both $node and $tree[3] point.

Please do note that it *is* harmful not to accept a reference

from a function that returns a reference. In some

cases, PHP will get confused and cause memory corruptions

which are very hard to find and debug. It is also

not a good idea to return a static value as reference, as

the PHP engine has problems with that too. In PHP 4.3,

both cases can lead to very hard to reproduce bugs and

crashes of PHP and the web server. In PHP 5, this works

all a little bit better. Here you can expect a warning and

it will behave “properly”. Hopefully, a backported fix

for this problem makes it into a new minor version of

PHP 4—PHP 4.4.

The Global Keyword

PHP has a feature that allows the use of a global variable

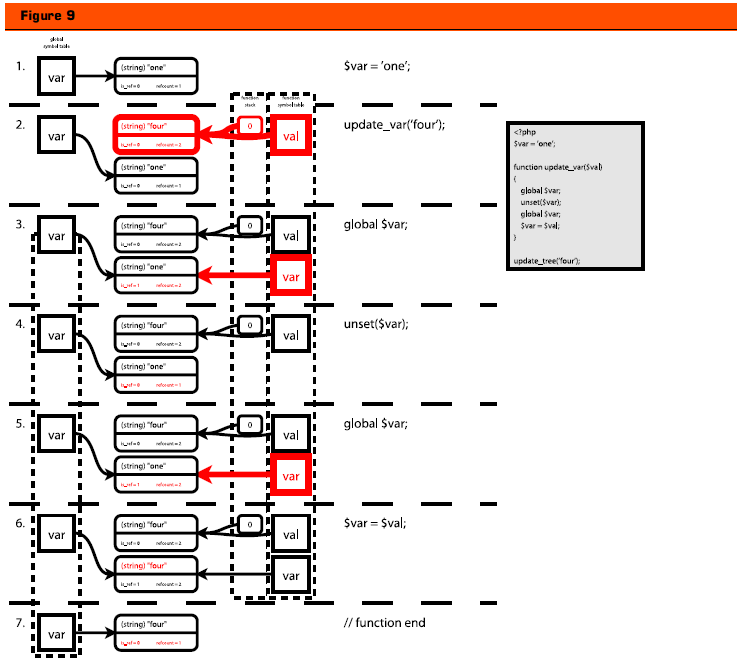
inside a function: you can make this connection

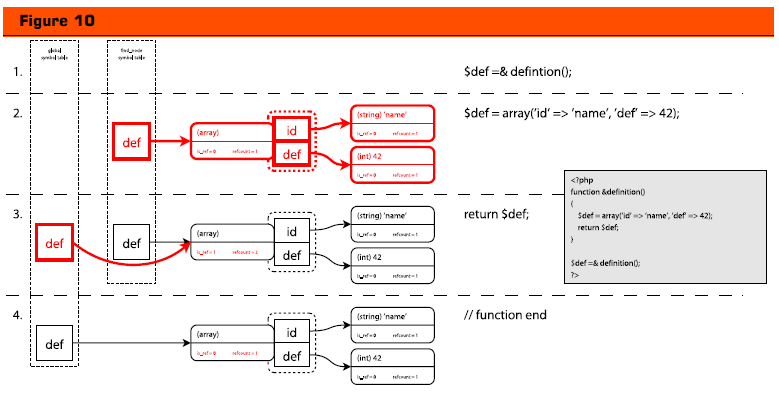
with the global keyword. This keyword will create a reference

between the local variable and the global one.

Figure 9 shows this in an example.

In step 1 and 2, we create the variable $var and call





the function update\_var() with the string literal “one”

as the sole parameter. At this point, we have two variable

containers. The first one is pointed to from the

global variable $var, and the second one is the $val

variable in the called function. The latter variable container

has a refcount value of 2, as both the variable on

the stack and the local variable $val point to it.

The global $var statement, in the function, creates a

new variable in the local scope, which is created as a

reference to the variable with the same name in the

global scope. As you can see in step 3, this increases the

refcount of the variable container from 1 to 2 and this

also sets the is\_ref value to 1.

In step 4, we unset the variable $var. Against some

people’s expectation, the global variable $var does not

get unset—as the unset() was done on a reference to

the global variable $var and not that variable itself. To

reestablish the reference, we employ the global keyword,

again in step 5. As you can see, we have re-created

the same situation as in step 3. Instead of using

global $var we could just as well have used $var =&

$GLOBALS[‘var’] as it would have created the exact

same situation.

In step 6, we continue to reassign the $var variable to

the function’s $val argument. This changes the value to

which both the global variable $var and the local variable

$var point; this is what you would expect from a

referenced variable. When the function ends, in step 7,

the reference from the variable in the scope of the function

disappears, and we end up with one variable container

with a refcount of 1 and an is\_ref value of 0.

Abusing References

In this section, I will give a few examples that show you

how references should not be used—in some cases

these examples might even create memory corruptions

in PHP 4.3 and lower.

Example 1: “Returning static values by-reference”. In

Figure 10, we have a very small script with a return-byreference

function called definition(). This function

simply returns an array that contains some elements.

Returning by reference makes no sense here, as the

exact same things would happen internally if the variable

container holding the array was returned by value,

except that in the intermediate step (step 3) the is\_ref

value of the container would not be set to 1, of course.

In case the $def variable in the function’s scope would

have been referenced by another variable, something

that might happen in a class method where you do

$def = $this->def then the return-by-reference properties

of the function would have copied the array,

because this creates a similar situation as in step 2 of

Figure 5.

Example 2: “Accepting references from a function

that doesn’t return references”. This is potentially dan-



why it doesn’t

work. The first reason is that the PHP internal function

preg\_split() does not return by reference—actually,

no internal function in PHP can return anything by reference.

So, assigning the return value by reference

from a function that doesn’t return a reference is pointless.

The second reason why there is no performance

benefit, here, is the same one as in Example 1, in the

previous paragraph: you’re returning a static value—

not a reference to a variable—it does not make sense to

make the split\_list() function to return-by-reference.

Conclusion

After reading this article, I hope that you now fully

understand how references, refcounting, and variables

work in PHP. It should also have explained that assigning

by reference does not always save you memory—

it’s better to let the PHP engine handle this optimization.

Do not try to outsmart PHP yourself here and only

use references when they are really needed.

In PHP 4.3, there are still some problems with references,

for which patches are in the works. These patches

are backports from PHP 5-specific code, and

although they work fine, they will break binary compatibility—

meaning that compiled extensions no longer

work after those patches are put into PHP. In my opinion,

those hard to produce memory corruption errors

should be fixed in PHP 4 too, though, so perhaps this

creates the need for a PHP 4.4 release. If you’re having

problems, you can try to use the patch located at

http://files.derickrethans.nl/patches/ze1-returnreference-

20050429.diff.txt

The PHP Manual also has some information on references,

although it does not explain the internals very

well. The URL for the section in PHP’s Manual is

http://php.net/language.references

FEATURE

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