# Address-of and dereference operators

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**&** address-of operator

***** dereference operator

# Address-of operator and dereferencing operator

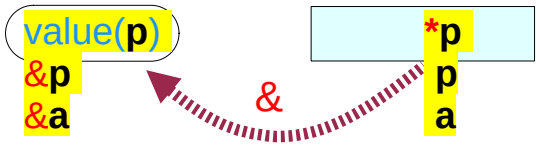
*address-of operator **&** : the address of a variable*

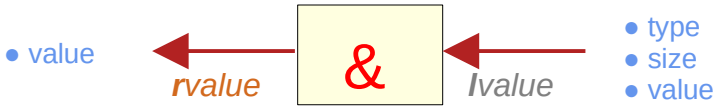
*a **variable** has a memory location whose value can be changed by an assignment*

*a **variable** must be an **l**value*

*__&variable__ returns the address of a variable*

*__&variable__ returns an **r**value*



# Address-of operator and dereferencing operator

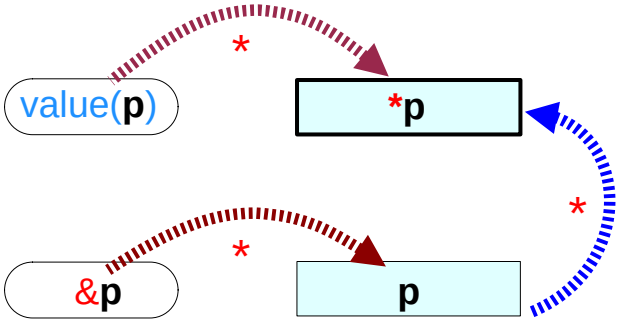
*dereferencing operator* ***** *: the content at an address*

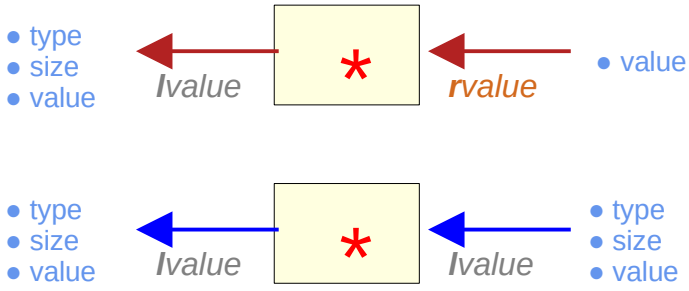
*an* ***address*** *can be an address value or a pointer variable that holds an address value*

*an* ***address*** *must be an* ***r****value, or evaluated to be an* ***r****value*

***** ***address*** *returns the content value at the address*

***** ***address*** *returns an* ***l****value*




***p** ≡ ***value(p)**

# lvalue and rvalue in assignments

***an assignment statement***

*Left Hand Side* *Right Hand Side*

***LHS*** = ***RHS***

- *in the **LHS**, only lvalue can exist*
- *rvalue can exist only in the **RHS***

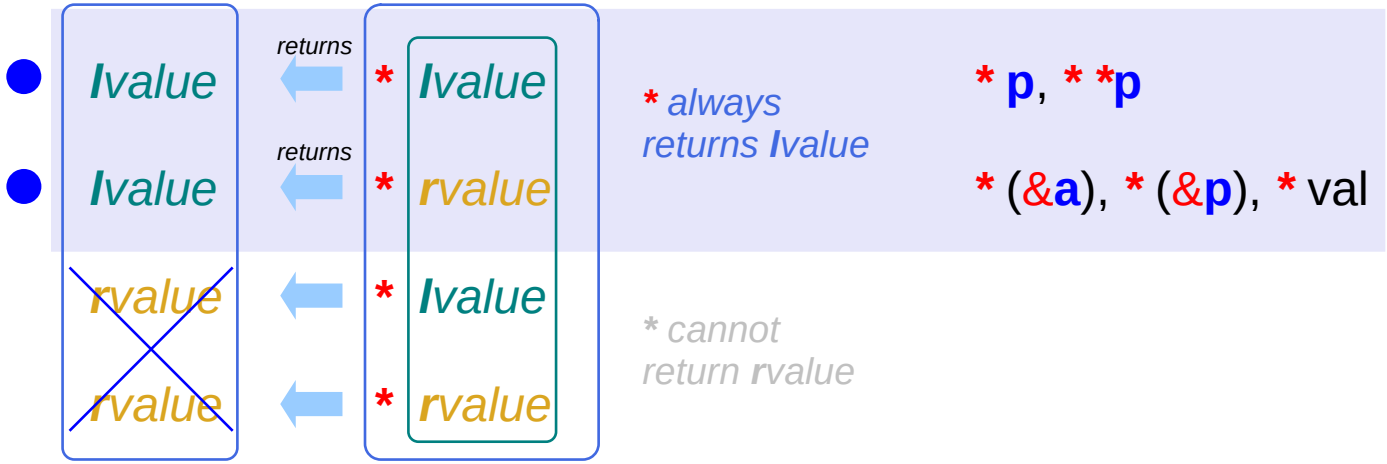
```
int    a,  b = 10 ;
int   *p, *q = &a ;
```

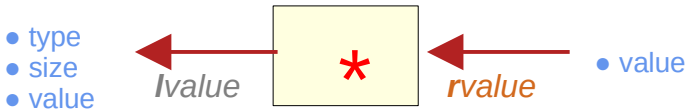
```
 a, b, p, q : lvalues   ... variables  ... RW
 *p, *q     : lvalues   ... variables  ... RW
&a, &b      : rvalues   ... constants  ... RO
```

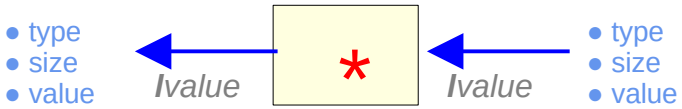
```
lvalue = lvalue
lvalue = rvalue
rvalue = lvalue
rvalue = rvalue
```

```
 p  =  q  ;
 p  = &a  ;
&a  =  p  ;
&a  = &b  ;
```

# lvalue and rvalue with * and & operators



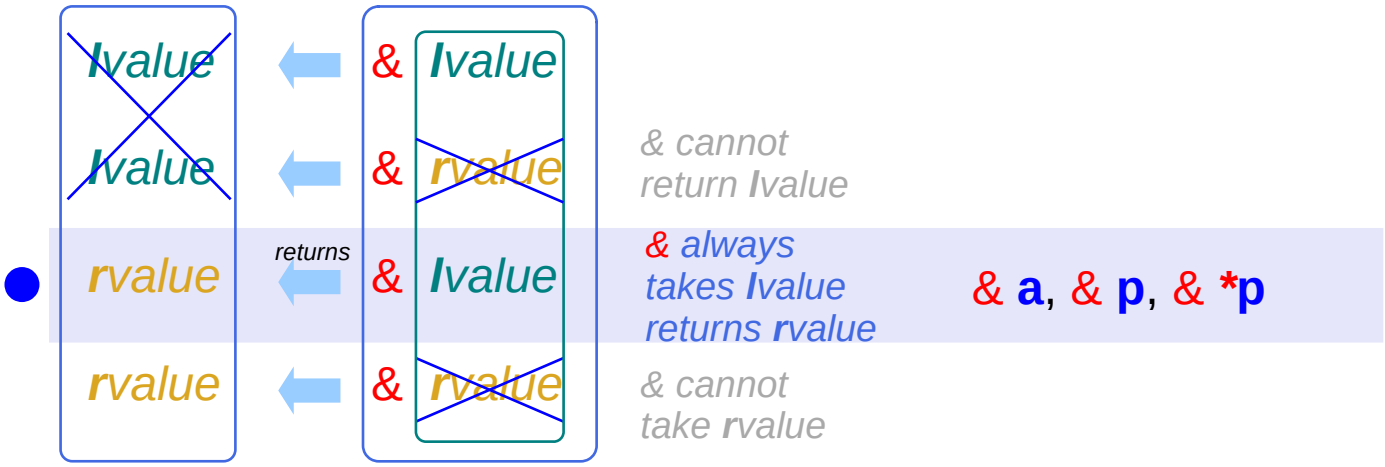



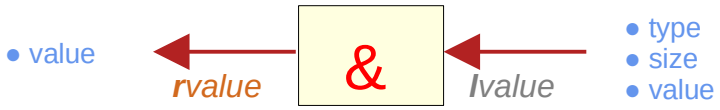

*p ≡ *value(p)

* can be applied to either an **lvalue** variable or a **rvalue** address

* **operand** becomes an **lvalue** variable thus it can be applied successively.

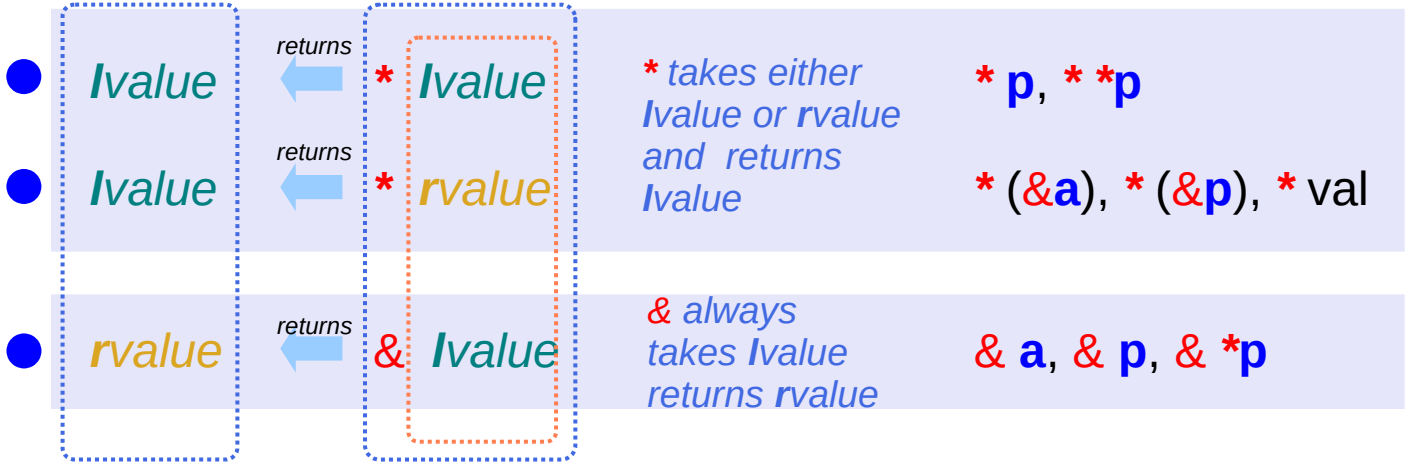
# lvalue and rvalue with * and & operators

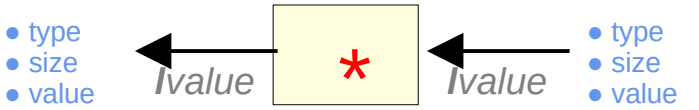


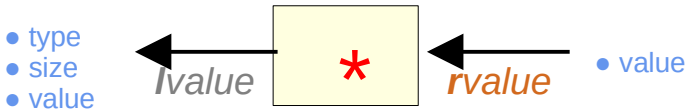




& can be applied
to only an **lvalue** variable and
returns only an **rvalue** address

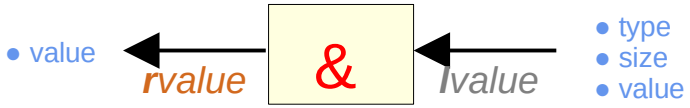
# lvalue and rvalue with * and & operators



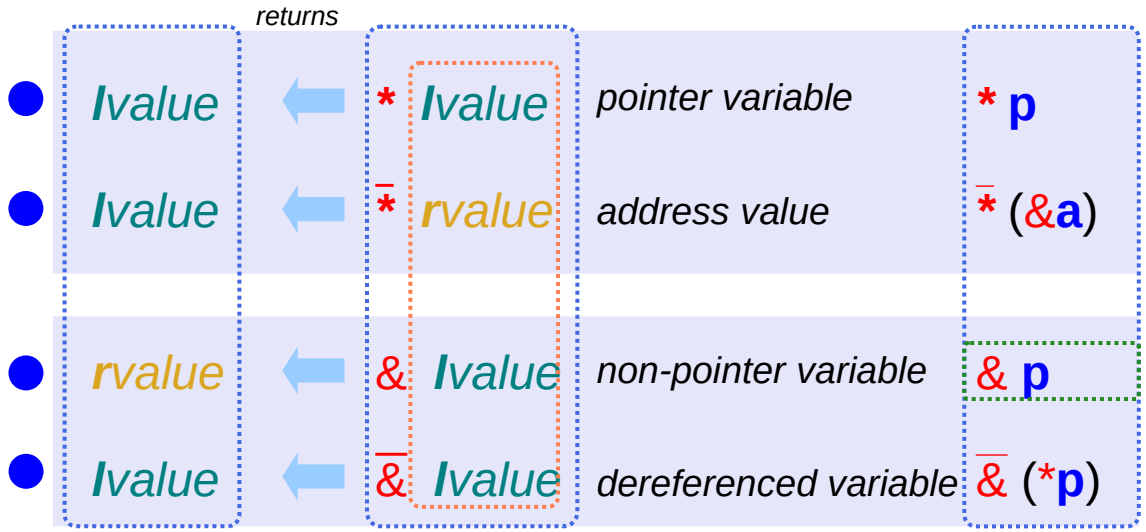




* (an **lvalue** variable)
* (an **rvalue** address)
* **operand** : an **lvalue** variable
* can be applied successively.



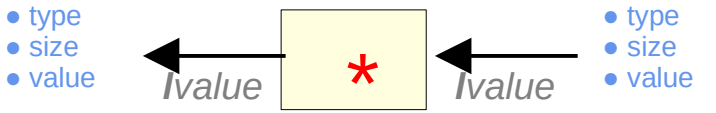

& (an **lvalue** variable)
& **operand** : an **rvalue** address,
& cannot be applied successively.

# lvalue and rvalue with * and & operators

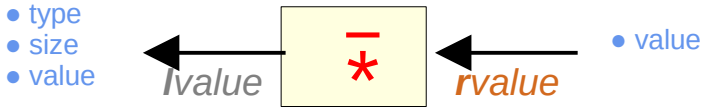



* can be applied successively.
&‾ can be applied successively.

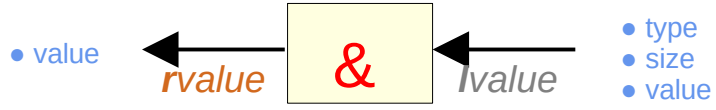
**p
&‾**p = *p
&‾&‾**p = &‾*p = p



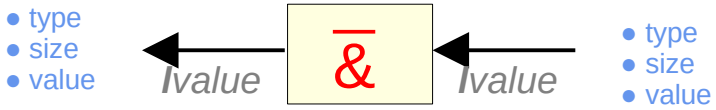

* (an **lvalue** variable)
* **operand**: an **lvalue** variable




*‾ (an **rvalue** address)
*‾ **operand**: an **lvalue** variable




& (an **lvalue** variable)
& **operand**: an **rvalue** address



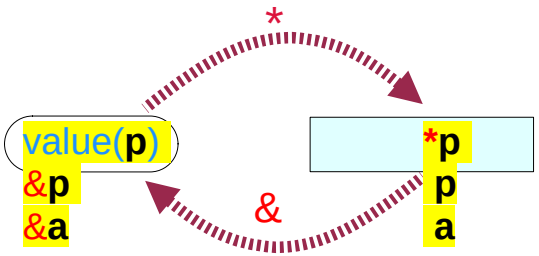

&‾ (an dereferenced **lvalue** variable)
&‾ **operand**: an **lvalue** variable

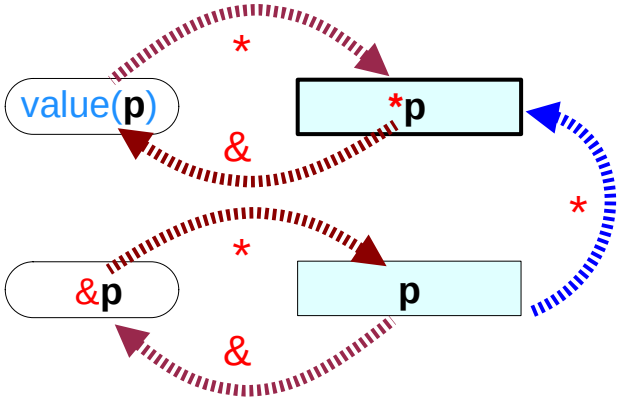
# Variable types

| | | |
|---|---|---|
| **a** | non-pointer variables | *lvalue* |
| **p** | pointer variables | *lvalue* |
| ***p** | dereferenced variables | *lvalue* |
| val | address values | *rvalue* |

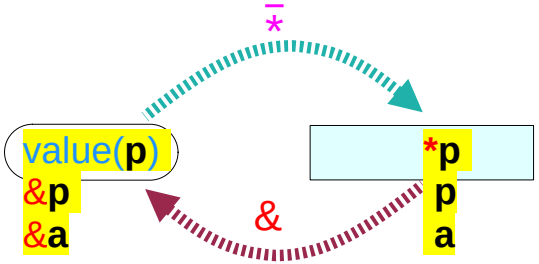
# Comparisons (1)

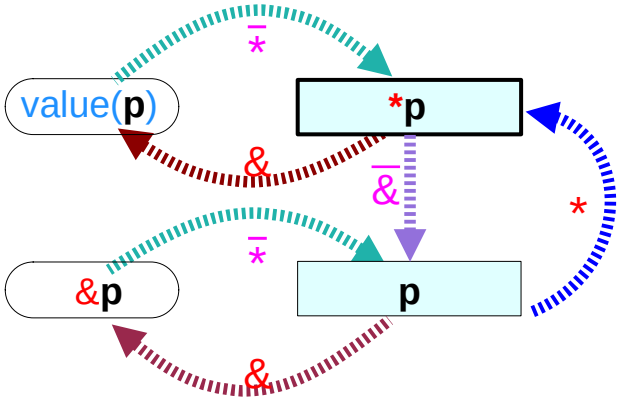
**C operators : *, &**




**augmented operators : $\overline{*}$, $\overline{\&}$**



# Comparisons (2)

**C operators : *, &**

| | | | |
|---|---|---|---|
| | × | a | lvalue |
| lvalue ← | * | p | lvalue |
| lvalue ← | * | * p | lvalue |
| lvalue ← | * | val | rvalue |

| | | | |
|---|---|---|---|
| rvalue ← | & | a | lvalue |
| rvalue ← | & | p | lvalue |
| rvalue ← | & | * p | lvalue |
| | × | val | rvalue |

**augmented operators : $\overline{*}$, $\overline{\&}$**

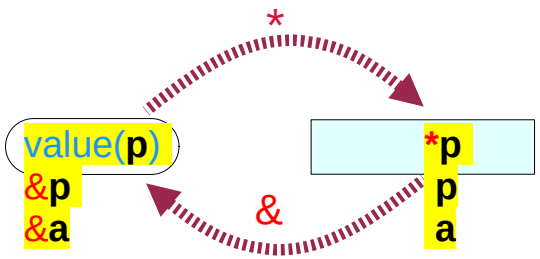
| | | | |
|---|---|---|---|
| | × | a | lvalue |
| lvalue ← | * | p | lvalue |
| lvalue ← | * | * p | lvalue |
| lvalue ← | $\overline{*}$ | val | rvalue |

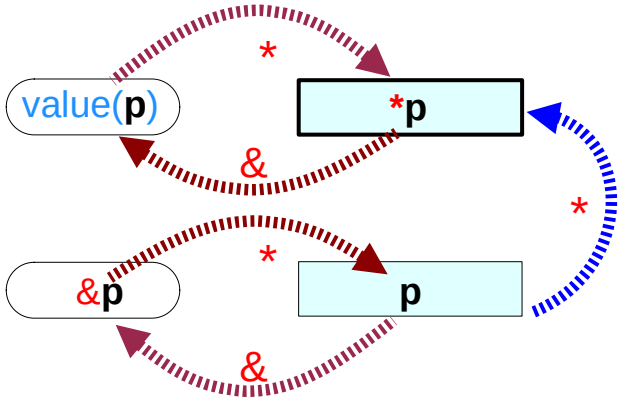
| | | | |
|---|---|---|---|
| rvalue ← | & | a | lvalue |
| rvalue ← | & | p | lvalue |
| rvalue ← | & | * p | lvalue |
| lvalue ← | $\overline{\&}$ | * p | lvalue |
| | × | val | rvalue |

# C operators : *, &

| | | | |
|---|---|---|---|
| | × | a | lvalue |
| lvalue ← | * | p | lvalue |
| lvalue ← | * | * p | lvalue |
| lvalue ← | * | val | rvalue |

| | | | |
|---|---|---|---|
| rvalue ← | & | a | lvalue |
| rvalue ← | & | p | lvalue |
| rvalue ← | & | * p | lvalue |
| | × | val | rvalue |

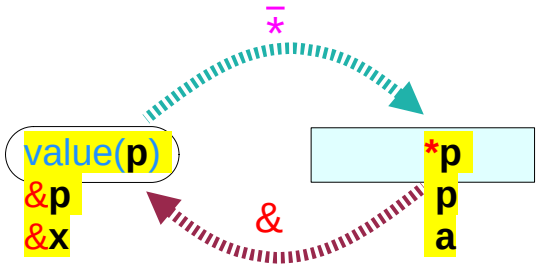


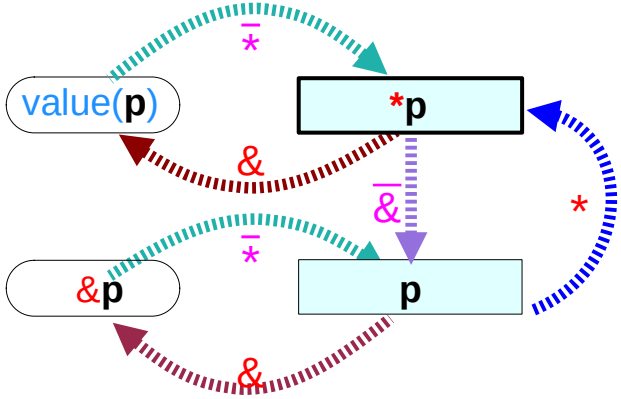



# Augmented operators : *̄, &̄

| | | | |
|---|---|---|---|
| | × | a | lvalue |
| lvalue ← | * | p | lvalue |
| lvalue ← | * | * p | lvalue |
| lvalue ← | *̄ | val | rvalue |

| | | | |
|---|---|---|---|
| rvalue ← | & | a | lvalue |
| rvalue ← | & | p | lvalue |
| rvalue ← | & | * p | lvalue |
| lvalue ← | &̄ | * p | lvalue |
| | × | val | rvalue |



# Recursive application of the address-of operator

~~&(&(&(c[i])[j])[k])~~

**& C operator**

takes only **lvalue** variable
returns **rvalue** address value
thus, the above expression is not possible

successive application of **&** is not possible

but, ***p** becomes a **lvalue** variable
* operator can be applied successively.

$\overline{\&}(\overline{\&}(\overline{\&}(c[i])[j])[k])$

**$\overline{\&}$ mathematical operator**

takes a dereferenced **lvalue** variable
returns **lvalue** variable

successive application of **$\overline{\&}$** is not possible

but, ***p** becomes a **lvalue** variable
* operator can be applied successively.

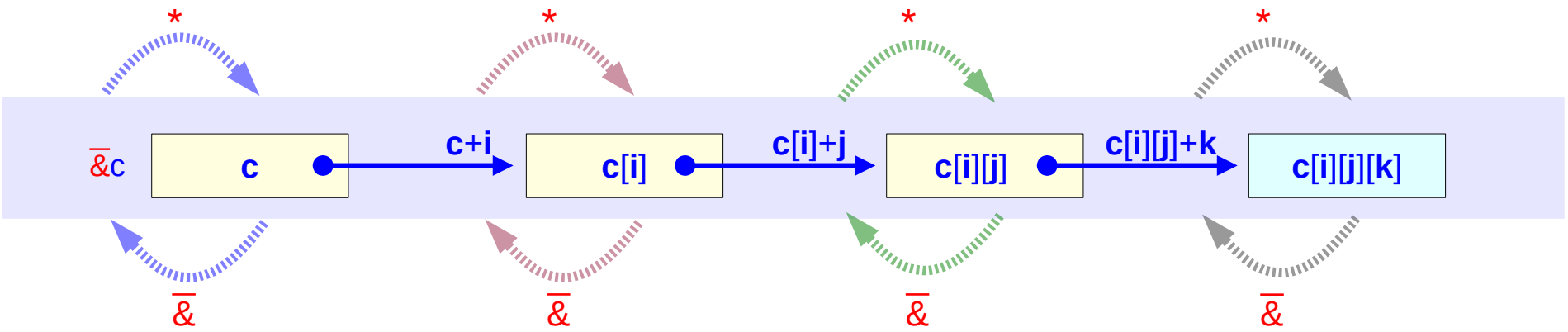
# Recursive application of the address-of operator

*(*(*(c+i)+j)+k)

*(*(*(c+i)+j)+k) =
*(*(c[i]+j)+k) =
*(c[i][j]+k) =
c[i][j][k]

&(&(&(c[i])[j])[k])

&(&(&(c[i])[j])[k]) =
(&(&(c[i])[j])+k) =
((&(c[i])+j)+k) =
(((c+i)+j)+k)



# Recursive application of the address-of operator

$\bar{*}v(\bar{*}v(\bar{*}v(c+i)+j)+k)$ $*(*(*(c+i)+j)+k)$

$*(*(*(c+i)+j)+k)$

value(**c**[**i**][**j**]+**k**) = **c**[**i**][**j**] + **k** * sizeof(**c**[0][0][0])
value(**c**[**i**] +**j**) = **c**[**i**] + **j** * sizeof(**c**[0][0])
value(**c**+**i**) = **c** + **i** * sizeof(**c**[0])

# Recursive application of the address-of operator

*(*(*(c+i)+j)+k)

*(*(c[i]+j)+k)

*(c[i][j]+k)

c[i][j][k]

$\overline{*}$v($\overline{*}$v($\overline{*}$v(c+i)+j)+k)

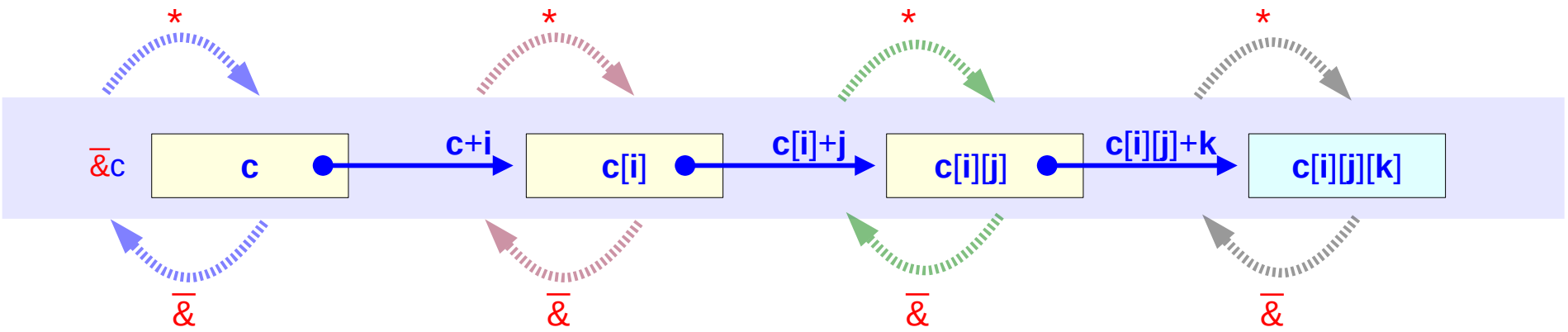
$\overline{\&}$(c[i][j][k]) = c[i][j] + k
$\overline{\&}$(c[i][j]) = c[i] + j
$\overline{\&}$(c[i]) = c + i

c[i][j][k] = *(c[i][j] +k)
c[i][j] = *(c[i] +j)
c[i] = *(c+i)

$\overline{\&}$(c[i][j][k]) = c[i][j] + k * sizeof(c[0][0][0])

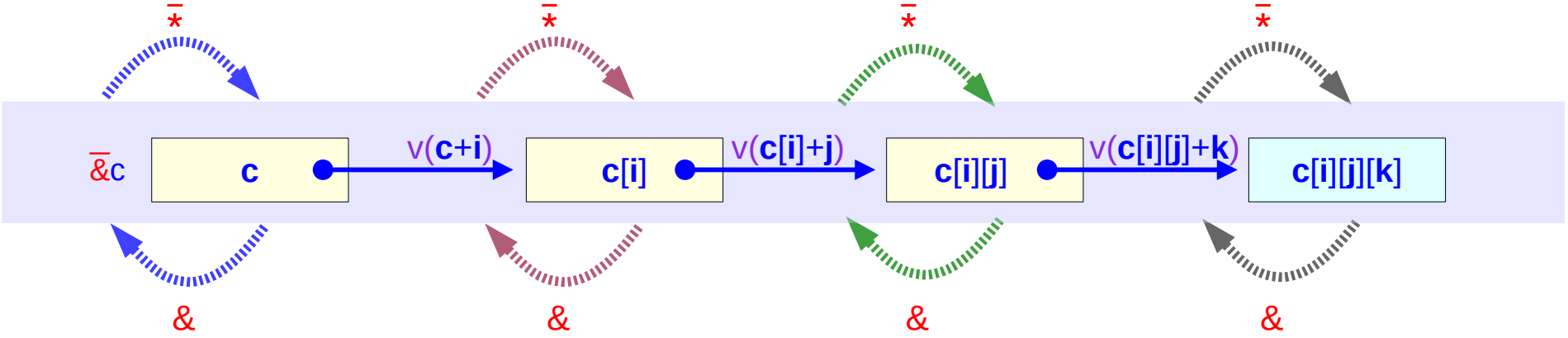
# Two step deferencing in type II (1) – without skipping

```
&(c[i][j][k])     = &(*(c[i][j]+k))     = c[i][j]    + k
&(c[i][j])        = &(*(c[i]+j))        = c[i]       + j
&(c[i])           = &(*(c+i))           = c          + i

*&(c[i][j][k])    = *&(*(c[i][j]+k))    = *(c[i][j]  +k)
*&(c[i][j])       = *&(*(c[i]+j))       = *(c[i]     +j)
*&(c[i])          = *&(*(c+i))          = *(c        +i)
```



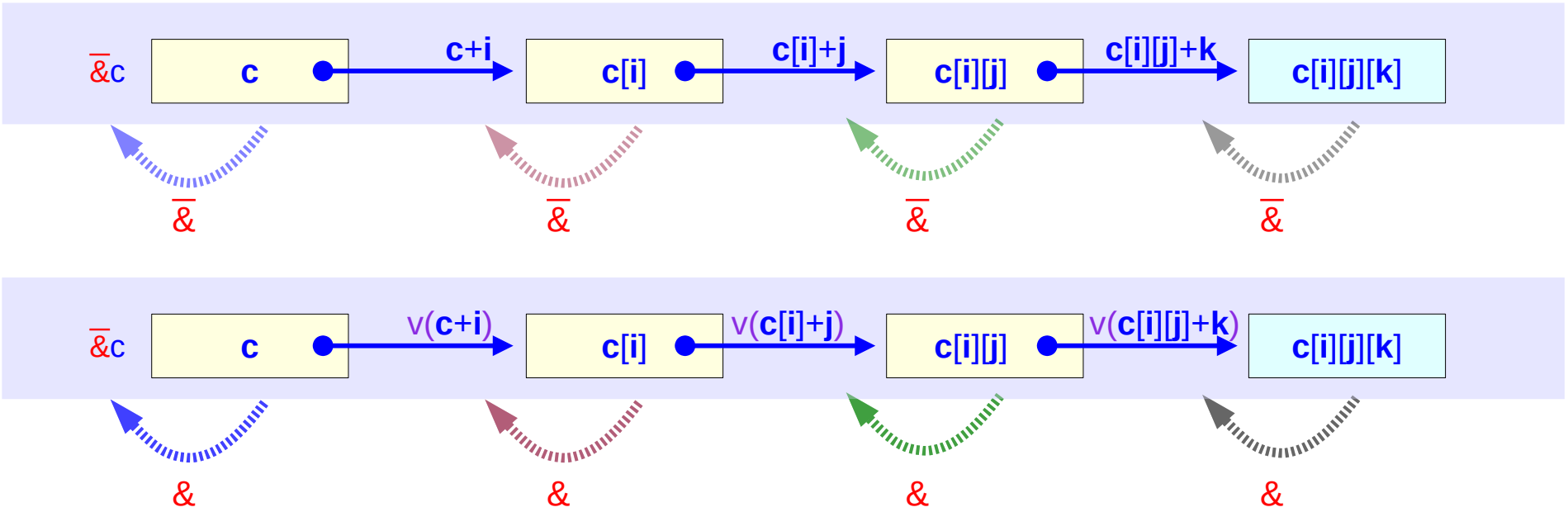
# Two step deferencing in type II (1) – without skipping

```
&(c[i][j][k])    = &(*(c[i][j]+k))    = value(c[i][j] +k)  = c[i][j]  + k * sizeof(c[0][0][0])
&(c[i][j])       = &(*(c[i]+j))       = value(c[i]    +j)  = c[i]     + j * sizeof(c[0][0])
&(c[i])          = &(*(c+i))          = value(c       +i)  = c        + i * sizeof(c[0])

*&(c[i][j][k])   = *&(*(c[i][j]+k))   = *value(c[i][j] +k) = *(c[i][j] + k * sizeof(c[0][0][0]))
*&(c[i][j])      = *&(*(c[i]+j))      = *value(c[i]    +j) = *(c[i]    + j * sizeof(c[0][0]))
*&(c[i])         = *&(*(c+i))         = *value(c       +i) = *(c       + i * sizeof(c[0]))
```



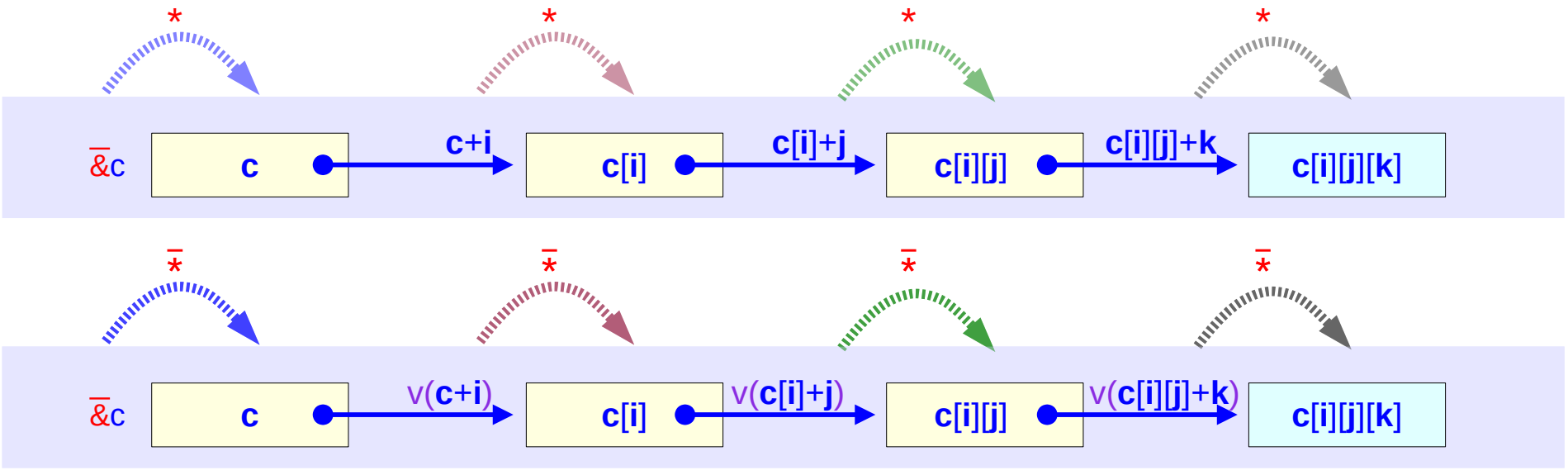
$\overline{\&}$(c[i][j][k]) = $\overline{\&}$(*(c[i][j]+k)) = c[i][j] + k
$\overline{\&}$(c[i][j]) = $\overline{\&}$(*(c[i]+j)) = c[i] + j
$\overline{\&}$(c[i]) = $\overline{\&}$(*(c+i)) = c + i

&(c[i][j][k]) = &(*(c[i][j]+k)) = c[i][j] + k * sizeof(c[0][0][0])
&(c[i][j]) = &(*(c[i]+j)) = c[i] + j * sizeof(c[0][0])
&(c[i]) = &(*(c+i)) = c + i * sizeof(c[0])



*&(c[i][j][k]) = *&(*(c[i][j]+k)) = *(c[i][j] +k)
*&(c[i][j]) = *&(*(c[i]+j)) = *(c[i] +j)
*&(c[i]) = *&(*(c+i)) = *(c +i)

*&(c[i][j][k]) = *&(*(c[i][j]+k)) = *(c[i][j] + k * sizeof(c[0][0][0]))
*&(c[i][j]) = *&(*(c[i]+j)) = *(c[i] + j * sizeof(c[0][0]))
*&(c[i]) = *&(*(c+i)) = *(c + i * sizeof(c[0]))



# Two step deferencing in type II (1) – without skipping

```
&(c[i][j][k])     = &(*(c[i][j]+k))     = c[i][j]     + k
&(c[i][j])        = &(*(c[i]+j))        = c[i]        + j
&(c[i])           = &(*(c+i))           = c           + i

*&(c[i][j][k])    = *&(*(c[i][j]+k))    = *(c[i][j]   +k)
*&(c[i][j])       = *&(*(c[i]+j))       = *(c[i]      +j)
*&(c[i])          = *&(*(c+i))          = *(c         +i)


&(c[i][j][k])     = &(*(c[i][j]+k))     = c[i][j]     + k * sizeof(c[0][0][0])
&(c[i][j])        = &(*(c[i]+j))        = c[i]        + j  * sizeof(c[0][0])
&(c[i])           = &(*(c+i))           = c           + i  * sizeof(c[0])

c[i][j][k]        = *&(*(c[i][j]+k))    = *(c[i][j]   + k * sizeof(c[0][0][0])
c[i][j]           = *&(*(c[i]+j))       = *(c[i]      + j  * sizeof(c[0][0]))
c[i]              = *&(*(c+i))          = *(c         + i  * sizeof(c[0]))
```

# Two step deferencing in type II (1) – without skipping

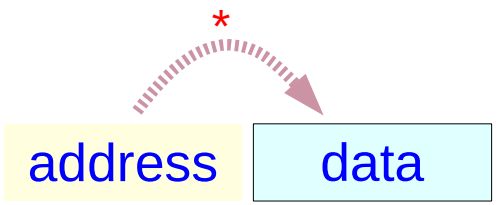
```
&(c[i][j][k])     = c[i][j]    + k
&(c[i][j])        = c[i]       + j
&(c[i])           = c          + i

c[i][j][k]        = *(c[i][j]  +k)
c[i][j]           = *(c[i]     +j)
c[i]              = *(c        +i)


&(c[i][j][k])     = c[i][j]    + k * sizeof(c[0][0][0])
&(c[i][j])        = c[i]       + j  * sizeof(c[0][0])
&(c[i])           = c          + i  * sizeof(c[0])

c[i][j][k]        = *(c[i][j]  + k * sizeof(c[0][0][0])
c[i][j]           = *(c[i]     + j  * sizeof(c[0][0]))
c[i]              = *(c        + i  * sizeof(c[0]))
```

# Two step deferencing in type II (1) – without skipping

| | | | | | |
|---|---|---|---|---|---|
| &(c[i][j][k]) | = c[i][j] | + k | &(c[i][j][k]) | = value(c[i][j] | + k) |
| &(c[i][j]) | = c[i] | + j | &(c[i][j]) | = value(c[i] | + j) |
| &(c[i]) | = c | + i | &(c[i]) | = value(c | + i) |
| c[i][j][k] | = *(c[i][j] | +k) | c[i][j][k] | = * value(c[i][j] | + k) |
| c[i][j] | = *(c[i] | +j) | c[i][j] | = * value(c[i] | + j) |
| c[i] | = *(c | +i) | c[i] | = * value(c | + i) |

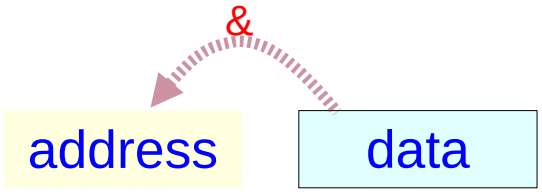
# Address-of & and dereference * C operators (1)

**Primitive** Data Type




*rvalue* &a → *lvalue* a
*constant* *variable*

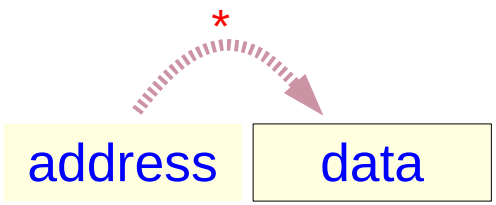
*lvalue* p → *lvalue* *p
*pointer* *variable*




*rvalue* &a ← *lvalue* a
*constant* *variable*

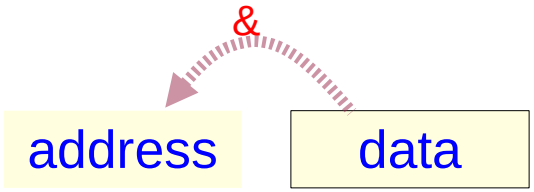
~~*lvalue*~~ p ← *lvalue* *p
*pointer* *variable*

**Pointer** Data Type




*rvalue* &q → *lvalue* q
*constant* *double pointer*

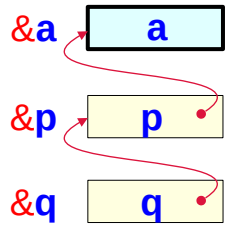
*lvalue* q → *lvalue* *q
*double pointer* *pointer*

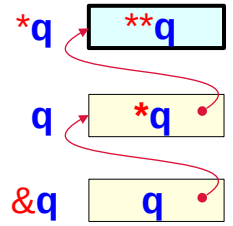



*rvalue* &q ← *lvalue* q
*constant* *double pointer*

~~*lvalue*~~ q ← *lvalue* *q
*double pointer* *pointer*

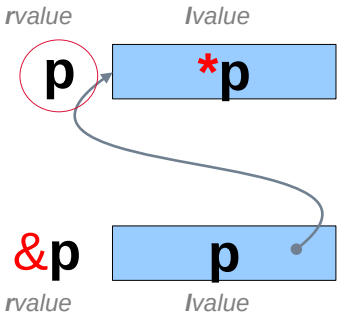
```
int   a ;
int *  p ;
int ** q ;
```



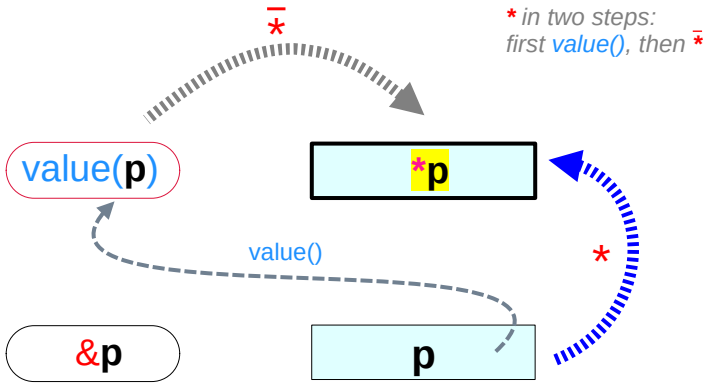
# & and * operators in pointer de-referecing

## Two step De-reference * operation

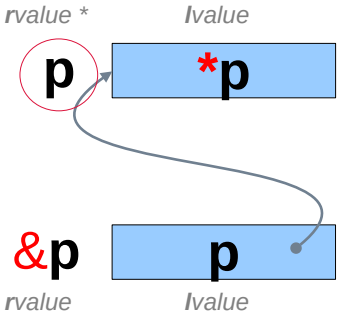



***p** must be evaluated to an address*
*value(**p**) before de-referencing ***p***

think a new operator :
$\overline{*}$ is a mathematical operator
$\overline{*}$ takes rvalue and returns lvalue

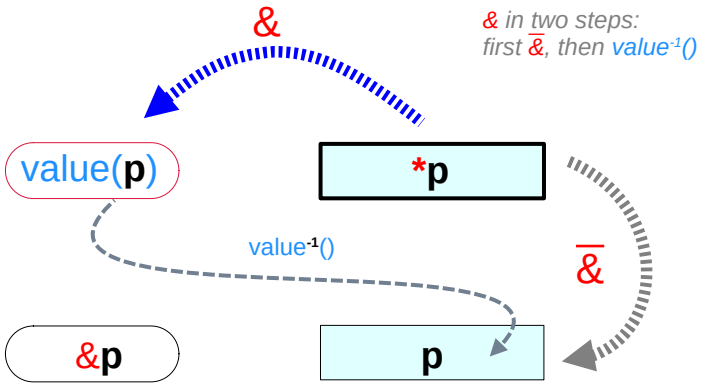



## Two step Address-of & operation

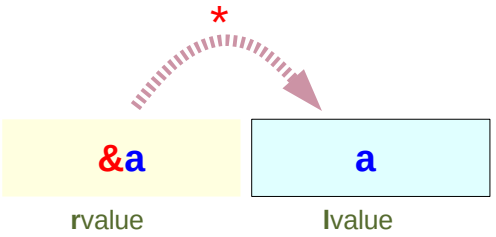



*assume that it is possible*
*to recover the variable **p** from value(**p**)*

think a new operator :
$\overline{\&}$ is a mathematical operator
$\overline{\&}$ takes lvalue and returns lvalue

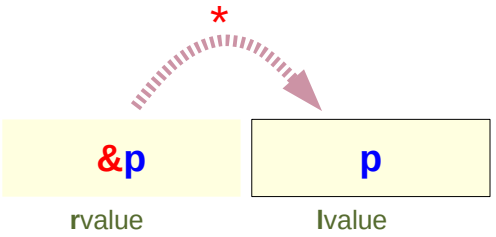


# Type, Size, and Value attributes of an **lvalue**




*lvalue* ⟵ ***rvalue***

***a*** ****&a***




*lvalue* ⟵ ***rvalue***

***p*** ****&p***

**lvalue** is associated with a memory location

**lvalue** has the following attributes
- Type
- Size
- Value

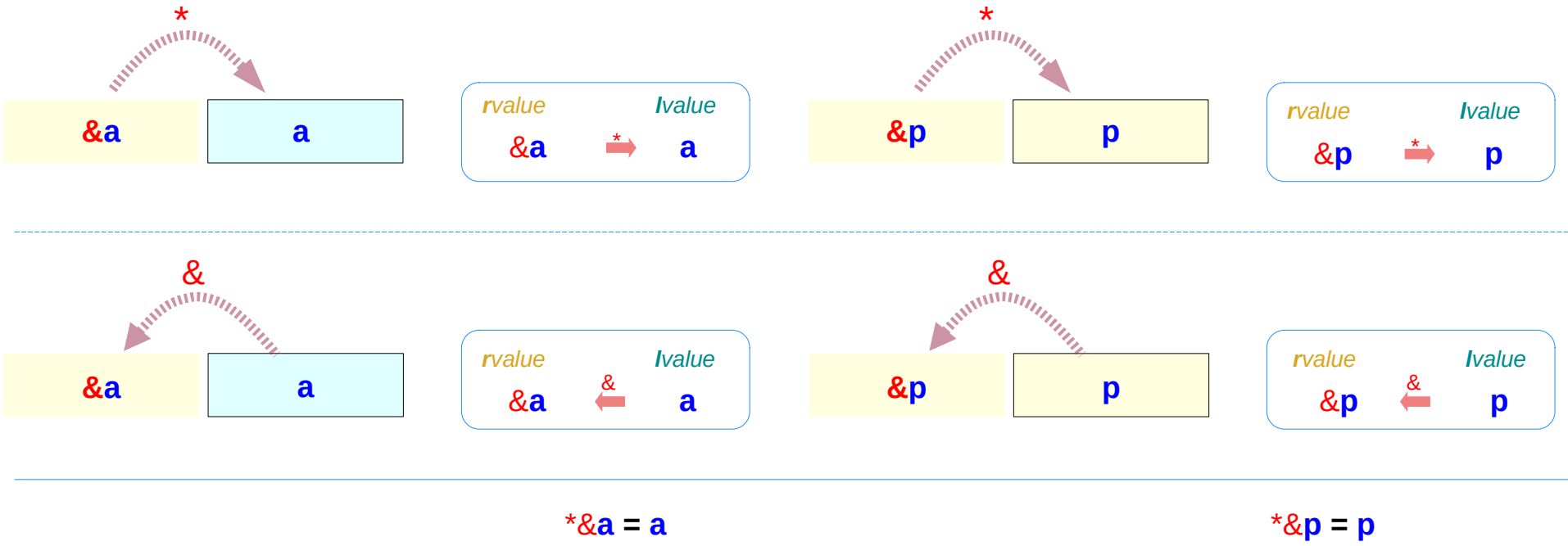
**rvalue** has the only attribute
- Value

assume the function value()

value(**lvalue**) returns
the Value attribute of **lvalue**

value(**rvalue**) returns
the Value attribute of **rvalue**

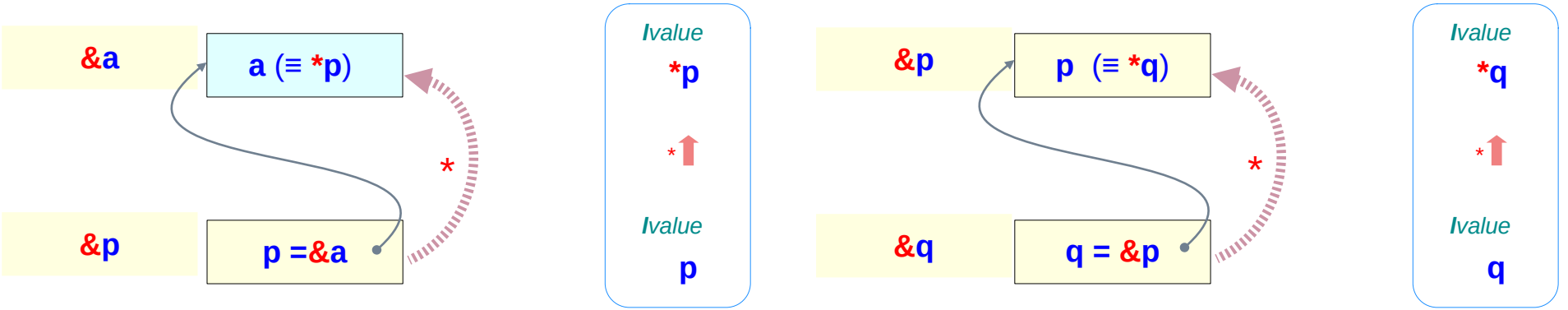
# Address-of & and dereference * C operators (1)

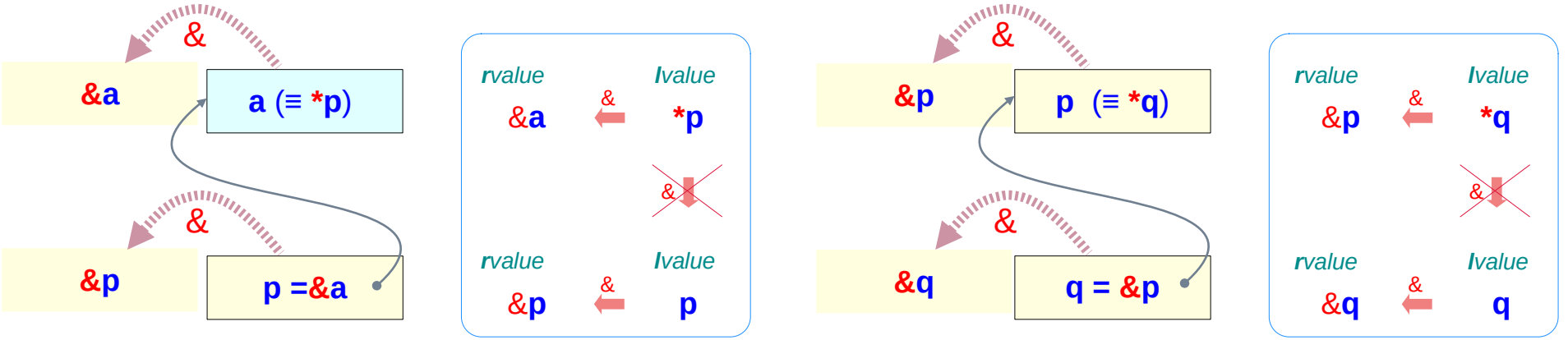



*&a = a

*&p = p

# Address-of & and dereference * C operators (2)



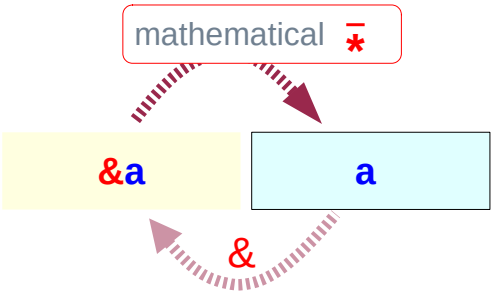

*&p = p

~~&*p = p~~ value(p)

*&q = q

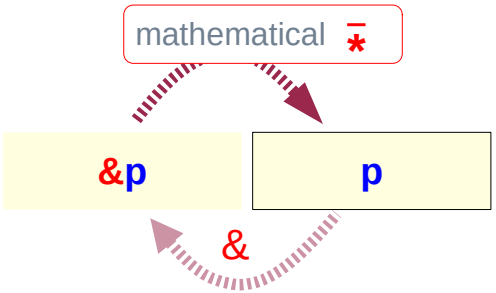
~~&*q = q~~ value(q)

# Introducing mathematical operators : $\overline{\&}$ and $\overline{*}$



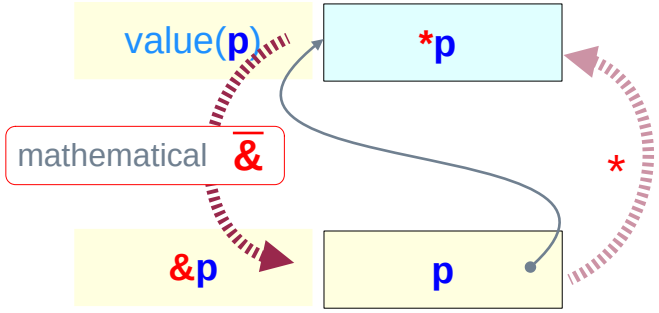

$\overline{*}$ &a = a

&a



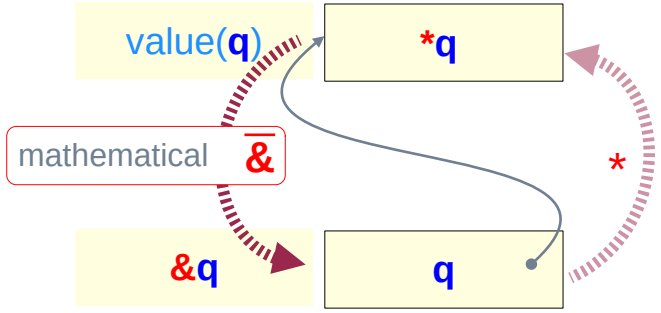

$\overline{*}$ &p = p

&p




*p

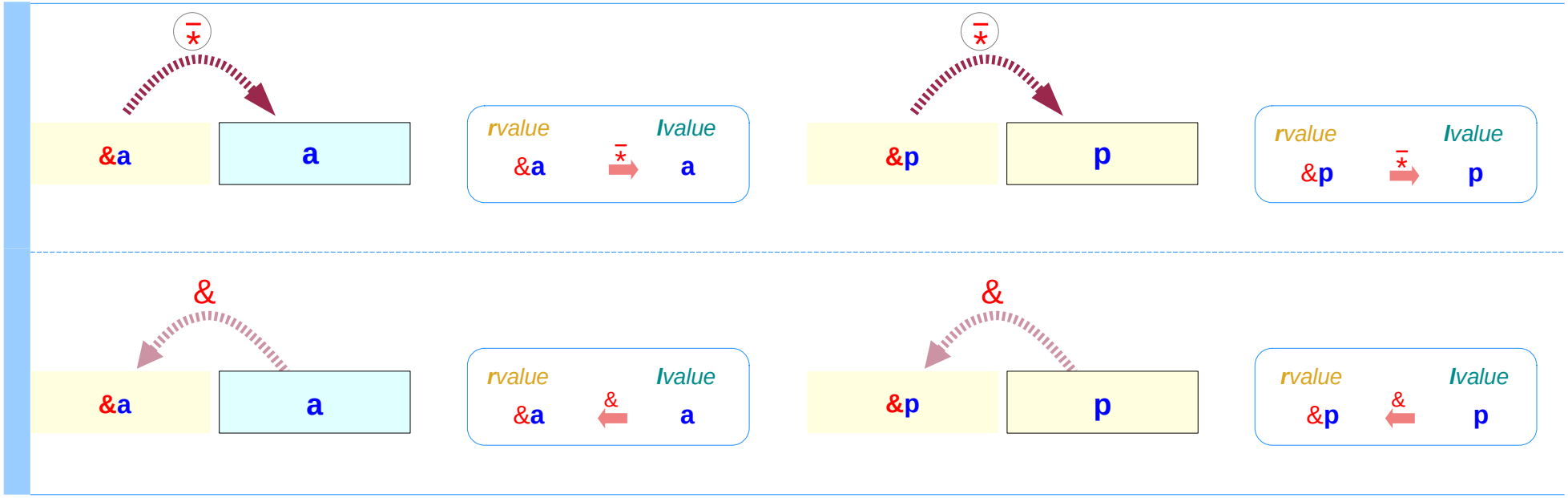
$\overline{\&}$ *p = p




*q

$\overline{\&}$ *q = q

# Inverse operators *̄ and &




*̄&a = a

&*̄&a = &a

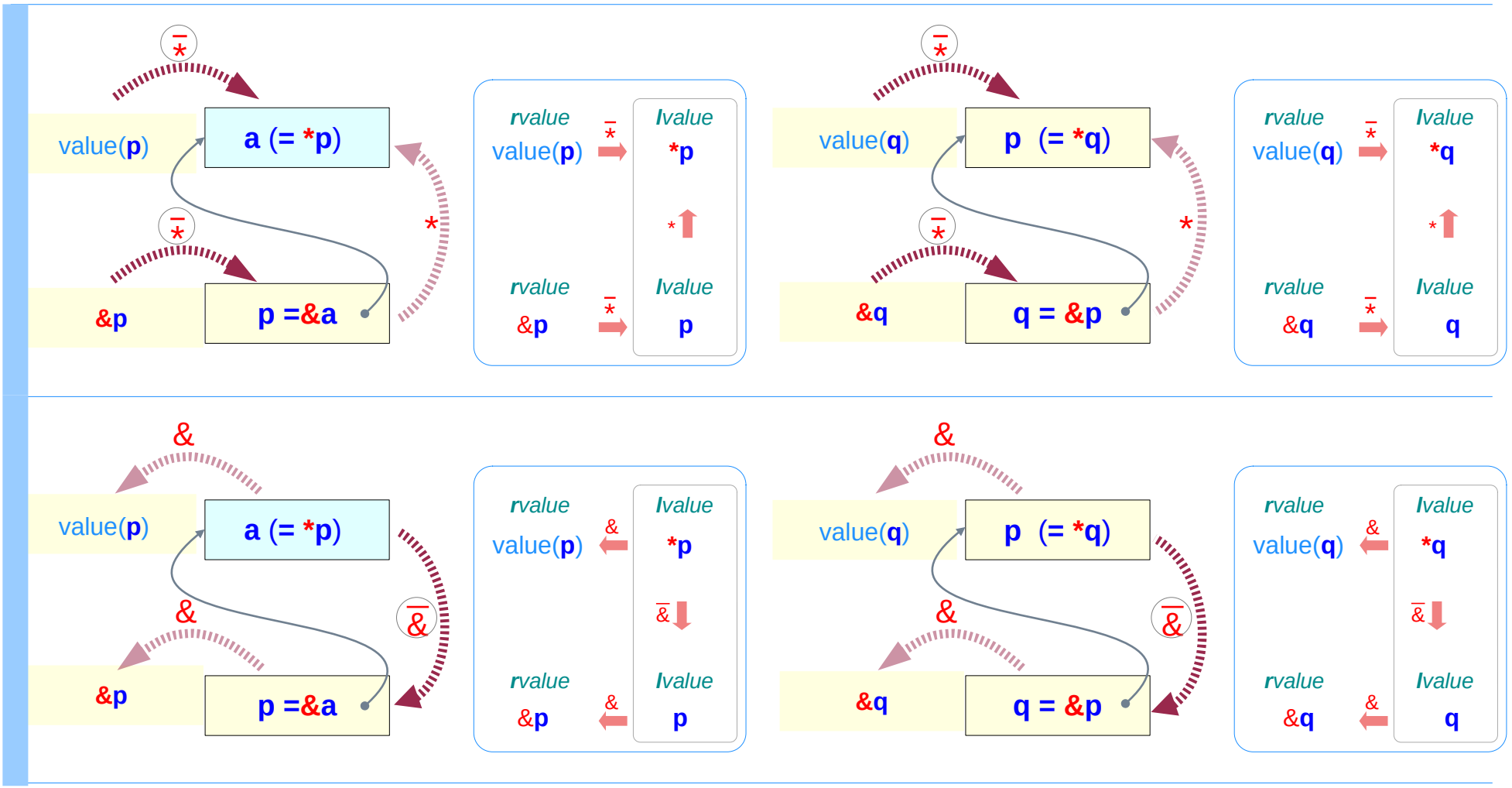
*̄ and & are
inverse operators
to each other

*̄&p = p

&*̄&p = &p

*̄ and & are
inverse operators
to each other

# Inverse operators $\overline{\&}$ and *




$\overline{*}\&p = p$

$\&\overline{*}p = p$

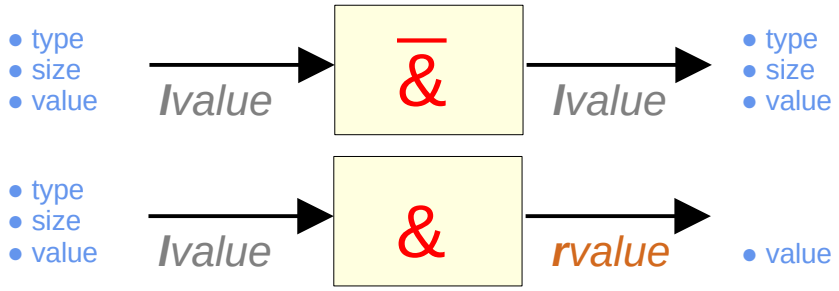
$\overline{*}\&q = q$

$\&\overline{*}q = q$

# C operators and mathematical operators

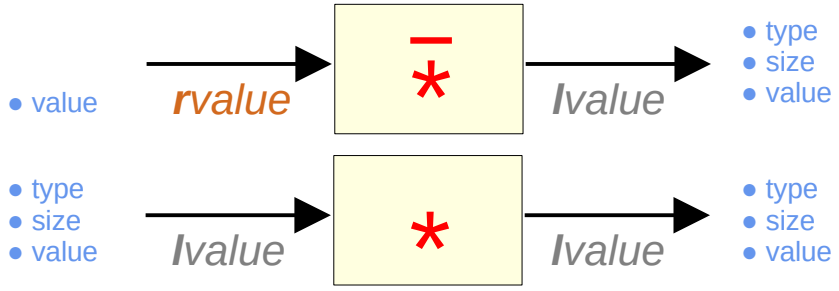
## Address-of operation

| &x | = | value(&x) |
|---|---|---|
| C Expressions | | Mixed Expressions |

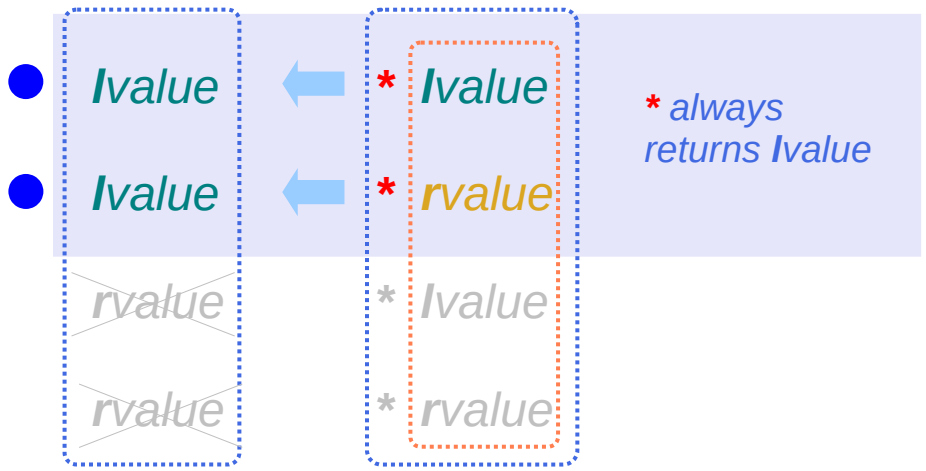


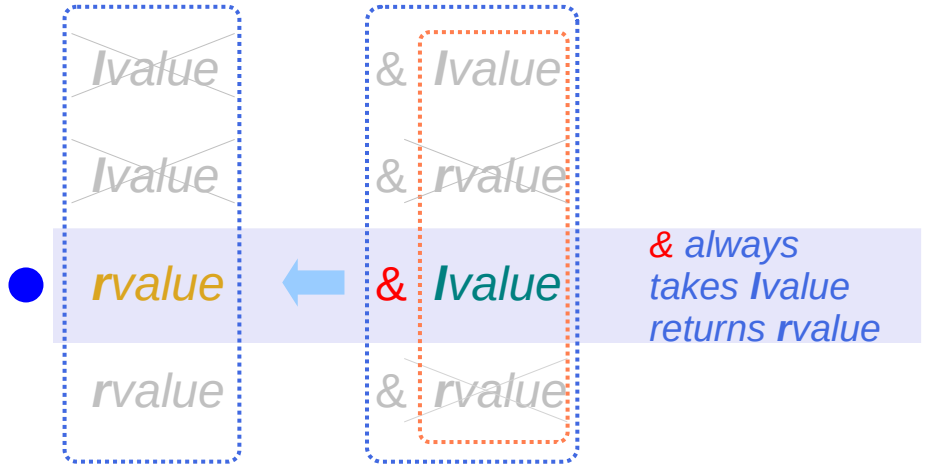

## De-reference operation

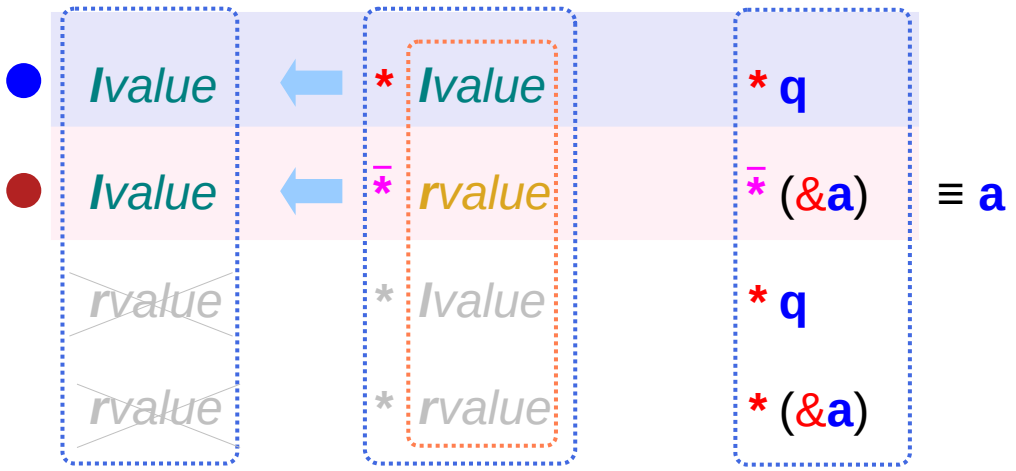
| *p | = | *value(p) |
|---|---|---|
| C Expressions | | Mixed Expressions |

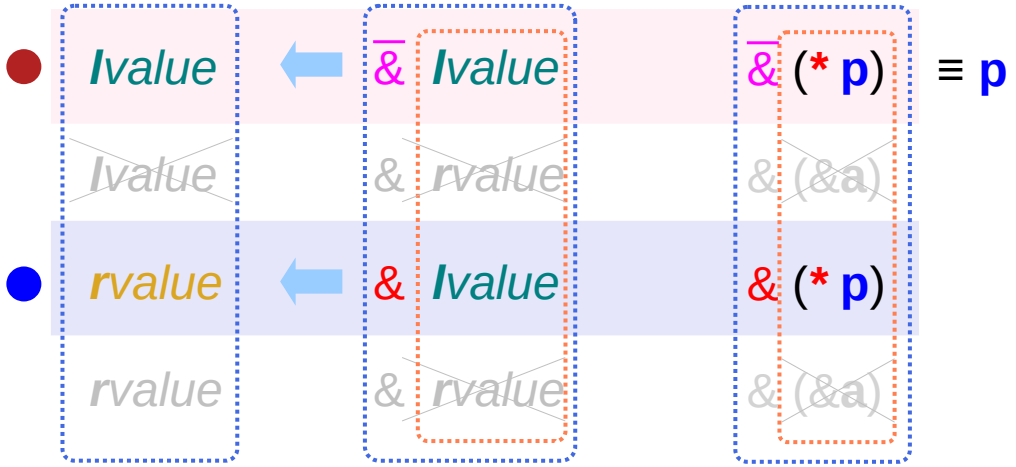


# lvalue and rvalue with * and & operators




**a**, **p**, **q** : lvalues … variables … RW
***p**, ***q**, ****q** : lvalues … variables … RW
**&a**, **&p**, **&q** : rvalues … constants … RO

# Examples of inverse operators

$\bar{*}\&a \Rightarrow a$

$\bar{*}\&p \Rightarrow p$

$\bar{*}\&q \Rightarrow q$

$\bar{*}value(p) \Rightarrow *p \Rightarrow a$

$\bar{*}value(q) \Rightarrow *q \Rightarrow p$

$\bar{*}value(*q) \Rightarrow **q \Rightarrow *p \Rightarrow a$

$\bar{\&}*p \Rightarrow p$

$\bar{\&}*q \Rightarrow q$

$\bar{\&}**q \Rightarrow *q$

**Extended Operators**

$*\&a \Rightarrow a$

$*\&p \Rightarrow p$

$*\&q \Rightarrow q$

$*p \Rightarrow a$

$*q \Rightarrow p$

$**q \Rightarrow *p \Rightarrow a$

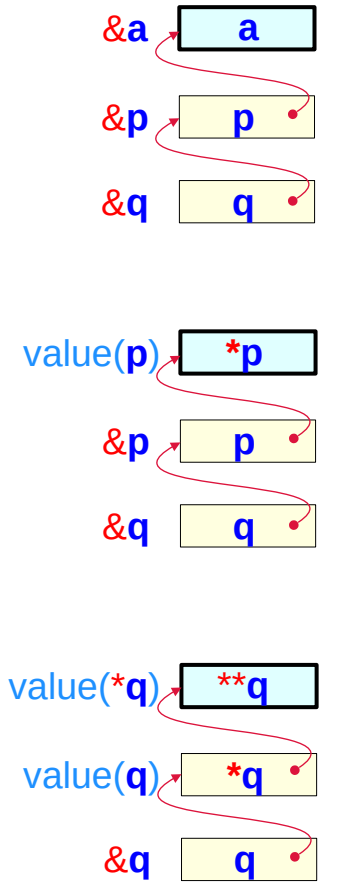
$\&*p \Rightarrow \&a$

$\&*q \Rightarrow \&p$

$\&**q \Rightarrow \&a$

**C Operators**

```
int    a ;
int *  p = & a ;
int ** q = & p ;
```



# Operands of mathematical operators : & and *

* address value

& * value(**P**) ➡ value(**P**)

* & variable

* &**X** ➡ **X**

& * pointer

& ***P** ➡ **P**

dereferenced pointer

& ~~pointer~~

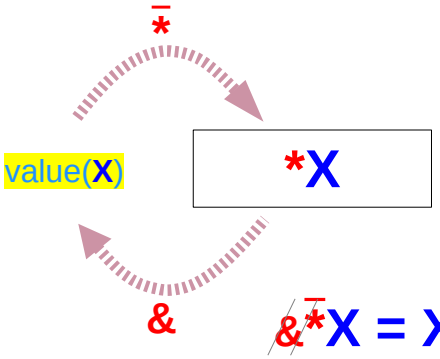
* &**Q** ➡ **Q**

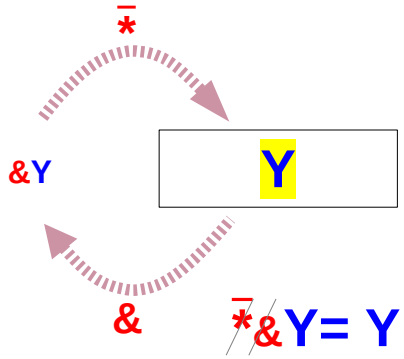
must be a dereferenced pointer

not considering
simultaneous pointing

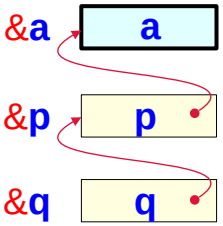
**Q** must be a dereferenced pointer
i.e, **Q = *p** ➡ &**Q = p**

# & and mathematical $\bar{*}$




```
int    a ;
int *  p = & a ;
int ** q = & p ;
```




& *value(**a**) = value(**a**)

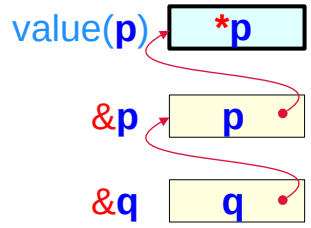
& *value(**p**) = value(**p**)

& *value(**q**) = value(**q**)

* &**a** = **a**

* &**p** = **p**

* &**q** = **q**




& ***a** = value(**a**)

& ***p** = value(**p**)

& ***q** = value(**q**)

* &**a** = **a**

* &**p** = **p**

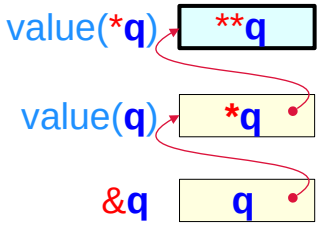
* &**q** = **q**

* &**a** = **a**

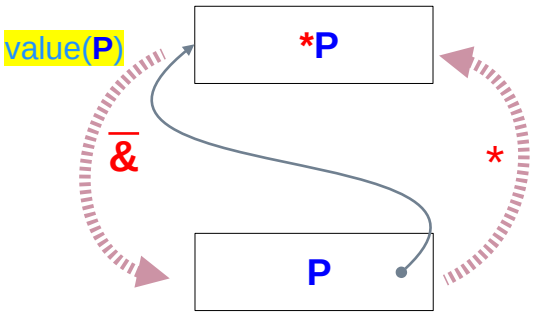
* &**p** = **p**

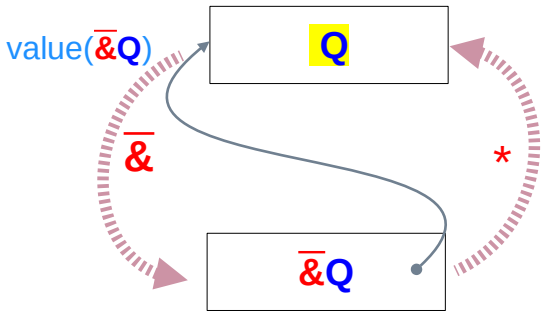
* &**q** = **q**

C expressions



# * and mathematical &




$\overline{\&}{}^{*}P = P$

if not considering simultaneous pointing

${}^{*}\overline{\&}Q = Q$

$\overline{\&}\ {}^{*}p = p$

$\overline{\&}\ {}^{*}q = q$

$\&\ {}^{*}p = value(p)$

$\&\ {}^{*}q = value(q)$

${}^{*}\ \overline{\&}{}^{*}p = {}^{*}p$

${}^{*}\ \overline{\&}{}^{*}q = {}^{*}q$

$\overline{{}^{*}}\ \&{}^{*}p = {}^{*}p$

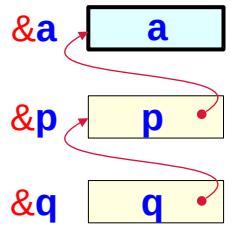
$\overline{{}^{*}}\ \&{}^{*}q = {}^{*}q$

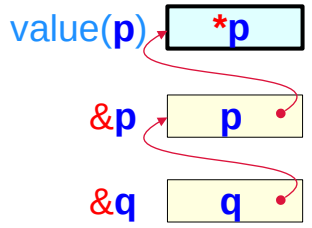
$* \ \&{}^{*}p = {}^{*}p$

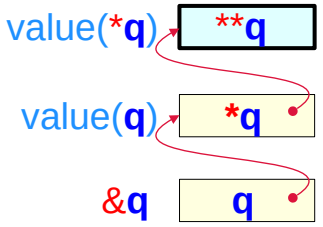
$* \ \&{}^{*}q = {}^{*}q$

C operators

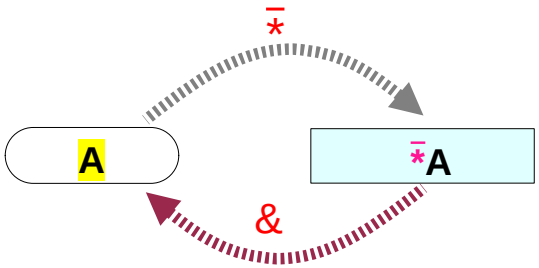
```
int    a ;
int *  p = & a ;
int ** q = & p ;
```



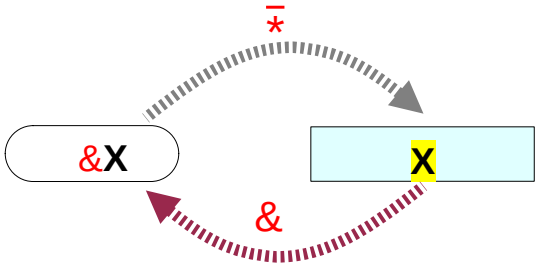



# Requirements of address and data



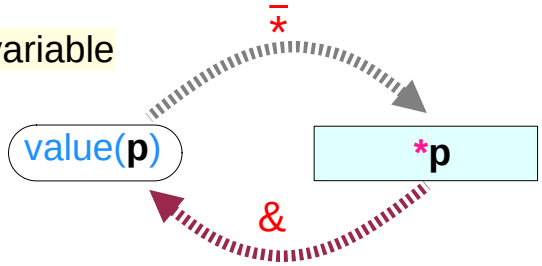

**A :** an address value - a number

value(**p**), &**p**, &**x**



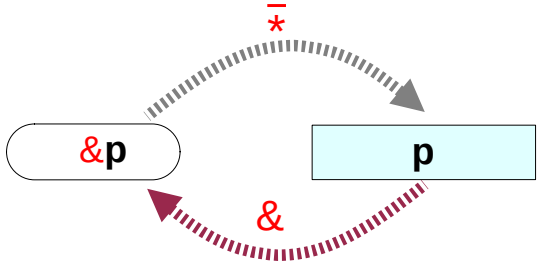

**X :** a variable ***p**, **p**, **a**

***p :** a dereferenced variable



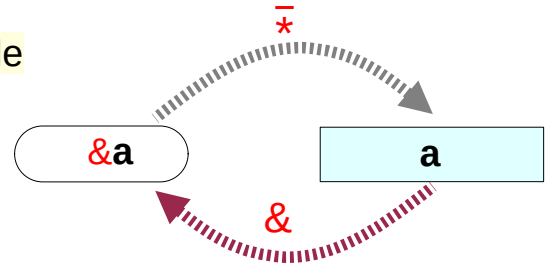

**Pointer Dereferencing**

**p :** a pointer variable




**Pointer Data**

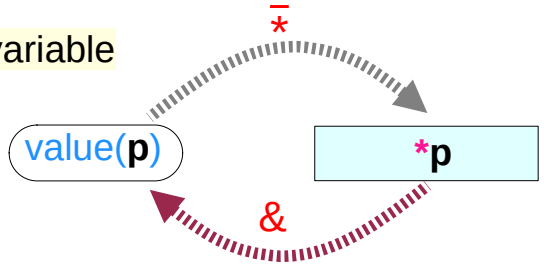
**a :** a primitive variable




**Non-pointer Data**

# Inverse relations of & and *̄ operators

***p :** a dereferenced variable

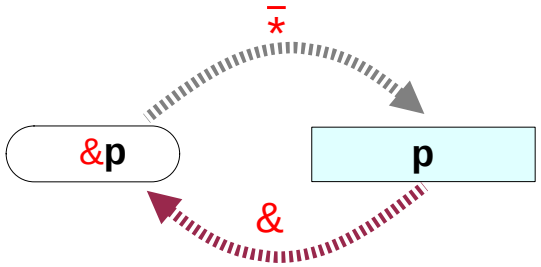



*̄ value(**p**) = ***p**

&*̄ value(**p**) = & ***p** = value(**p**)

*̄&*̄value(**p**) = *̄&***p** = *̄value(**p**) = ***p**

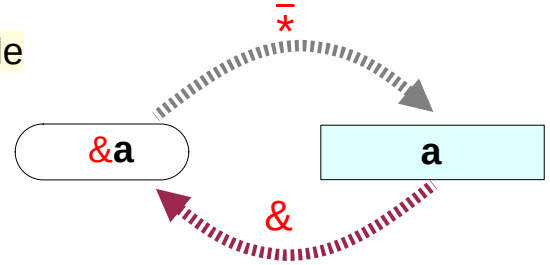
**p :** a pointer variable




*̄ &**p** = **p**

&*̄ &**p** = &**p**

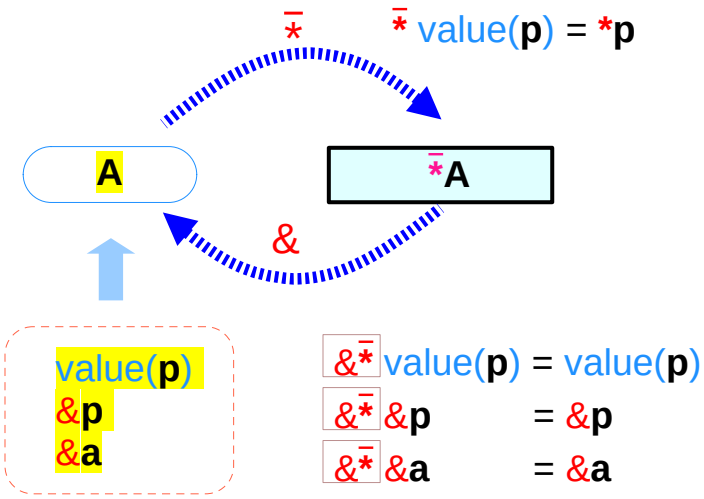
**a :** a primitive variable

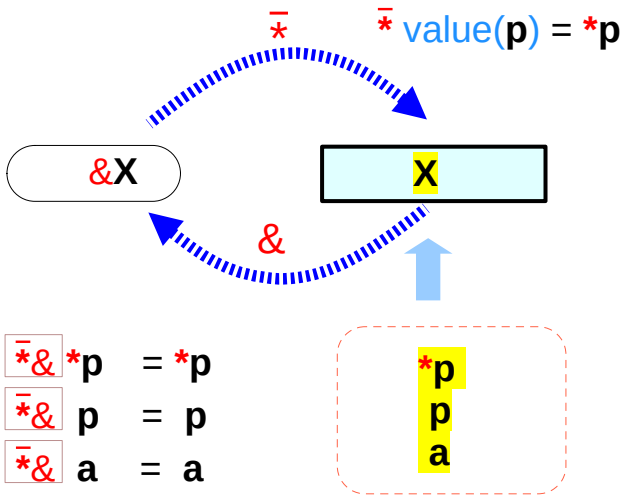


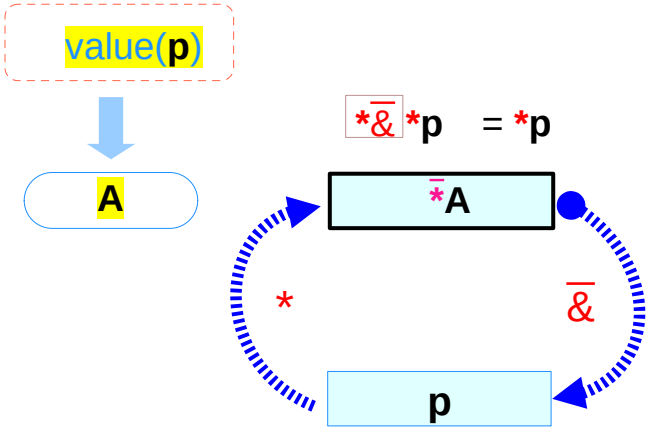

*̄ &**a** = **a**

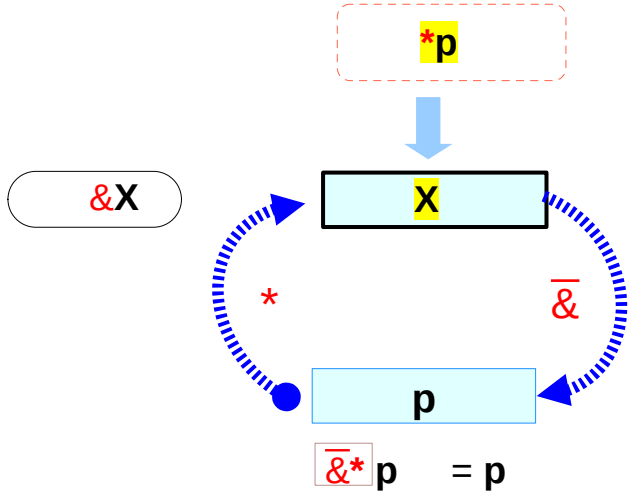
&*̄ &**a** = &**a**

# Requirements of pointed address and data



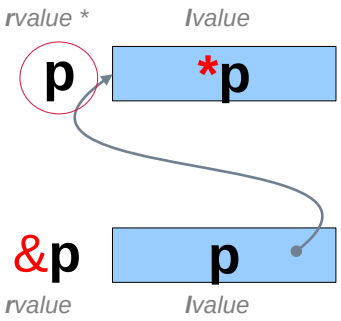



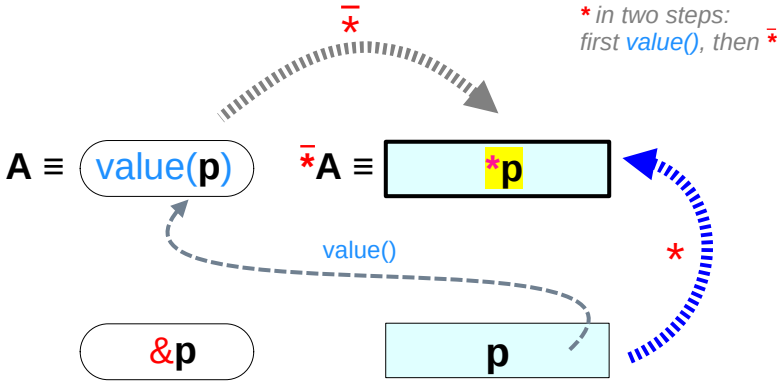



# & and * operators in pointer de-referecing (1)

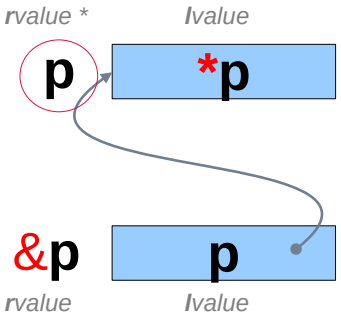
## Two step De-reference * operation



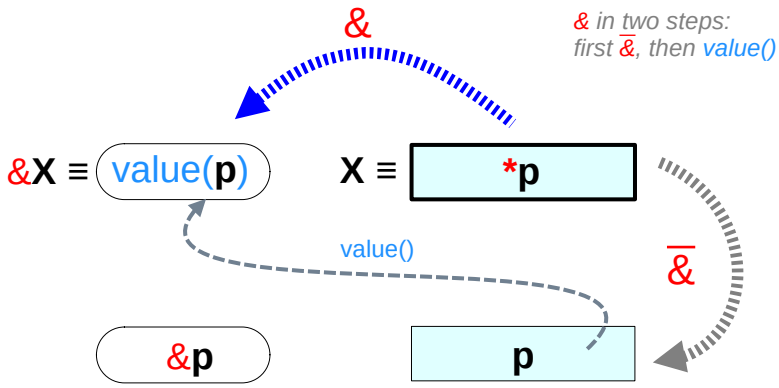

| | | |
|---|---|---|
| *p | = | $\bar{*}$value(p) |
| C Expressions | | Mixed Expressions |
| $\bar{*}$A | = | *value$^{-1}$(A) |




## Two step Address-of & operation

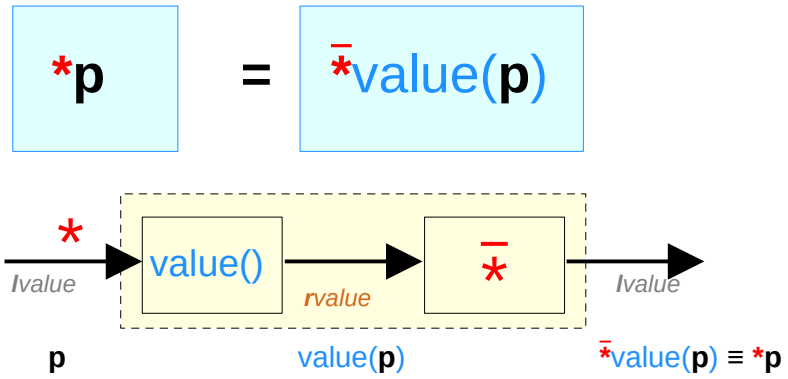


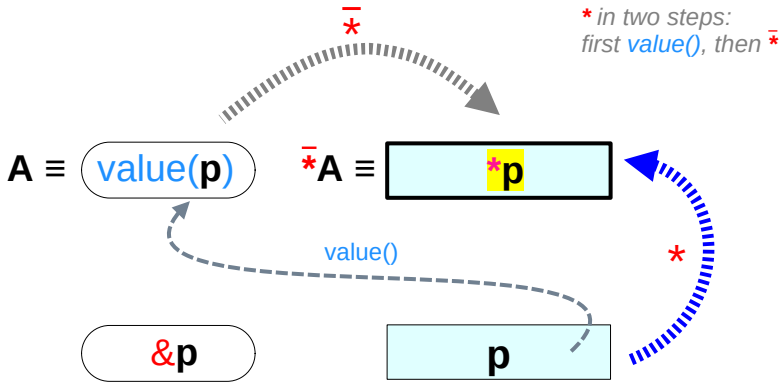

| | | |
|---|---|---|
| &X | = | value($\bar{\&}$X) |
| C Expressions | | Mixed Expressions |
| $\bar{\&}$X | = | value$^{-1}$(&X) |



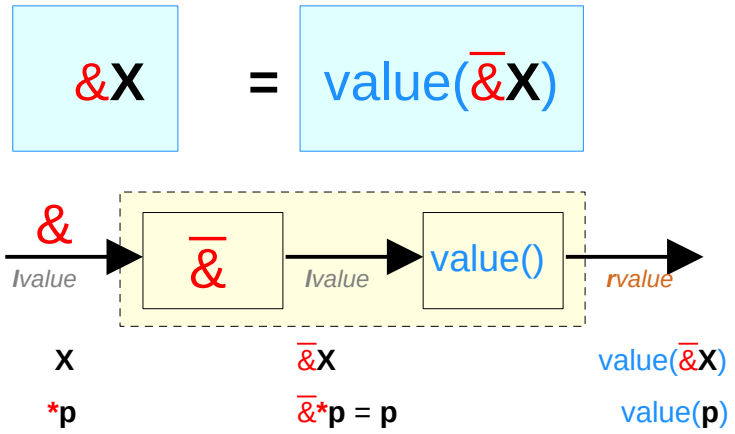
# & and * operators in pointer de-referecing (2)

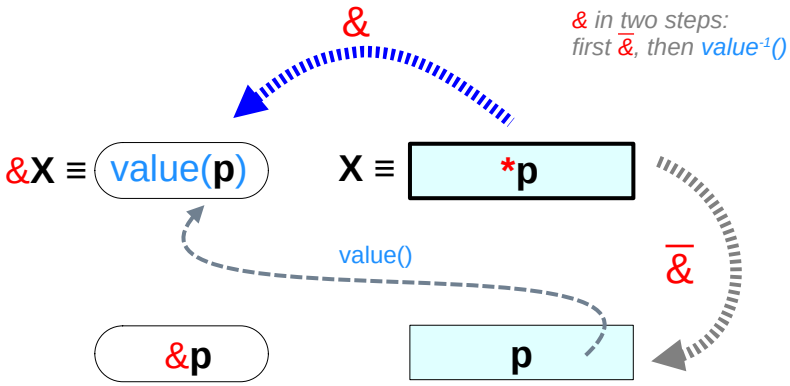
## Two step De-reference * operation



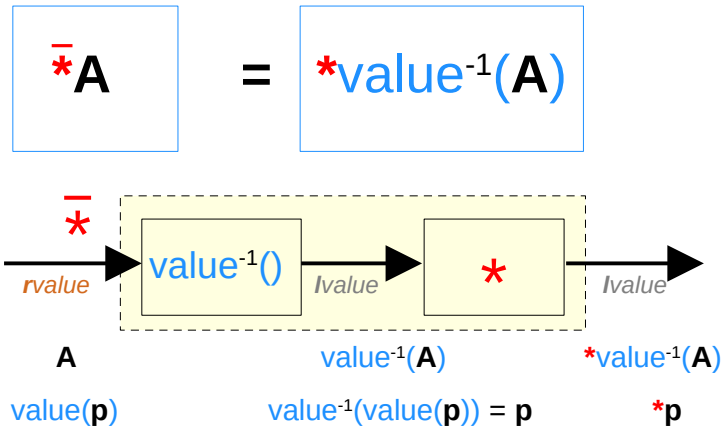

## Two step Address-of & operation

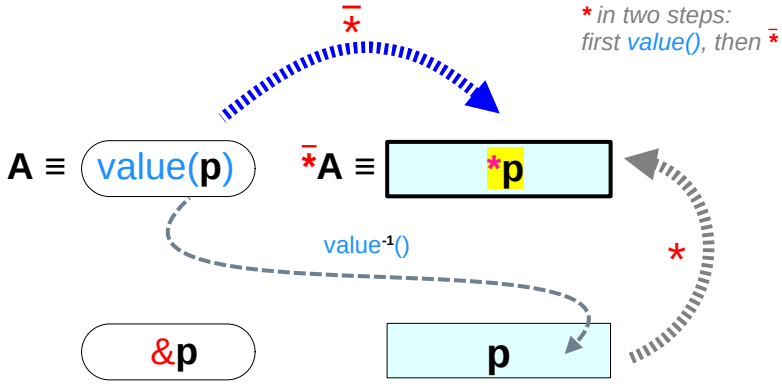


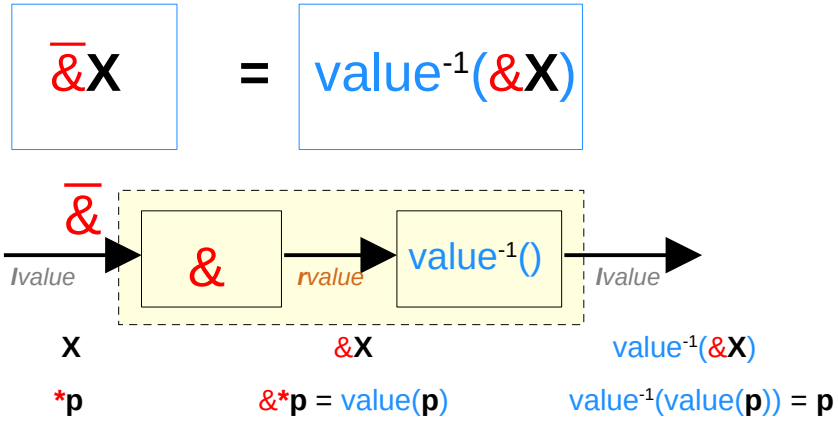
# & and * operators in pointer de-referecing (3)

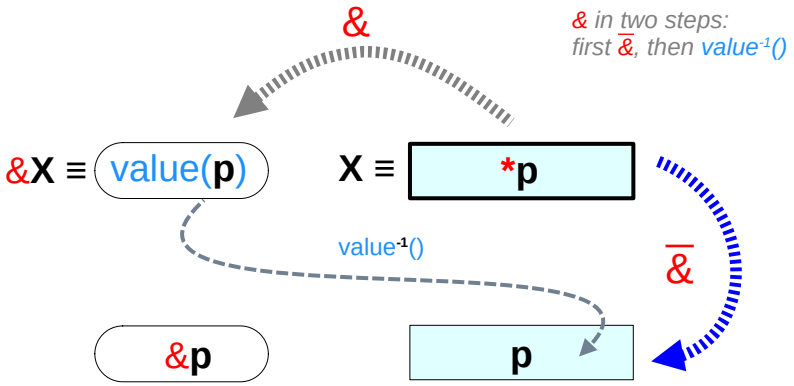
## Two step De-reference * operation




## Two step Address-of & operation



# Two step address-of & and $\overline{\&}$ operators

for &X, X can be *p, p, a

| &X | = | value($\overline{\&}$X) |
|---|---|---|

C Expressions

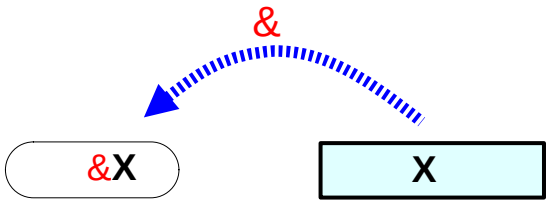
*p a dereferenced variable
p a pointer variable
a a primitive variable

& X

& *p = $\overline{\&}$ * value(p)
= value(p)

& p

& a




for $\overline{\&}$X = p, X must be *p

| $\overline{\&}$X | = | value$^{-1}$(&X) |
|---|---|---|

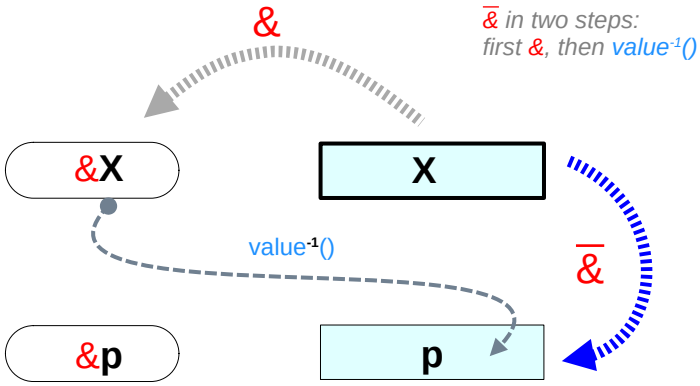
*p a dereferenced variable
~~p a pointer variable~~
~~a a primitive variable~~

$\overline{\&}$ X = p

$\overline{\&}$ *p ≡ p

~~$\overline{\&}$ p~~

~~$\overline{\&}$ a~~



# Two step de-referece *̄ and * operators

for *̄**A**, **A** can be value(**p**), &**p**, &**a**

*value(**p**)* *value of a pointer variable*
*&**p*** *address of a pointer variable*
*&**a*** *address of a primitive variable*

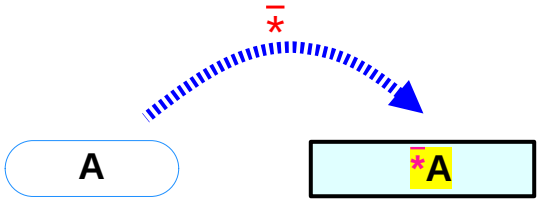
*̄**A** = ***value**$^{-1}$(**A**)

*̄ **A**

*̄ value(**p**) = ***p**

*̄ &**p** = **p**

*̄ &**a** = **a**




for *̄**A** = ***p**, **A** must be value(**p**)

*value(**p**)* *value of a pointer variable*
~~*&**p*** *address of a pointer variable*~~
~~*&**a*** *address of a primitive variable*~~

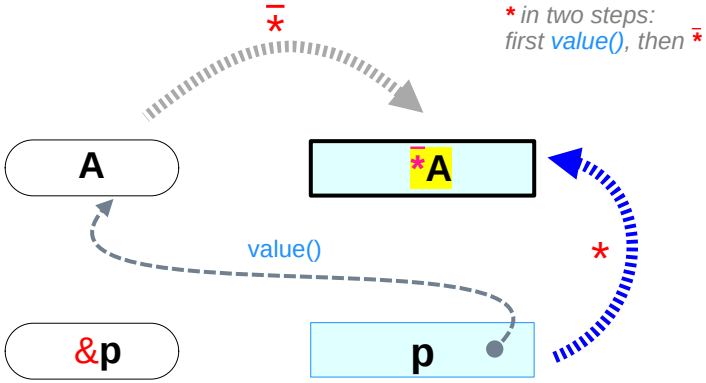
***p** = *̄***value**(**p**)

***p**

***p** ≡ *̄value(**p**)

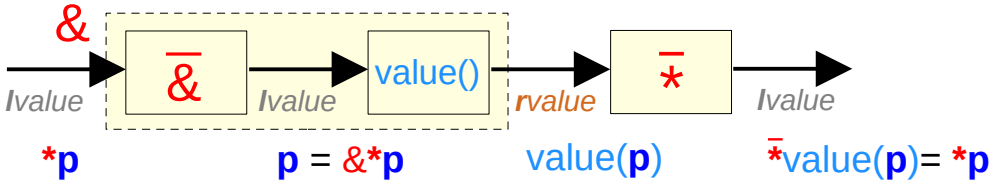
~~* &**p** = **p**~~

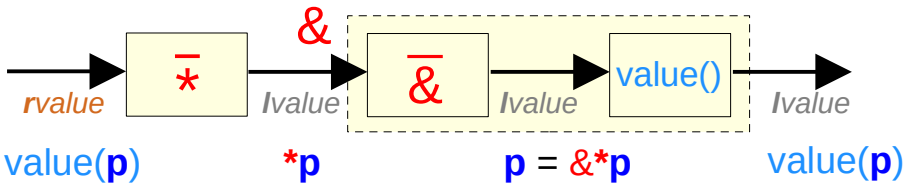
~~* &**a** = **a**~~

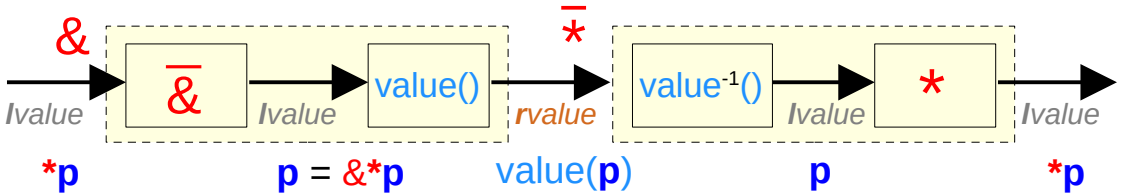


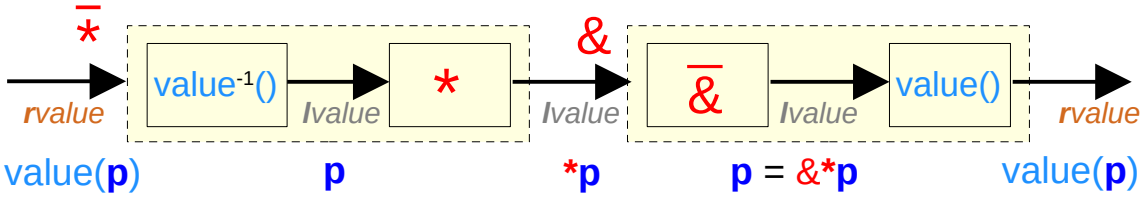

C Expressions

# Inverse operators : & and $\bar{*}$ in pointer de-referencing



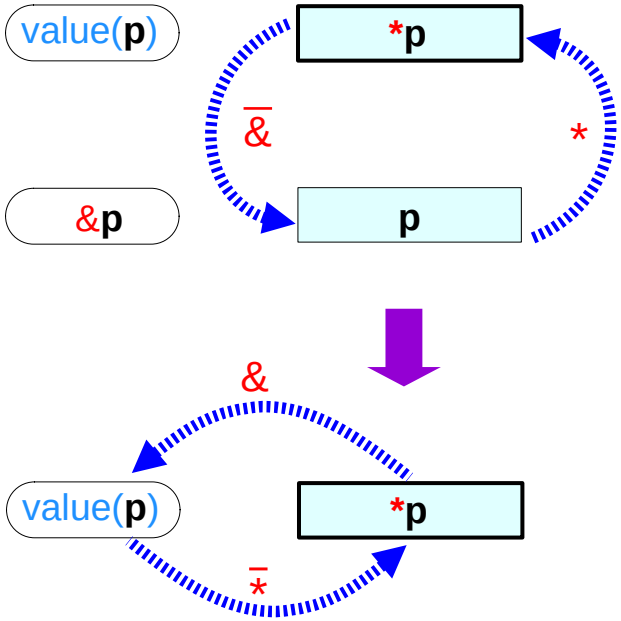



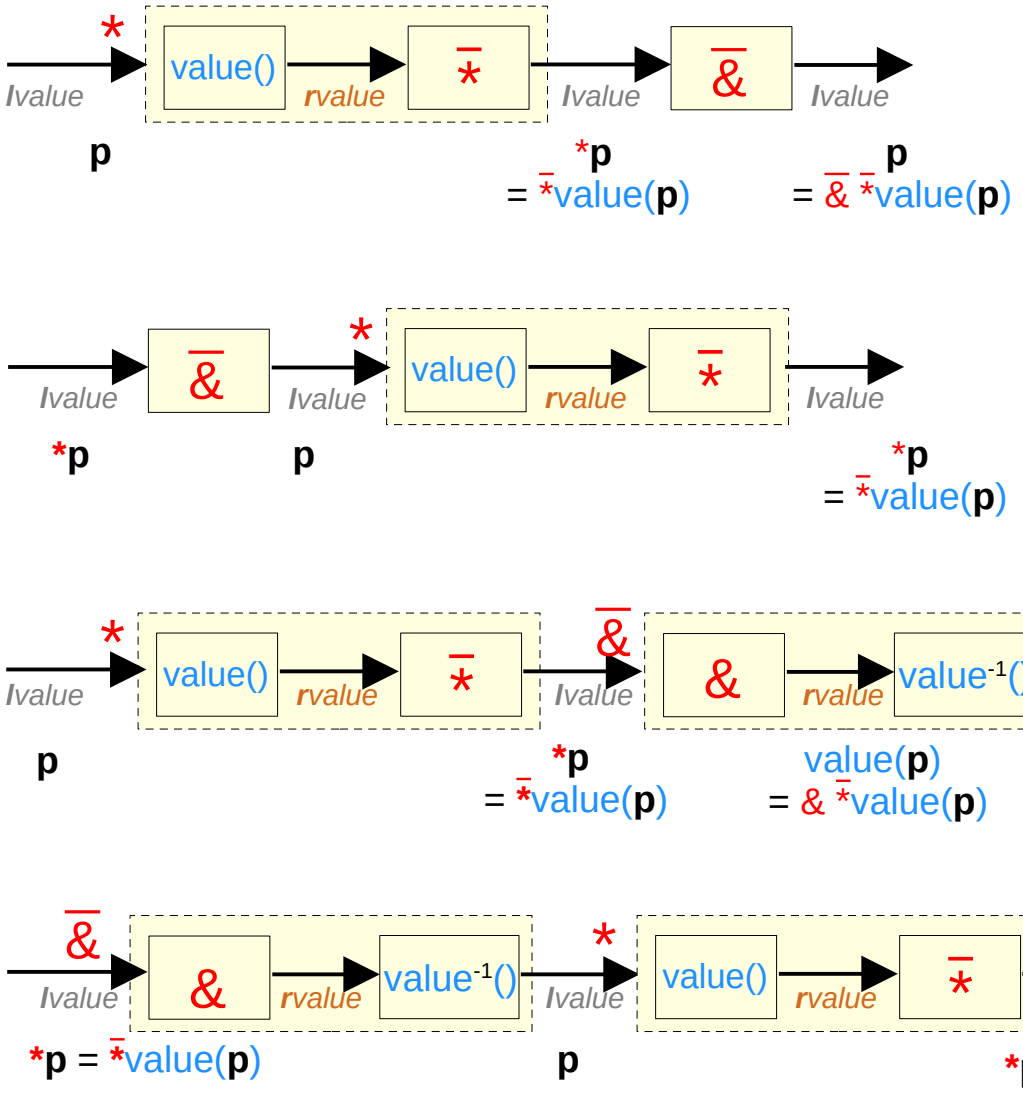

$\bar{*}$ value(**p**) = ***p**

$\bar{*}$ value(**p**) = & ***p** = value(**p**)

$\bar{*}\&\ \bar{*}$value(**p**) = $\bar{*}\&$ ***p** = $\bar{*}$value(**p**) = ***p**



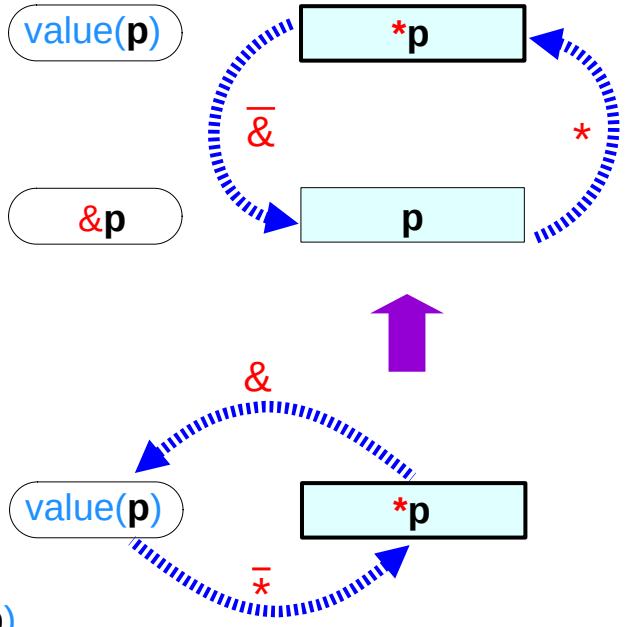
# Inverse operators of & and *




$\bar{*}$ value(**p**) = ***p**

$\bar{\&}$ * **p** = **p**  **p** = $\bar{\&}$ $\bar{*}$value(**p**)

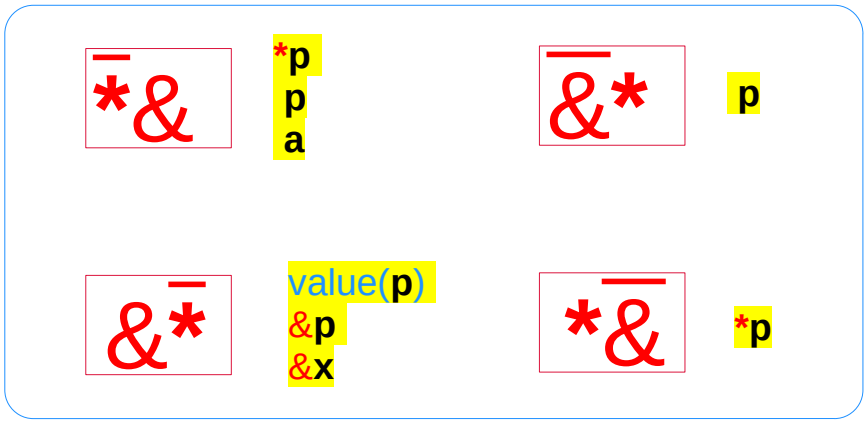
* $\bar{\&}$ ***p** = ***p**  value(**p**) = $\bar{\&}$ $\bar{*}$value(**p**)



# Inverse operators in pointer referencing (1)

*& *p = *p
*& p = p
*& a = a

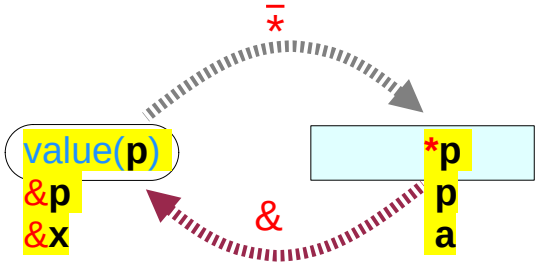
&* value(p) = value(p)
&* &p = &p
&* &a = &a

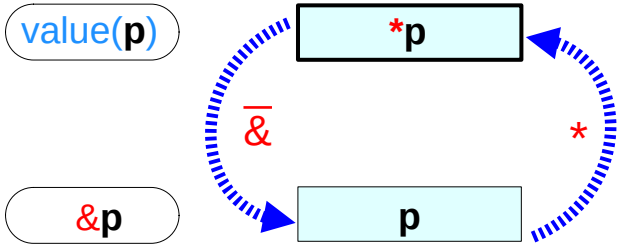



&* p = p

*& *p = *p

**Math expressions**

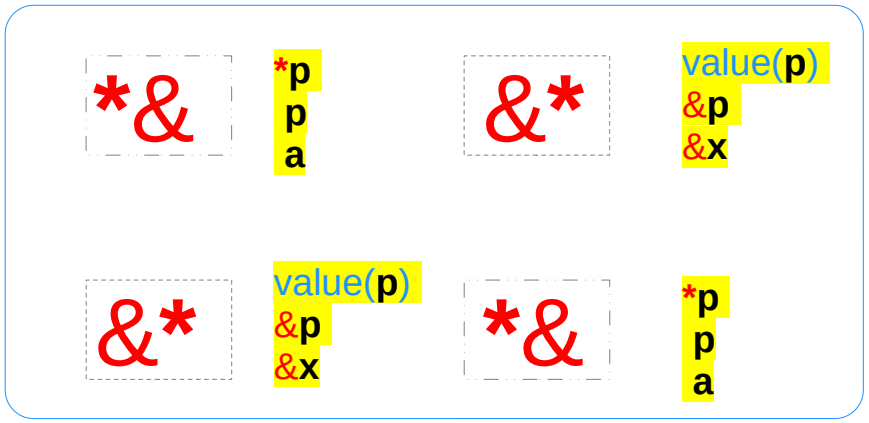


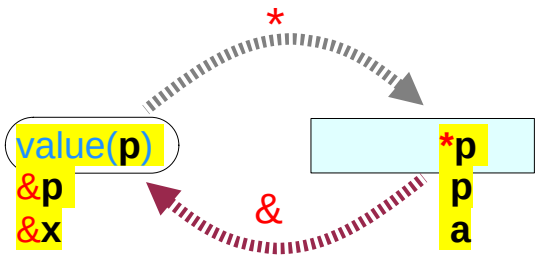
# Inverse operators in pointer referencing (2)

*& *p = *p
*& p = p
*& a = a

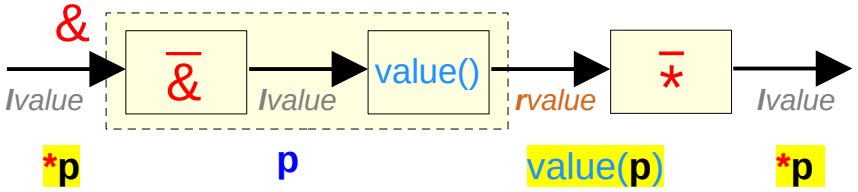
&* value(p) = value(p)
&* &p = &p
&* &a = &a

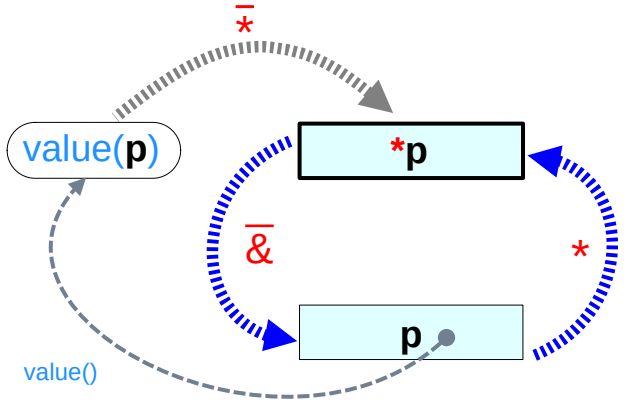


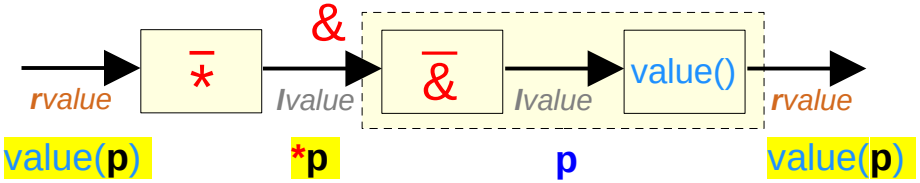

**C expressions**

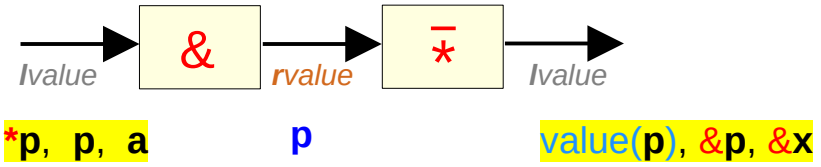


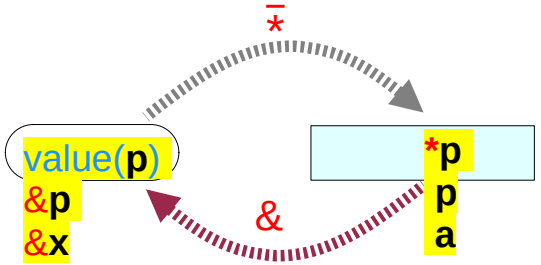
# Inverse operators in pointer referencing (3)

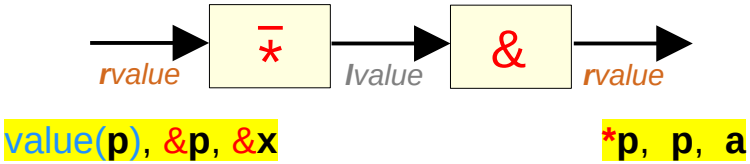


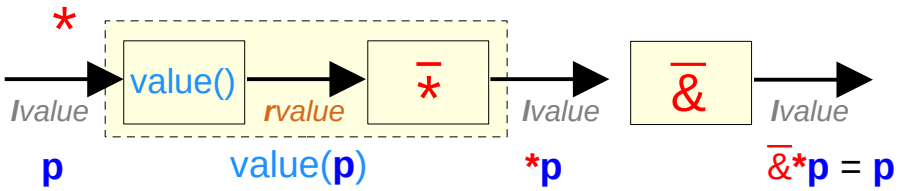



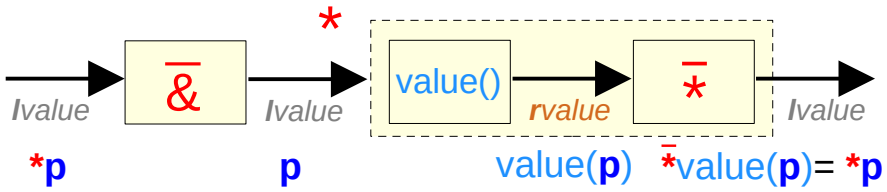



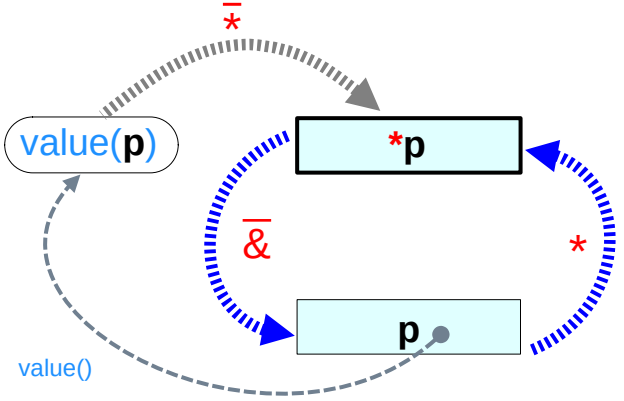



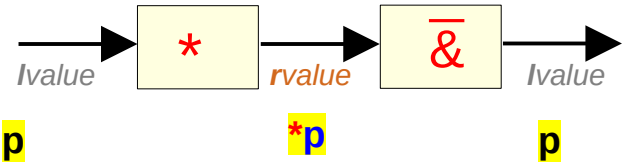



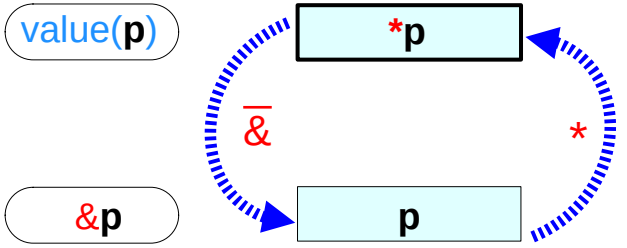
# Inverse operators in pointer referencing (3)

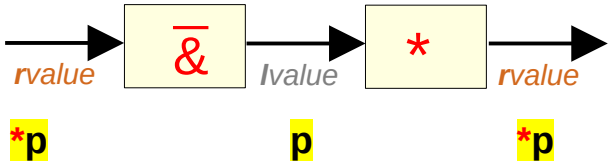


## References


[1] Essential C, Nick Parlante
[2] Efficient C Programming, Mark A. Weiss
[3] C A Reference Manual, Samuel P. Harbison & Guy L. Steele Jr.
[4] C Language Express, I. K. Chun