Multilevel Pointers

Advanced C

Pointers – Multilevel

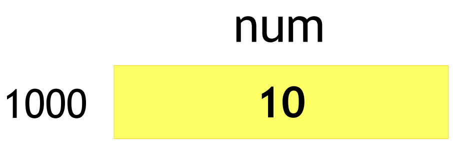
- A pointer, pointing to another pointer which can be pointing to others pointers and so on is know as multilevel pointers.
- We can have any level of pointers.
- As the depth of the level increase we have to bit careful while dealing with it.

Advanced C

Pointers - Multilevel

001_example.c

```
#include <stdio.h>

int main()
{
    int num = 10;
    int *ptr1 = &num;
    int **ptr2 = &ptr1;
    int ***ptr3 = &ptr2;

    printf(“%d”, ptr3);
    printf(“%d”, *ptr3);
    printf(“%d”, **ptr3);
    printf(“%d”, ***ptr3);

    return 0;
}
```

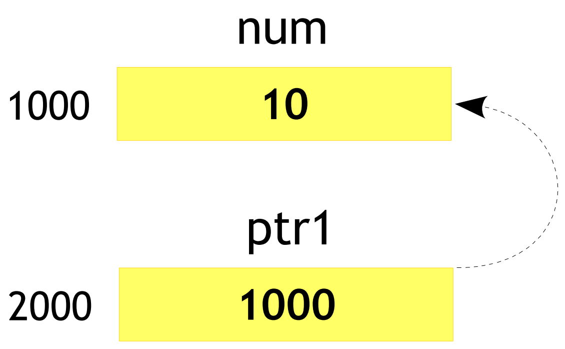


Advanced C

Pointers - Multilevel

001_example.c

```
#include <stdio.h>

int main()
{
    int num = 10;
    int *ptr1 = &num;
    int **ptr2 = &ptr1;
    int ***ptr3 = &ptr2;

    printf("%d", ptr3);
    printf("%d", *ptr3);
    printf("%d", **ptr3);
    printf("%d", ***ptr3);

    return 0;
}
```

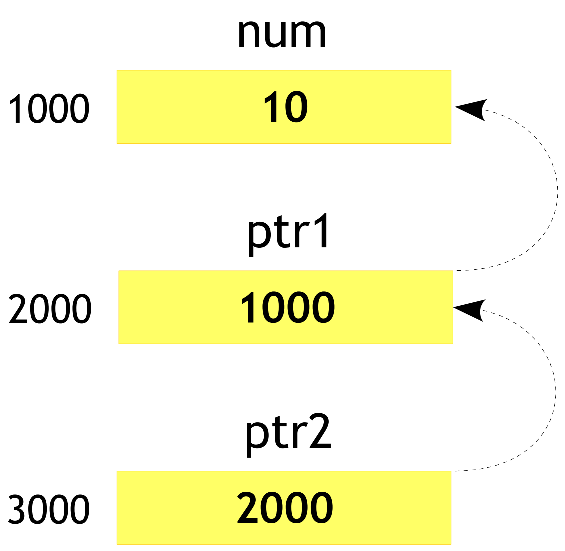


Advanced C

Pointers - Multilevel

001_example.c

```c
#include <stdio.h>

int main()
{
    int num = 10;
    int *ptr1 = &num;
    int **ptr2 = &ptr1;
    int ***ptr3 = &ptr2;

    printf("%d", ptr3);
    printf("%d", *ptr3);
    printf("%d", **ptr3);
    printf("%d", ***ptr3);

    return 0;
}
```



num

1000 | 10

ptr1

2000 | 1000

ptr2

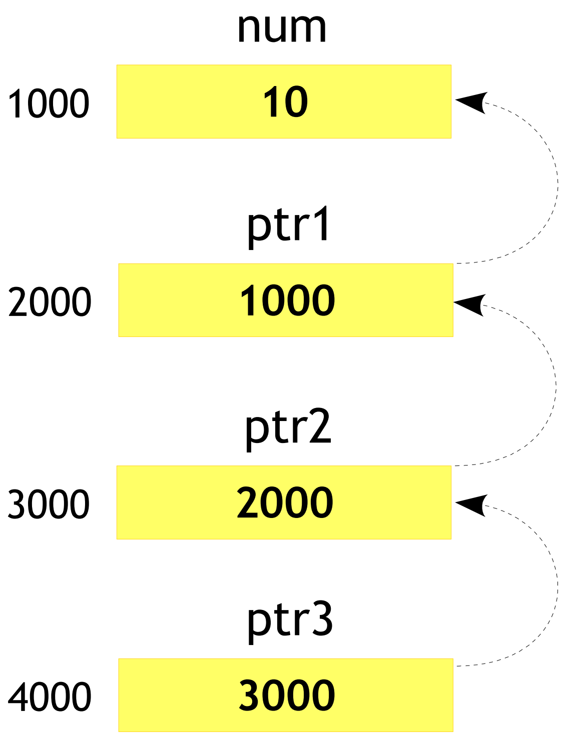
3000 | 2000

Advanced C

Pointers – Multilevel

001_example.c

```
#include <stdio.h>

int main()
{
    int num = 10;
    int *ptr1 = &num;
    int **ptr2 = &ptr1;
    int ***ptr3 = &ptr2;

    printf(“%d”, ptr3);
    printf(“%d”, *ptr3);
    printf(“%d”, **ptr3);
    printf(“%d”, ***ptr3);

    return 0;
}
```

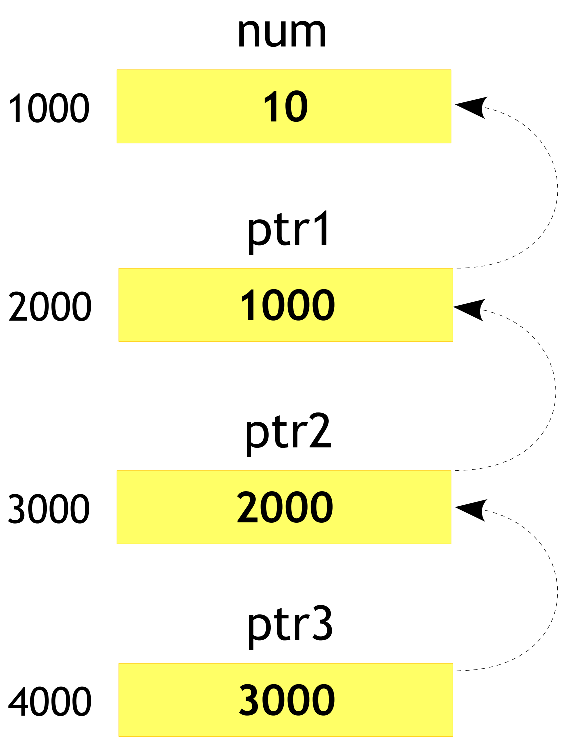


Advanced C

Pointers – Multilevel

001_example.c

```
#include <stdio.h>

int main()
{
    int num = 10;
    int *ptr1 = &num;
    int **ptr2 = &ptr1;
    int ***ptr3 = &ptr2;

    printf(“%d”, ptr3);
    printf(“%d”, *ptr3);
    printf(“%d”, **ptr3);
    printf(“%d”, ***ptr3);

    return 0;
}
```



num
1000 10

ptr1
2000 1000

ptr2
3000 2000

ptr3
4000 3000

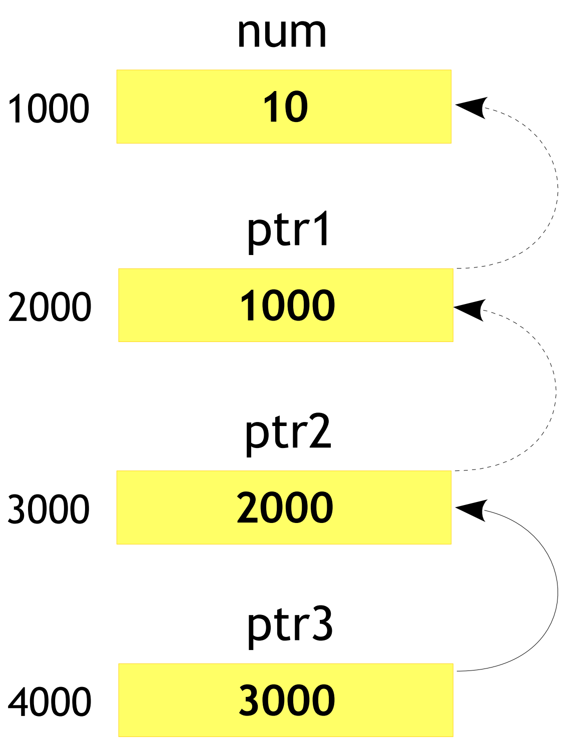
Output → 3000

Advanced C

Pointers - Multilevel

001_example.c

```c
#include <stdio.h>

int main()
{
    int num = 10;
    int *ptr1 = &num;
    int **ptr2 = &ptr1;
    int ***ptr3 = &ptr2;

    printf(“%d”, ptr3);
    printf(“%d”, *ptr3);
    printf(“%d”, **ptr3);
    printf(“%d”, ***ptr3);

    return 0;
}
```



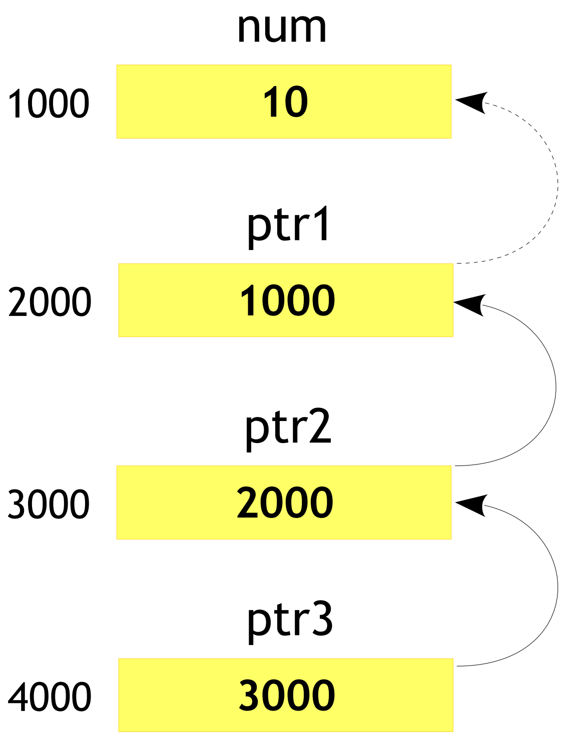
Output → 2000

Advanced C

Pointers – Multilevel

001_example.c

```
#include <stdio.h>

int main()
{
    int num = 10;
    int *ptr1 = &num;
    int **ptr2 = &ptr1;
    int ***ptr3 = &ptr2;

    printf(“%d”, ptr3);
    printf(“%d”, *ptr3);
    printf(“%d”, **ptr3);
    printf(“%d”, ***ptr3);

    return 0;
}
```



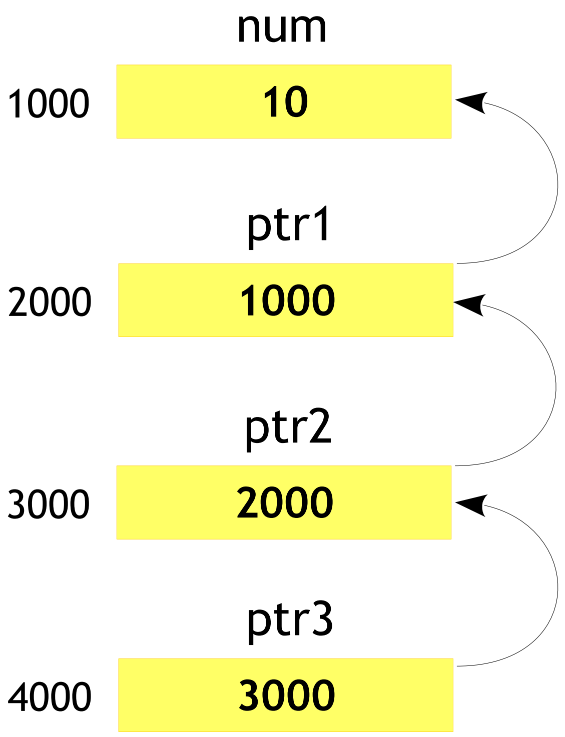
Output → 1000

Advanced C

Pointers – Multilevel

001_example.c

```
#include <stdio.h>

int main()
{
    int num = 10;
    int *ptr1 = &num;
    int **ptr2 = &ptr1;
    int ***ptr3 = &ptr2;

    printf(“%d”, ptr3);
    printf(“%d”, *ptr3);
    printf(“%d”, **ptr3);
    printf(“%d”, ***ptr3);

    return 0;
}
```



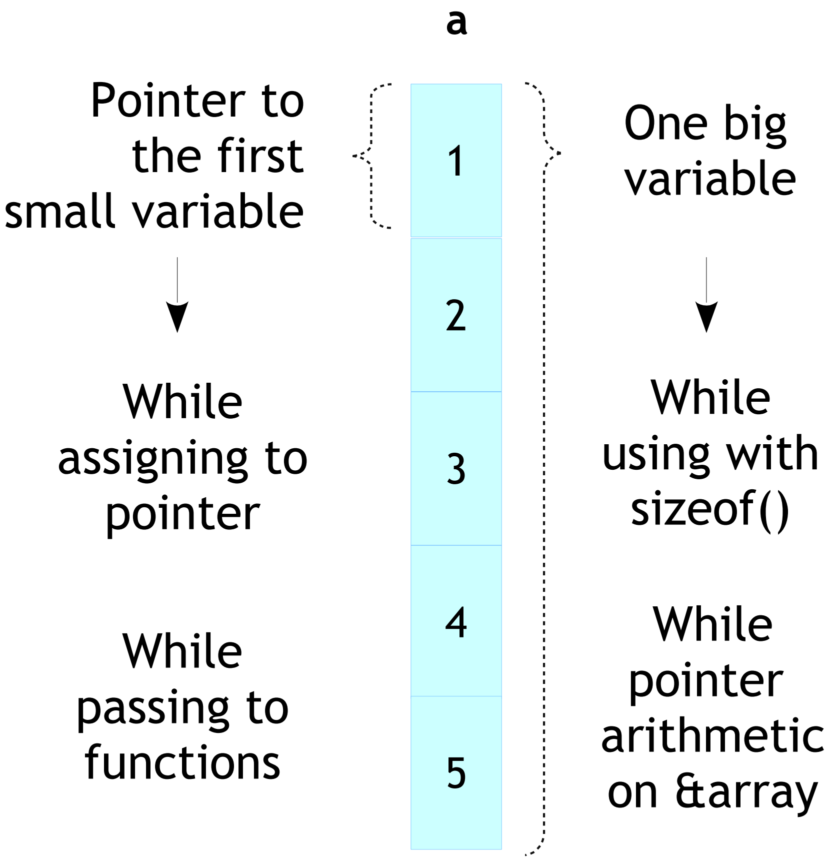
Output → 10

Advanced C

Arrays - Interpretations

Example

```
#include <stdio.h>

int main()
{
    int a[5] = {1, 2, 3, 4, 5};

    return 0;
}
```



Pointer to the first small variable

While assigning to pointer

While passing to functions

One big variable

While using with sizeof()

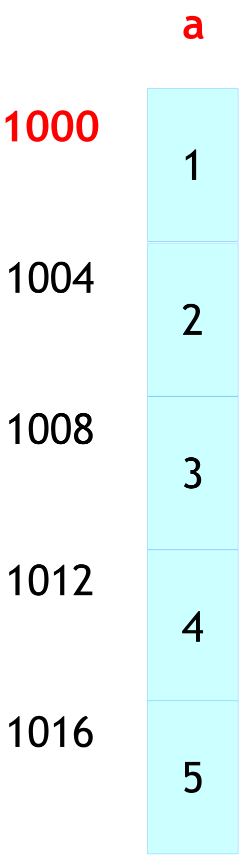
While pointer arithmetic on &array

Advanced C

Arrays - Interpretations

002_example.c

```c
#include <stdio.h>

int main()
{
    int a[5] = {1, 2, 3, 4, 5};

    printf(“%p\n”, a);
    printf(“%p\n”, &a[0]);
    printf(“%p\n”, &a);

    return 0;
}
```



a

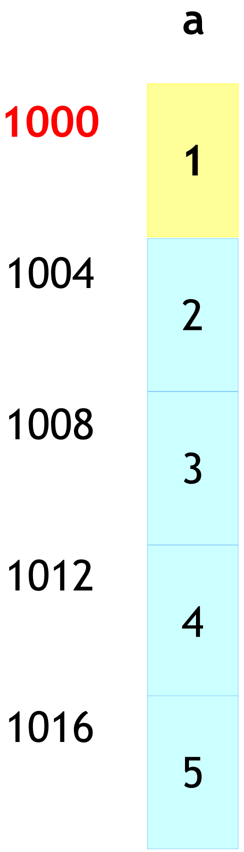
1000	1
1004	2
1008	3
1012	4
1016	5

Advanced C

Arrays - Interpretations

002_example.c

```c
#include <stdio.h>

int main()
{
    int a[5] = {1, 2, 3, 4, 5};

    printf(“%p\n”, a);
    printf(“%p\n”, &a[0]);
    printf(“%p\n”, &a);

    return 0;
}
```



a

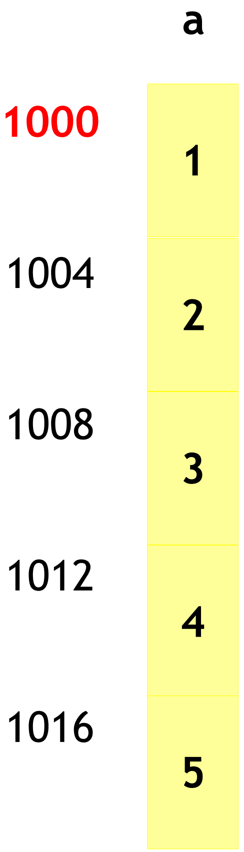
1000	1
1004	2
1008	3
1012	4
1016	5

Advanced C

Arrays - Interpretations

002_example.c

```
#include <stdio.h>

int main()
{
    int a[5] = {1, 2, 3, 4, 5};

    printf("%p\n", a);
    printf("%p\n", &a[0]);
    printf("%p\n", &a);

    return 0;
}
```



a

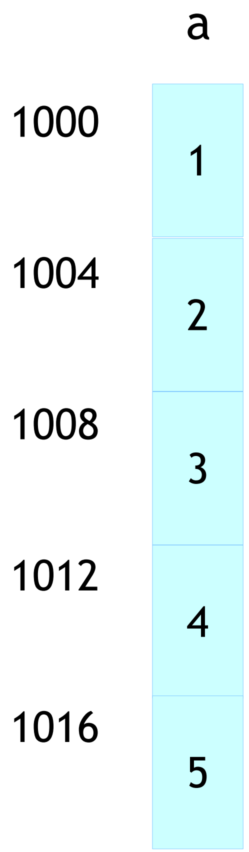
1000	1
1004	2
1008	3
1012	4
1016	5

Advanced C

Arrays - Interpretations

003_example.c

```
#include <stdio.h>

int main()
{
    int a[5] = {1, 2, 3, 4, 5};

    printf(“%p\n”, a + 1);
    printf(“%p\n”, &a[0] + 1);
    printf(“%p\n”, &a + 1);

    return 0;
}
```



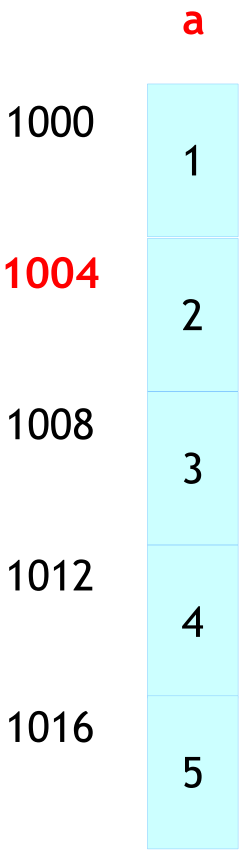
	a
1000	1
1004	2
1008	3
1012	4
1016	5

Advanced C

Arrays - Interpretations

003_example.c

```c
#include <stdio.h>

int main()
{
    int a[5] = {1, 2, 3, 4, 5};

    printf("%p\n", a + 1);
    printf("%p\n", &a[0] + 1);
    printf("%p\n", &a + 1);

    return 0;
}
```

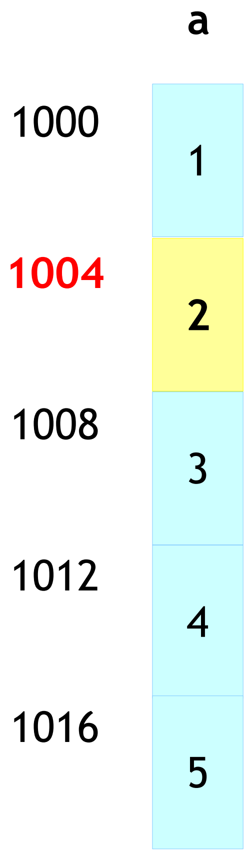


Advanced C

Arrays - Interpretations

003_example.c

```c
#include <stdio.h>

int main()
{
    int a[5] = {1, 2, 3, 4, 5};

    printf("%p\n", a + 1);
    printf("%p\n", &a[0] + 1);
    printf("%p\n", &a + 1);

    return 0;
}
```



a

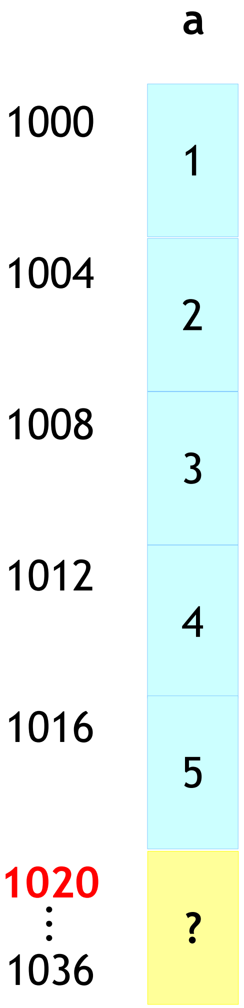
1000	1
1004	2
1008	3
1012	4
1016	5

Advanced C

Arrays – Interpretations

003_example.c

```
#include <stdio.h>

int main()
{
    int a[5] = {1, 2, 3, 4, 5};

    printf("%p\n", a + 1);
    printf("%p\n", &a[0] + 1);
    printf("%p\n", &a + 1);

    return 0;
}
```



	a
1000	1
1004	2
1008	3
1012	4
1016	5
1020 ⋮ 1036	?

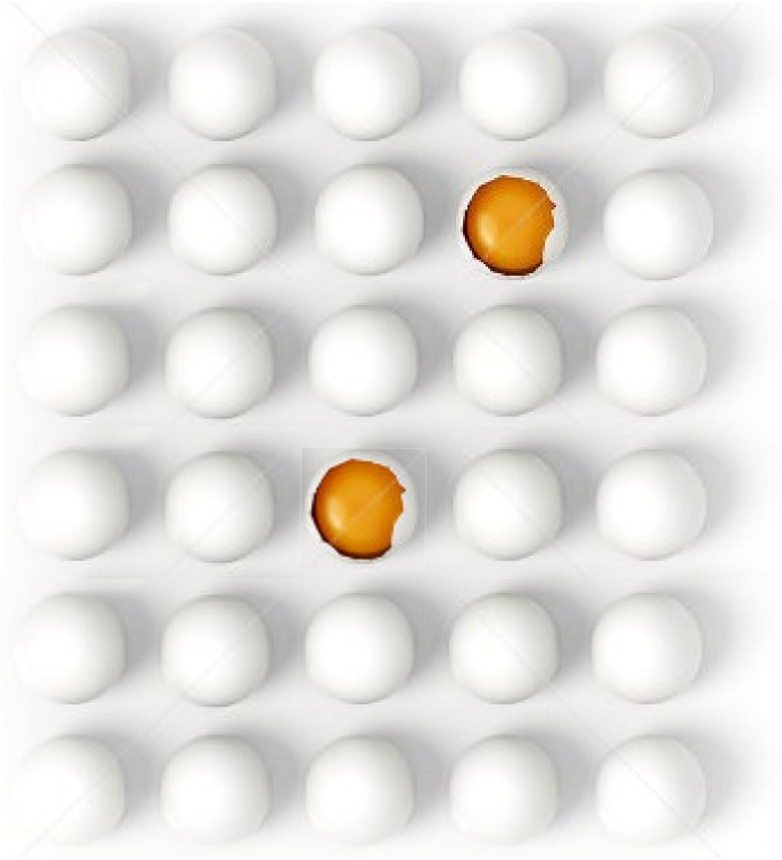
Advanced C

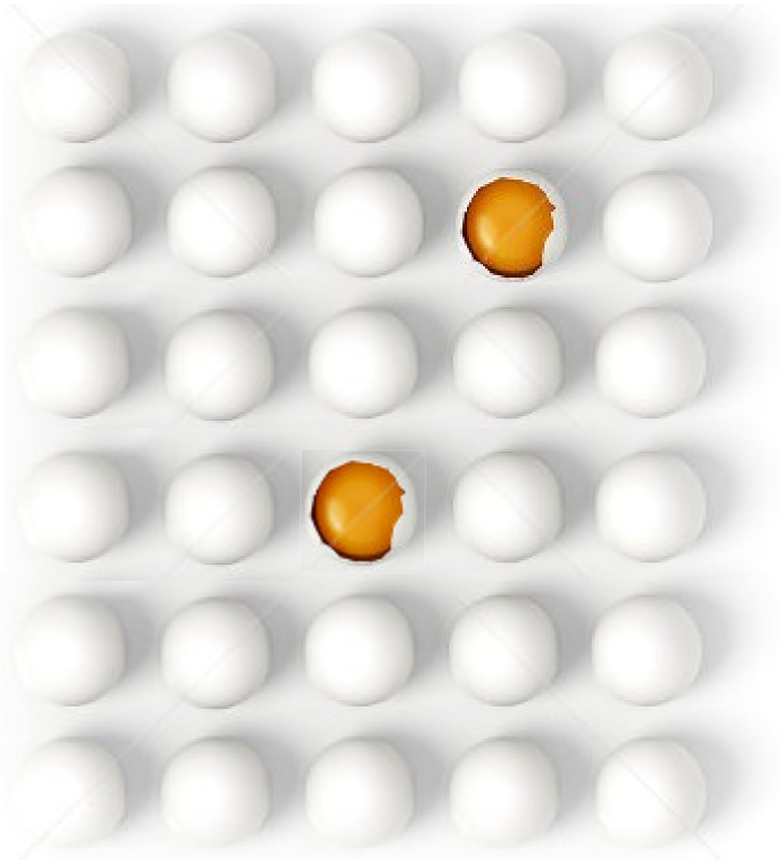
Arrays – Interpretations

- So in summary, if we try to print the address of a[]
  - a - prints the value of the constant pointer
  - &a[0] - prints the address of the first element pointed by a
  - &a – prints the address of the whole array which pointed by a
- Hence all the lines will print **1000** as output
- These concepts plays a very important role in multi dimension arrays

Advanced C

Arrays



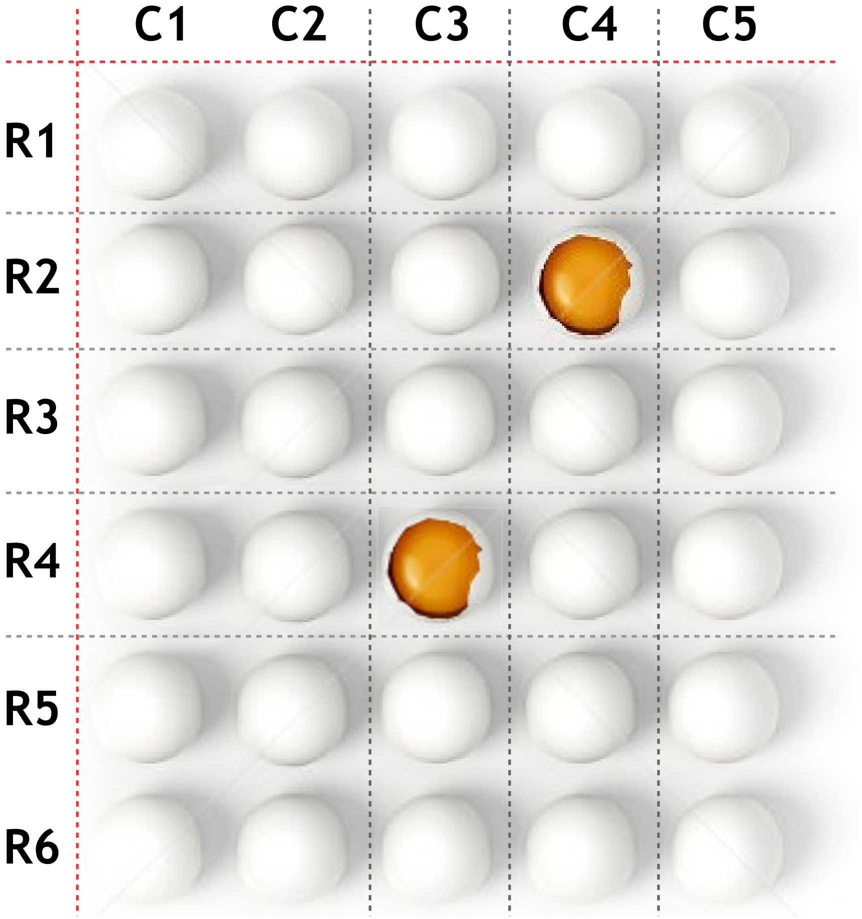


- Find the broken eggs!

- Hmm, how should I proceed with count??

Advanced C

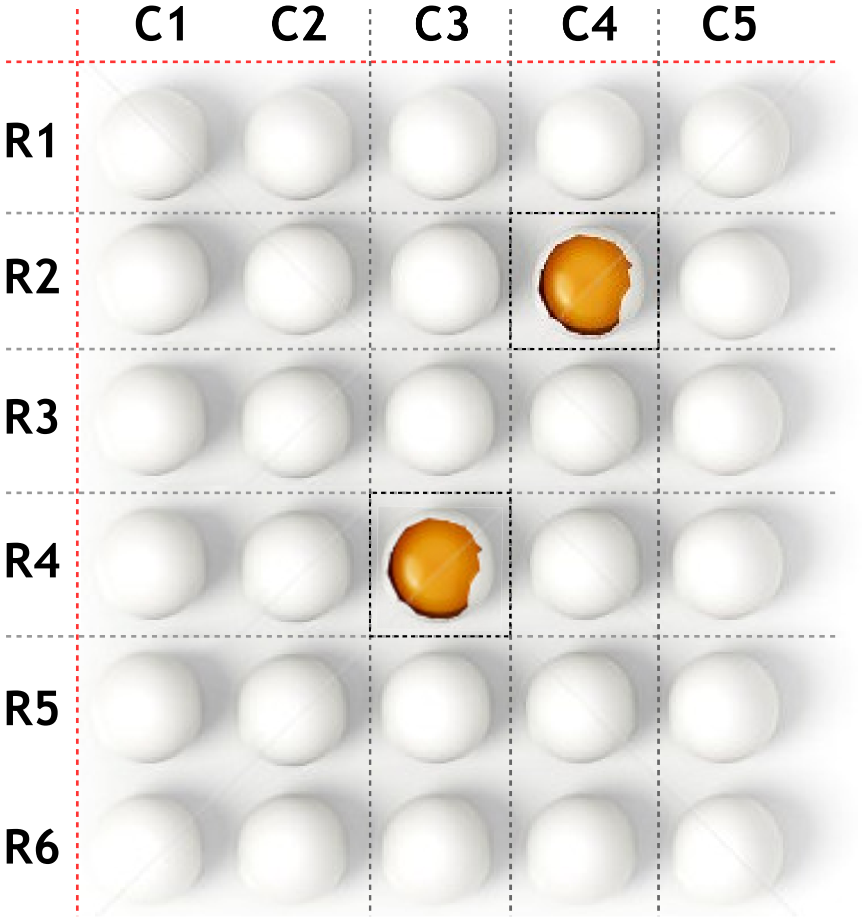
Arrays – 2D



- Now is it better to tell which one broken??

Advanced C

Arrays – 2D



- So in matrix method it becomes bit easy to locate items
- In other terms we can reference the location with easy indexing
- In this case we can say the broken eggs are at

  R2-C4 and R4-C3

  or

  C4-R2 and C3-R4

Advanced C

Arrays – 2D

- The matrix in computer memory is a bit tricky!!
- Why?. Since its a sequence of memory
- So pragmatically, it is a concept of dimensions is generally referred
- The next slide illustrates the expectation and the reality of the memory layout of the data in a system

Advanced C

Arrays – 2D

Concept Illustration

	C0	C1	C2	C3
R0	123	9	234	39
R1	23	155	33	2
R2	100	88	8	111
R3	201	101	187	22

System Memory

1001	123
1002	9
1003	234
1004	39
1005	23
1006	155
1007	33
1008	2
1009	100
1010	88
1011	8
1012	111
1013	201
1014	101
1015	187
1016	22

Advanced C

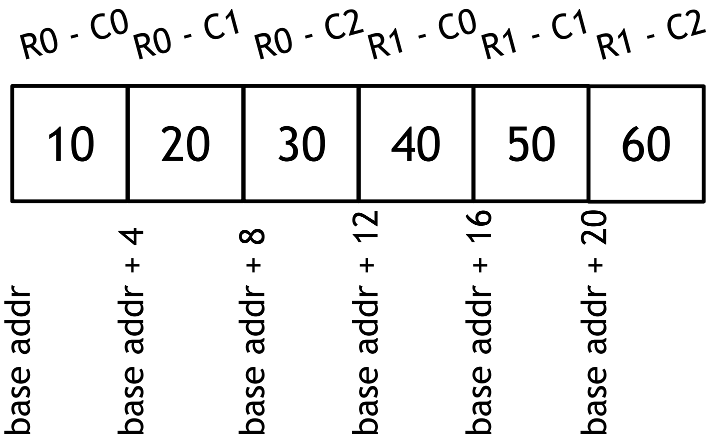
Arrays - 2D

Syntax

```
data_type name[ROW][COL];

Where ROW * COL represents number of elements
Memory occupied by array = (number of elements * size of an element)
                         = (ROW * COL * <size of data_type>)
```

Example

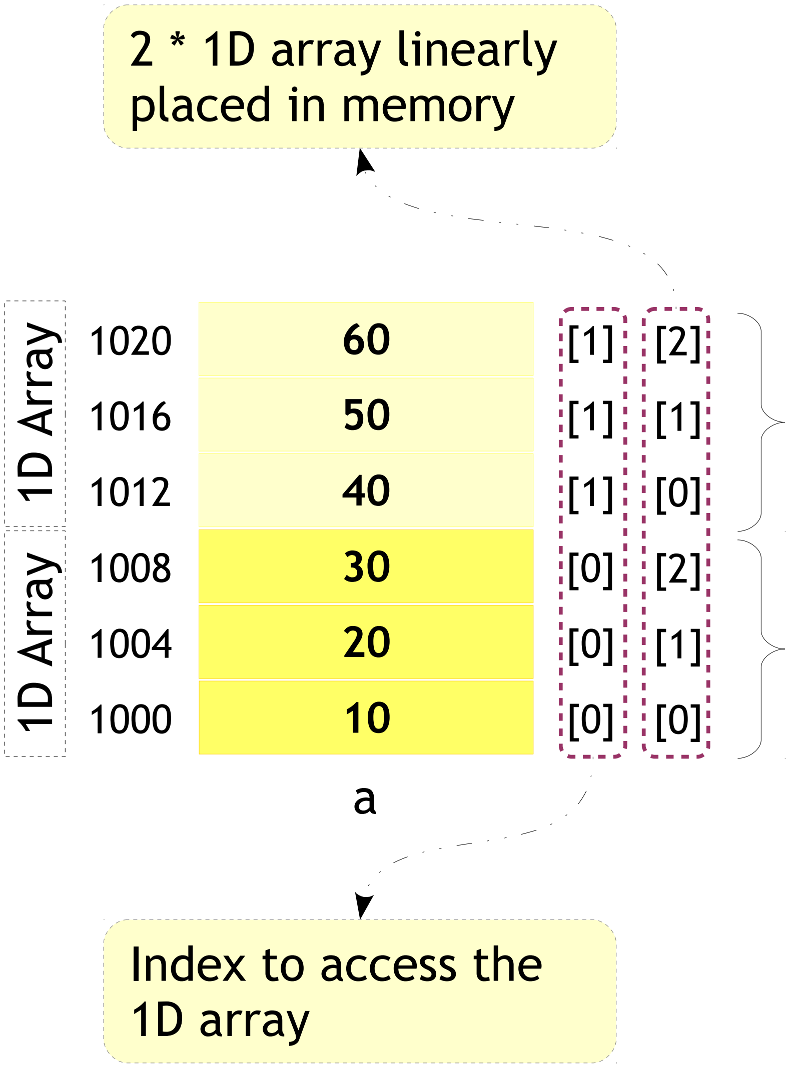
```
int a[2][3] = {{10, 20, 30}, {40, 50, 60}};
```



R0 - C0	R0 - C1	R0 - C2	R1 - C0	R1 - C1	R1 - C2
10	20	30	40	50	60
base addr	base addr + 4	base addr + 8	base addr + 12	base addr + 16	base addr + 20

Advanced C

Arrays – 2D - Referencing



2 * 1D array linearly placed in memory

1D Array	1020	**60**	[1]	[2]
	1016	**50**	[1]	[1]
	1012	**40**	[1]	[0]
1D Array	1008	**30**	[0]	[2]
	1004	**20**	[0]	[1]
	1000	**10**	[0]	[0]

Index to access the 1D array

2nd 1D Array with base address 1012
a[1] = &a[1][0] = a + 1 → 1012

1st 1D Array with base address 1000
a[0] = &a[0][0] = a + 0 → 1000

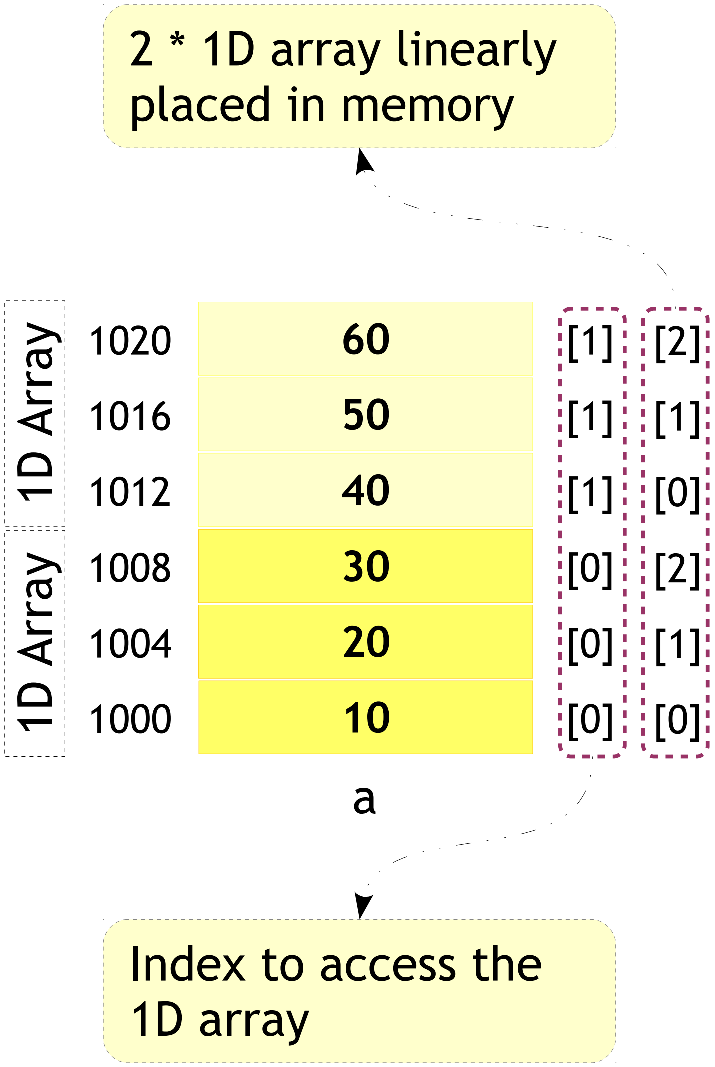
Core Principle

- Dereferencing nth - dimensional array will return (n - 1)th -dimensional array
  - Example : dereferencing 2D array will return 1D array
- Dereferencing 1D array will return 'data element'
  - Example : Dereferencing 1D integer array will return integer

Array	Dimension
&a	n + 1
a	n
*a	n - 1

Advanced C

Arrays – 2D - Dereferencing



2 * 1D array linearly placed in memory
1D Array
1D Array
a
Index to access the 1D array

1020	60	[1]	[2]
1016	50	[1]	[1]
1012	40	[1]	[0]
1008	30	[0]	[2]
1004	20	[0]	[1]
1000	10	[0]	[0]

Example 1: Say **a[0][1]** is to be accessed, then decomposition happens like,

a[0][1] =

= *(a[0] + (1 * sizeof(type)))

= *(*(a + (0 * sizeof(1D array))) + (1 * sizeof(type)))

= *(*(a + (0 * 12)) + (1 * 4))

= *(*(a + 0) + 4)

= *(*a + 0 + 4)

= *(*a + 4)

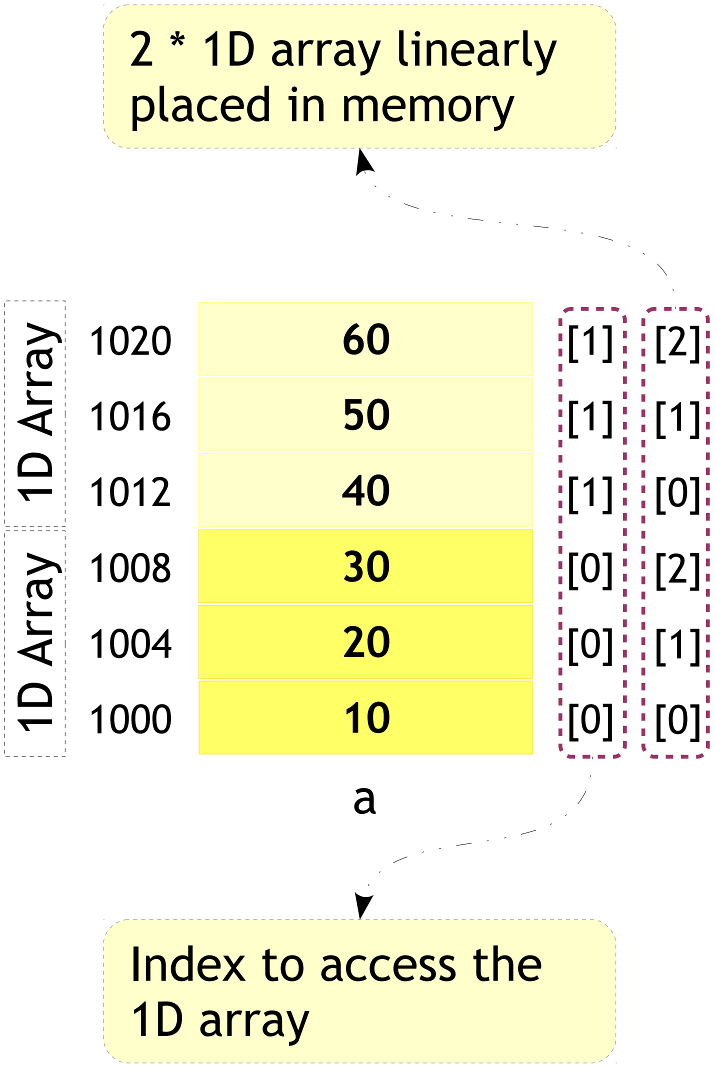
= *(1000 + 4)

= *(1004))

= 20

Advanced C

Arrays – 2D - Dereferencing



2 * 1D array linearly placed in memory

	Address	a		
1D Array	1020	60	[1]	[2]
	1016	50	[1]	[1]
	1012	40	[1]	[0]
1D Array	1008	30	[0]	[2]
	1004	20	[0]	[1]
	1000	10	[0]	[0]

Index to access the 1D array

Example 1: Say **a[1][1]** is to be accessed, then decomposition happens like,

```
a[1][1] =

= *(a[1] + (1 * sizeof(type)))
= *(*(a + (1 * sizeof(1D array))) + (1 * sizeof(type)))
= *(*(a + (1 * 12)) + (1 * 4))
= *(*(a + 12) + 4)
= *(*a + 12 + 4)
= *(*a + 16)
= *(1000 + 16)
= *(1016)
= 50
```

Address of a[r][c] = value(a) + r * sizeof(1D array) + c * sizeof(type)

Advanced C

Arrays – 2D - DIY

- WAP to find the MIN and MAX of a 2D array

Advanced C

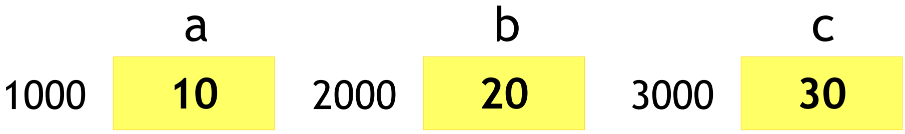
Pointers – Array of pointers

Synatx

```
datatype *ptr_name[SIZE]
```

004_example.c

```
#include <stdio.h>

int main()
{
    int a = 10;
    int b = 20;
    int c = 30;

    int *ptr[3];

    ptr[0] = &a;
    ptr[1] = &b;
    ptr[2] = &c;

    return 0;
}
```



Advanced C

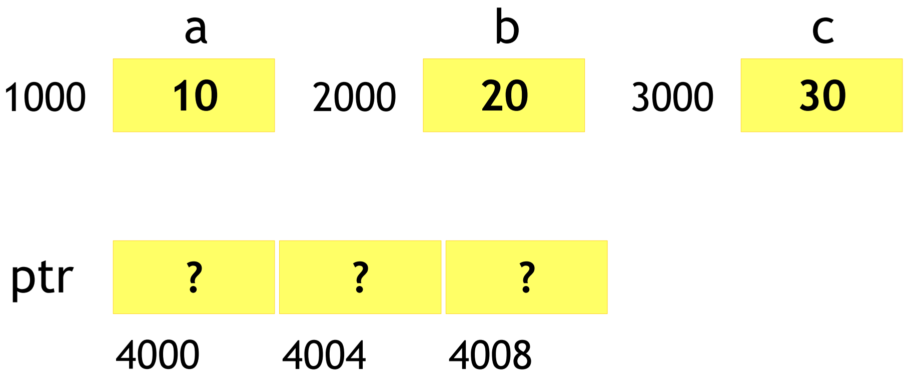
Pointers – Array of pointers

Synatx

```
datatype *ptr_name[SIZE]
```

004_example.c

```
#include <stdio.h>

int main()
{
     int a = 10;
     int b = 20;
     int c = 30;

     int *ptr[3];

     ptr[0] = &a;
     ptr[1] = &b;
     ptr[2] = &c;

     return 0;
}
```



Advanced C

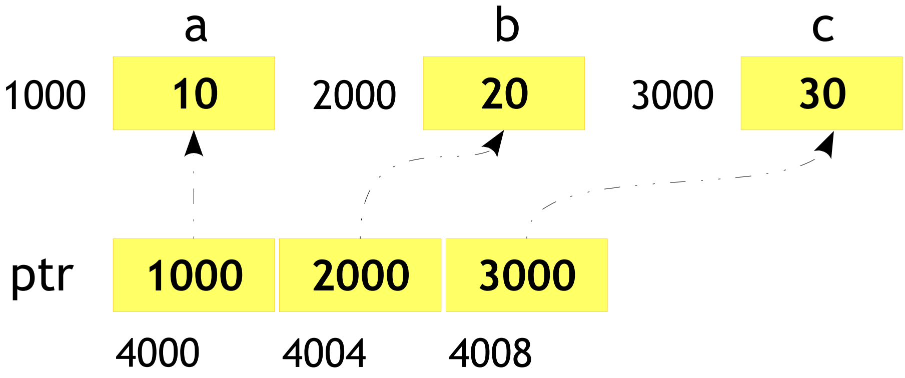
Pointers – Array of pointers

Synatx

```
datatype *ptr_name[SIZE]
```

004_example.c

```
#include <stdio.h>

int main()
{
    int a = 10;
    int b = 20;
    int c = 30;

    int *ptr[3];

    ptr[0] = &a;
    ptr[1] = &b;
    ptr[2] = &c;

    return 0;
}
```



Advanced C

Pointers – Array of pointers

Synatx

```
datatype *ptr_name[SIZE]
```

005_example.c

```
#include <stdio.h>

int main()
{
    int a[2] = {10, 20};
    int b[2] = {30, 40};
    int c[2] = {50, 60};

    int *ptr[3];

    ptr[0] = a;
    ptr[1] = b;
    ptr[2] = c;

    return 0;
}
```

1004	20		2004	40		3004	60	
1000	10	a	2000	30	b	3000	50	c

Advanced C

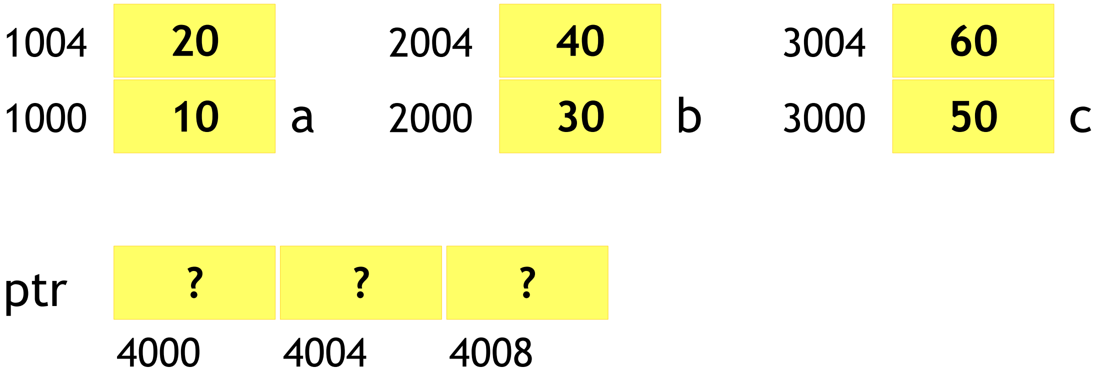
Pointers - Array of pointers

Synatx

```
datatype *ptr_name[SIZE]
```

005_example.c

```
#include <stdio.h>

int main()
{
    int a[2] = {10, 20};
    int b[2] = {30, 40};
    int c[2] = {50, 60};

    int *ptr[3];

    ptr[0] = a;
    ptr[1] = b;
    ptr[2] = c;

    return 0;
}
```



1004 20 | 2004 40 | 3004 60

1000 10 a | 2000 30 b | 3000 50 c

ptr ? ? ?

4000 4004 4008

Advanced C

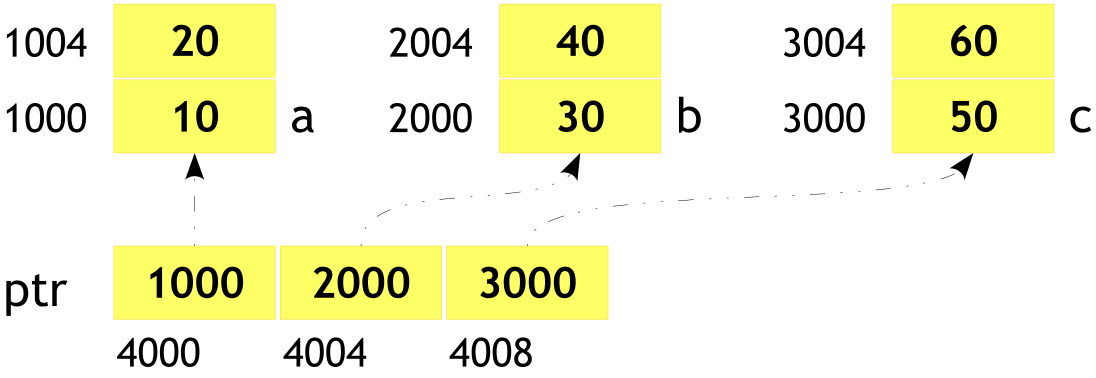
Pointers – Array of pointers

Synatx

```
datatype *ptr_name[SIZE]
```

005_example.c

```
#include <stdio.h>

int main()
{
    int a[2] = {10, 20};
    int b[2] = {30, 40};
    int c[2] = {50, 60};

    int *ptr[3];

    ptr[0] = a;
    ptr[1] = b;
    ptr[2] = c;

    return 0;
}
```

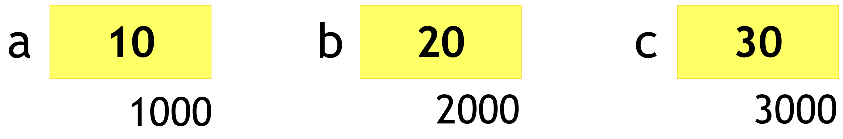


Advanced C

Pointers – Array of pointers

006_example.c

```
#include <stdio.h>

void print_array(int **p)
{
    int i;

    for (i = 0; i < 3; i++)
    {
        printf(“%d ”, *p[i]);
        printf(“at %p\n”, p[i]);
    }
}

int main()
{
    int a = 10;
    int b = 20;
    int c = 30;
    int *ptr[3] = {&a, &b, &c};

    print_array(ptr);

    return 0;
}
```

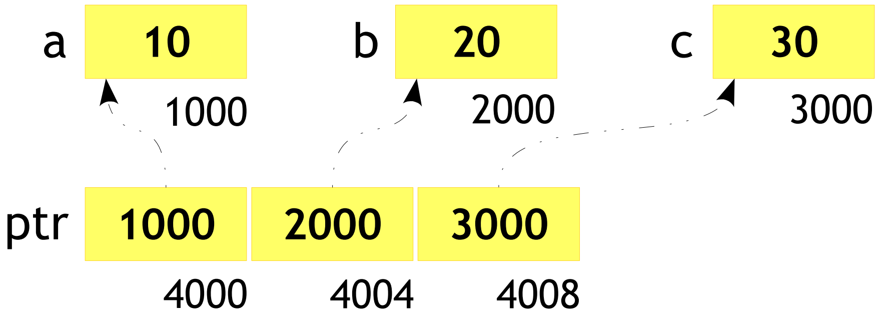


Advanced C

Pointers – Array of pointers

006_example.c

```
#include <stdio.h>

void print_array(int **p)
{
     int i;

     for (i = 0; i < 3; i++)
     {
          printf(“%d ”, *p[i]);
          printf(“at %p\n”, p[i]);
     }
}

int main()
{
     int a = 10;
     int b = 20;
     int c = 30;
     int *ptr[3] = {&a, &b, &c};

     print_array(ptr);

     return 0;
}
```

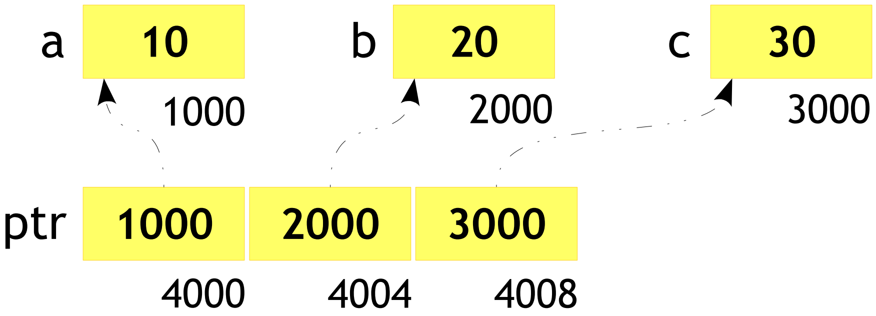


Advanced C

Pointers – Array of pointers

006_example.c

```
#include <stdio.h>

void print_array(int **p)
{
    int i;

    for (i = 0; i < 3; i++)
    {
        printf("%d ", *p[i]);
        printf("at %p\n", p[i]);
    }
}

int main()
{
    int a = 10;
    int b = 20;
    int c = 30;
    int *ptr[3] = {&a, &b, &c};

    print_array(ptr);

    return 0;
}
```

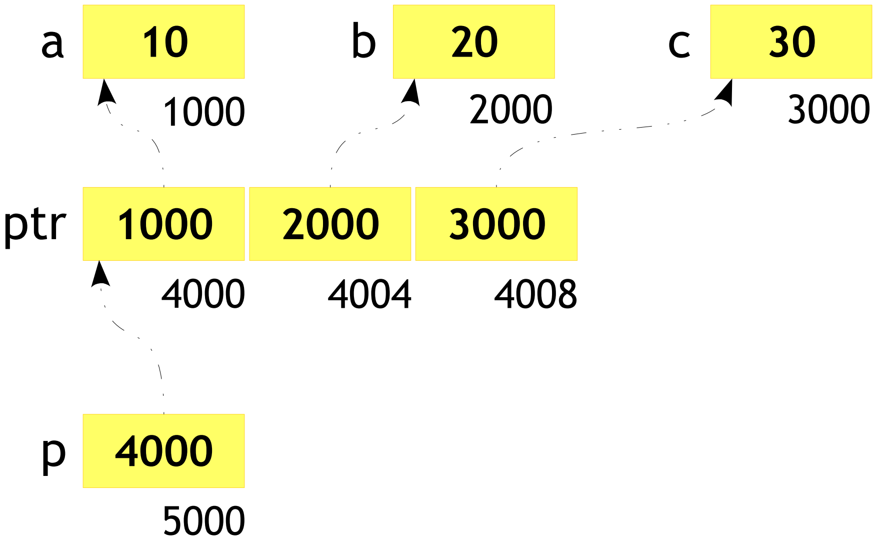


Advanced C

Pointers – Array of pointers

006_example.c

```c
#include <stdio.h>

void print_array(int **p)
{
    int i;

    for (i = 0; i < 3; i++)
    {
        printf(“%d ”, *p[i]);
        printf(“at %p\n”, p[i]);
    }
}

int main()
{
    int a = 10;
    int b = 20;
    int c = 30;
    int *ptr[3] = {&a, &b, &c};

    print_array(ptr);

    return 0;
}
```



a 10 1000

b 20 2000

c 30 3000

ptr 1000 2000 3000

4000 4004 4008

p 4000 5000

Advanced C

Pointers – Array of strings

007_example.c

```
#include <stdio.h>

int main()
{
    char s[3][8] = {
                      “Array”,
                      “of”,
                      “Strings”
                   }

    printf(“%s %s %s\n”, s[0], s[1], s[2]);

    return 0;
}
```

	s
1000	'A'
1001	'r'
1002	'r'
1003	'a'
1004	'y'
1005	'\0'
1006	?
1007	?
1008	'o'
1009	'f'
1010	'\0'
1011	?
1012	?
1013	?
1014	?
1015	?
1016	'S'
1017	't'
1018	'r'
1019	'i'
1020	'n'
1021	'g'
1022	's'
1023	'\0'

	s
1000	0x41
1001	0x72
1002	0x72
1003	0x61
1004	0x79
1005	0x00
1006	?
1007	?
1008	0x6F
1009	0x66
1010	0x00
1011	?
1012	?
1013	?
1014	?
1015	?
1016	0x53
1017	0x74
1018	0x72
1019	0x69
1020	0x6E
1021	0x67
1022	0x73
1023	0x00

Advanced C

Pointers – Array of strings

008_example.c

```
#include <stdio.h>

int main()
{
    char *s[3];

    s[0] = “Array”;
    s[1] = “of”;
    s[2] = “Strings”;

    printf(“%s %s %s\n”, s[0], s[1], s[2]);

    return 0;
}
```

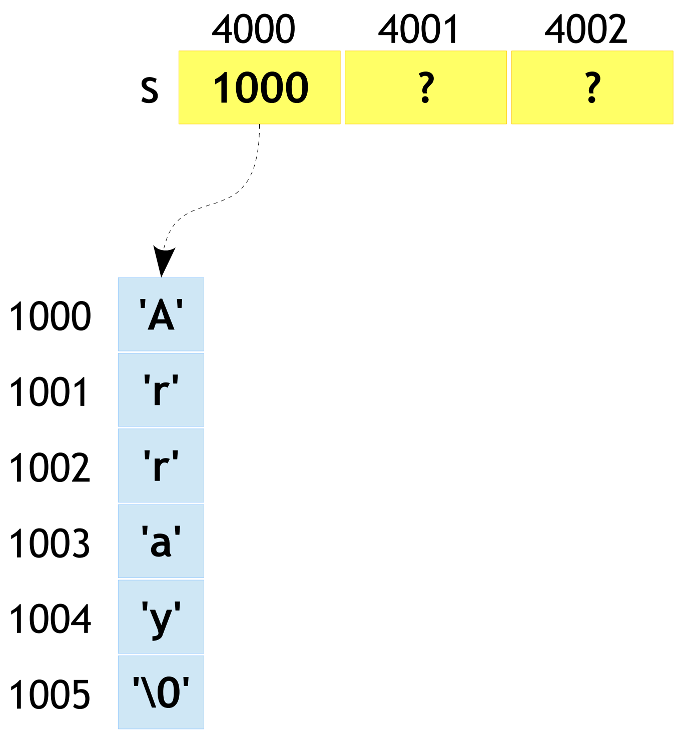
	4000	4001	4002
s	?	?	?

Advanced C

Pointers – Array of strings

008_example.c

```
#include <stdio.h>

int main()
{
    char *s[3];

    s[0] = “Array”;
    s[1] = “of”;
    s[2] = “Strings”;

    printf(“%s %s %s\n”, s[0], s[1], s[2]);

    return 0;
}
```



	4000	4001	4002
s	1000	?	?

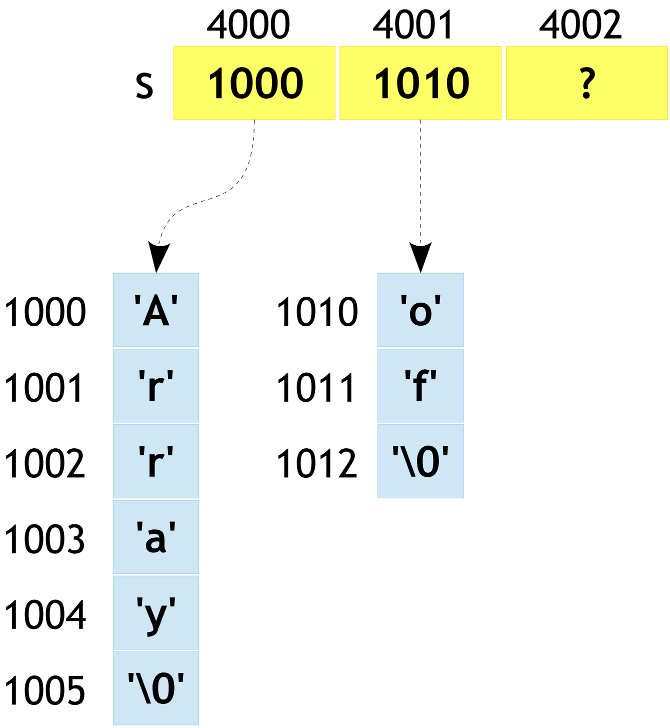
1000	'A'
1001	'r'
1002	'r'
1003	'a'
1004	'y'
1005	'\0'

Advanced C

Pointers – Array of strings

008_example.c

```
#include <stdio.h>

int main()
{
    char *s[3];

    s[0] = “Array”;
    s[1] = “of”;
    s[2] = “Strings”;

    printf(“%s %s %s\n”, s[0], s[1], s[2]);

    return 0;
}
```



	4000	4001	4002
s	1000	1010	?

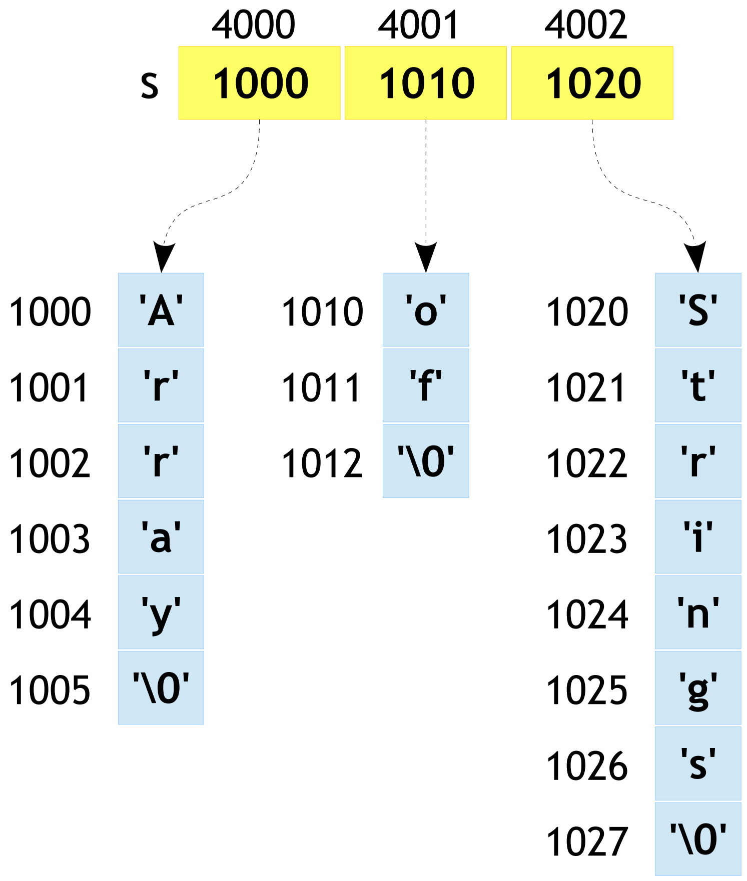
1000	'A'	1010	'o'
1001	'r'	1011	'f'
1002	'r'	1012	'\0'
1003	'a'		
1004	'y'		
1005	'\0'		

Advanced C

Pointers – Array of strings

008_example.c

```c
#include <stdio.h>

int main()
{
    char *s[3];

    s[0] = “Array”;
    s[1] = “of”;
    s[2] = “Strings”;

    printf(“%s %s %s\n”, s[0], s[1], s[2]);

    return 0;
}
```



	4000	4001	4002
s	1000	1010	1020

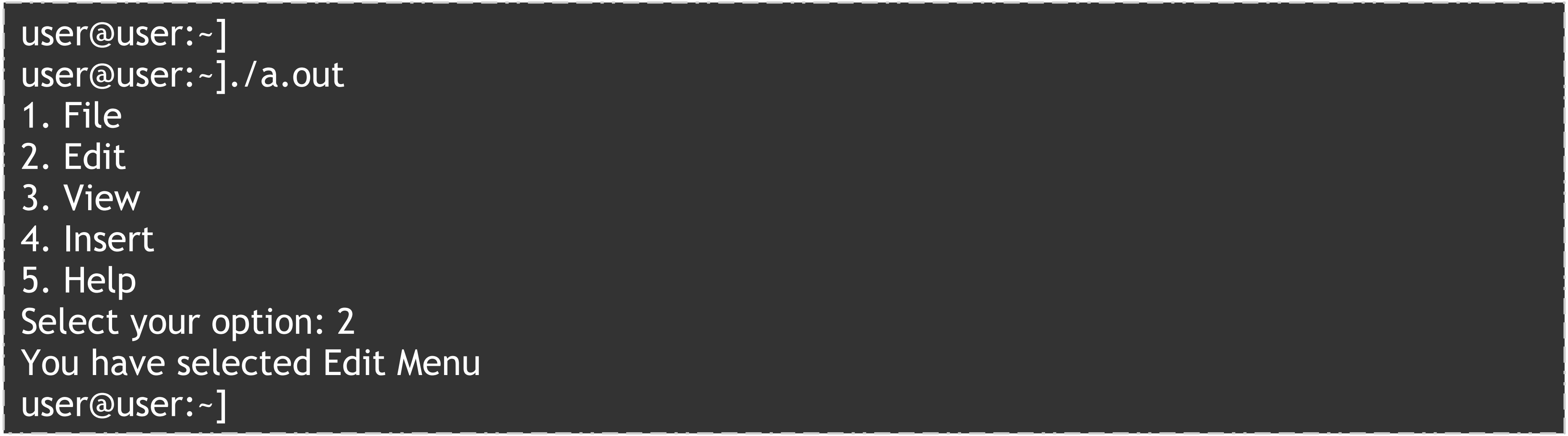
1000	'A'	1010	'o'	1020	'S'
1001	'r'	1011	'f'	1021	't'
1002	'r'	1012	'\0'	1022	'r'
1003	'a'			1023	'i'
1004	'y'			1024	'n'
1005	'\0'			1025	'g'
				1026	's'
				1027	'\0'

Advanced C

Pointers – Array of strings

- W.A.P to print menu and select an option
  - Menu options { File, Edit, View, Insert, Help }
- The prototype of print_menu function
  - void print_menu (char **menu);

Screen Shot



```
user@user:~]
user@user:~]./a.out
1. File
2. Edit
3. View
4. Insert
5. Help
Select your option: 2
You have selected Edit Menu
user@user:~]
```

Advanced C

Pointers – Array of strings

- Command line arguments
  - Refer to PPT “11_functions_part2”

Advanced C

Pointers – Pointer to an Array

Syntax

```
datatype (*ptr_name)[SIZE];
```

009_example.c

```
int main()
{
    int array[3] = {1, 2, 3};
    int *ptr;

    ptr = array;

    printf(“%d\n”, *ptr);

    return 0;
}
```

- Pointer to an array!!, why is the syntax so weird??
- Isn't the code shown left is an example for pointer to an array?
- Should the code print as 1 in output?
- Yes, everything is fine here except the dimension of the array.
- This is perfect code for 1D array

Advanced C

Pointers – Pointer to an Array

Syntax

```
datatype (*ptr_name)[SIZE];
```

010_example.c

```
int main()
{
    int array[3] = {1, 2, 3};
    int (*ptr)[3];

    ptr = array;

    printf(“%d\n”, **ptr);

    return 0;
}
```

- So in order to point to 2D array we would prefer the given syntax
- Ookay, Isn't a 2D array linearly arranged in the memory?

  So can I write the code as shown?
- Hmm!, Yes but the compiler would warn you on the assignment statement
- Then how should I write?

Advanced C

Pointers – Pointer to an Array

Syntax

```
datatype (*ptr_name)[SIZE];
```

011_example.c

```
int main()
{
    int array[3] = {1, 2, 3};
    int (*ptr)[3];

    ptr = &array;

    printf(“%d\n”, **ptr);

    return 0;
}
```

- Hhoho, isn't **array** is equal to **&array**?? what is the difference?
- Well the difference lies in the compiler interpretation while pointer arithmetic and hence
- Please see the difference in the next slides

Advanced C

Pointers – Pointer to an Array

012_example.c

```
int main()
{
    int array[3] = {1, 2, 3};
    int *p1;
    int (*p2)[3];

    p1 = array;
    p2 = &array;

    printf(“%p %p\n”, p1 + 0, p2 + 0);
    printf(“%p %p\n”, p1 + 1, p2 + 1);
    printf(“%p %p\n”, p1 + 2, p2 + 2);

    return 0;
}
```

Advanced C

Pointers – Pointer to an Array

012_example.c

```
int main()
{
    int array[3] = {1, 2, 3};
    int *p1;
    int (*p2)[3];

    p1 = array;
    p2 = &array;

    printf("%p %p\n", p1 + 0, p2 + 0);
    printf("%p %p\n", p1 + 1, p2 + 1);
    printf("%p %p\n", p1 + 2, p2 + 2);

    return 0;
}
```

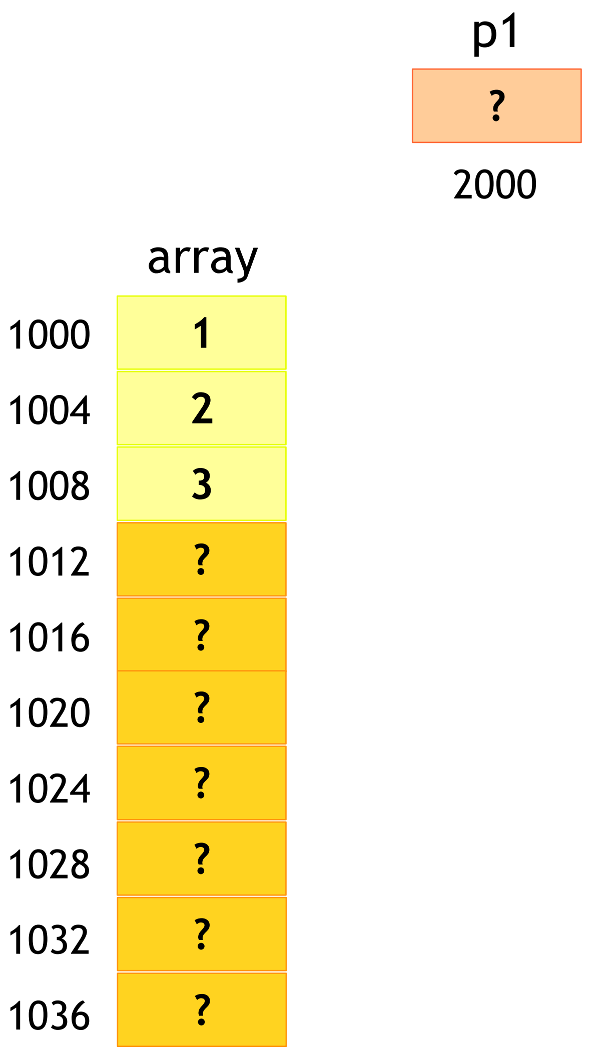
	array
1000	1
1004	2
1008	3
1012	?
1016	?
1020	?
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Pointer to an Array

012_example.c

```c
int main()
{
    int array[3] = {1, 2, 3};
    int *p1;
    int (*p2)[3];

    p1 = array;
    p2 = &array;

    printf("%p %p\n", p1 + 0, p2 + 0);
    printf("%p %p\n", p1 + 1, p2 + 1);
    printf("%p %p\n", p1 + 2, p2 + 2);

    return 0;
}
```



p1

p1
?
2000

array

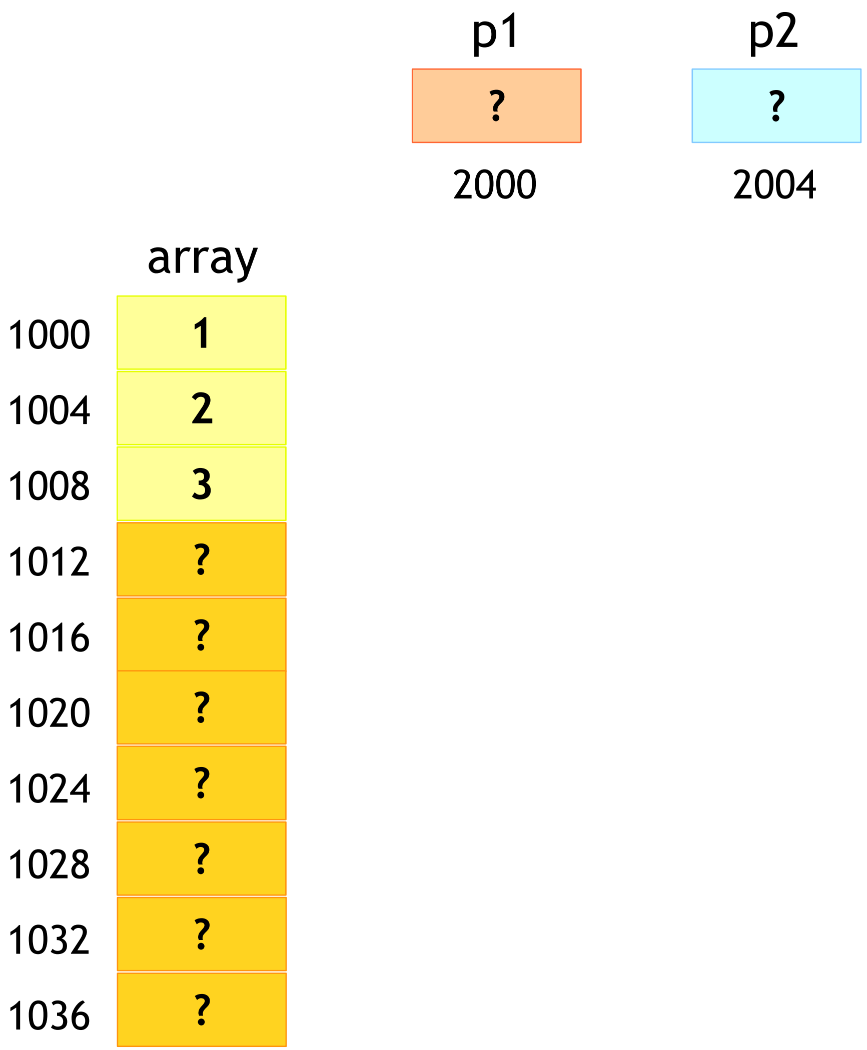
	array
1000	1
1004	2
1008	3
1012	?
1016	?
1020	?
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Pointer to an Array

012_example.c

```c
int main()
{
     int array[3] = {1, 2, 3};
     int *p1;
     int (*p2)[3];

     p1 = array;
     p2 = &array;

     printf("%p %p\n", p1 + 0, p2 + 0);
     printf("%p %p\n", p1 + 1, p2 + 1);
     printf("%p %p\n", p1 + 2, p2 + 2);

     return 0;
}
```



p1	p2
?	?
2000	2004

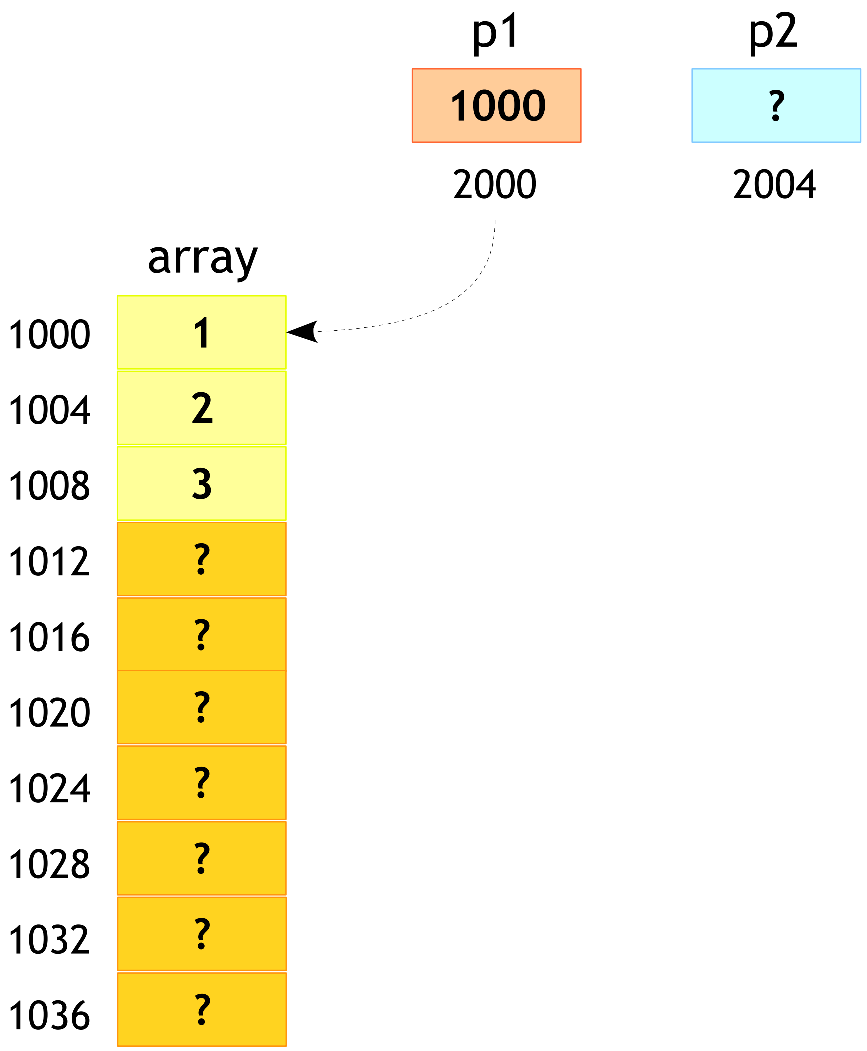
	array
1000	1
1004	2
1008	3
1012	?
1016	?
1020	?
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Pointer to an Array

012_example.c

```
int main()
{
    int array[3] = {1, 2, 3};
    int *p1;
    int (*p2)[3];

    p1 = array;
    p2 = &array;

    printf("%p %p\n", p1 + 0, p2 + 0);
    printf("%p %p\n", p1 + 1, p2 + 1);
    printf("%p %p\n", p1 + 2, p2 + 2);

    return 0;
}
```

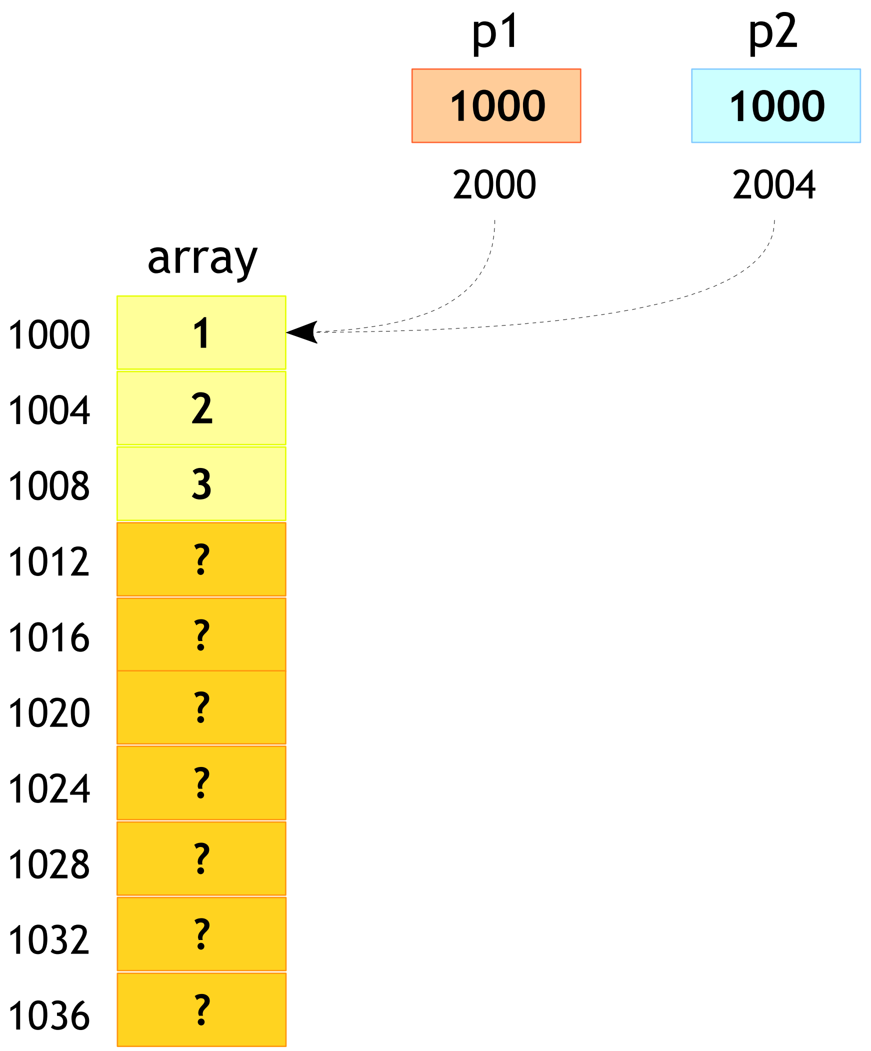


Advanced C

Pointers – Pointer to an Array

012_example.c

```
int main()
{
     int array[3] = {1, 2, 3};
     int *p1;
     int (*p2)[3];

     p1 = array;
     p2 = &array;

     printf("%p %p\n", p1 + 0, p2 + 0);
     printf("%p %p\n", p1 + 1, p2 + 1);
     printf("%p %p\n", p1 + 2, p2 + 2);

     return 0;
}
```

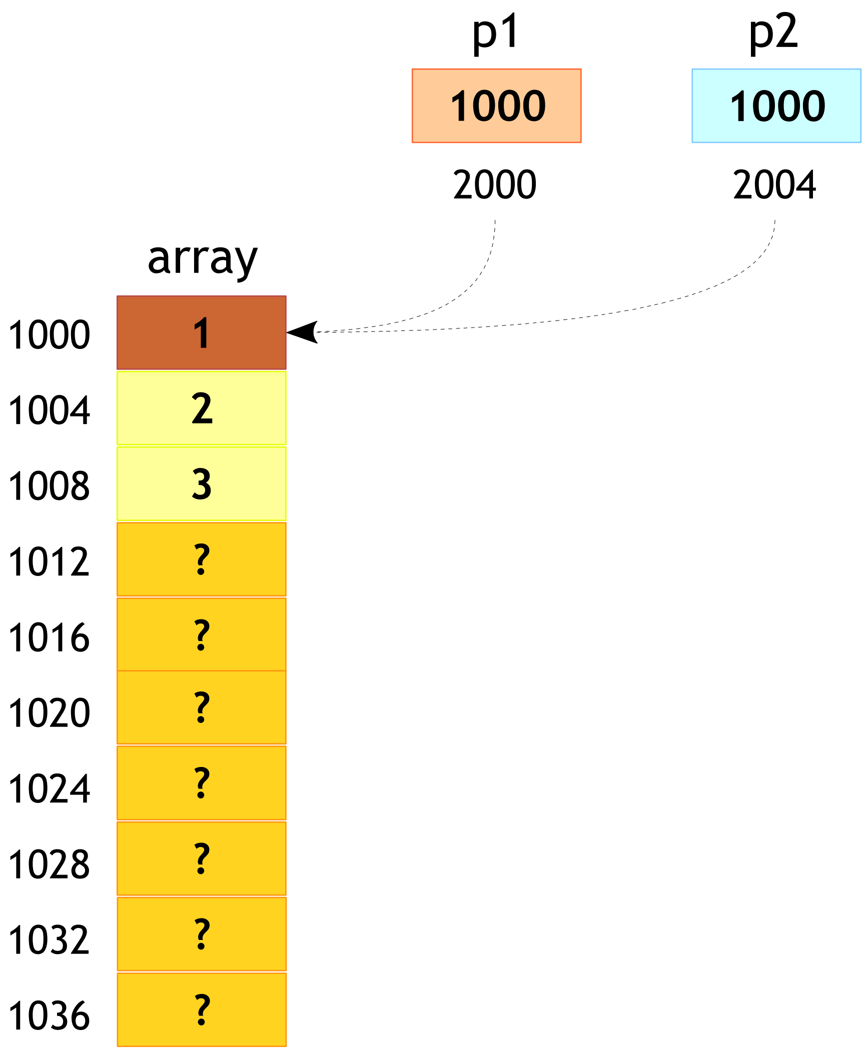


Advanced C

Pointers – Pointer to an Array

012_example.c

```
int main()
{
    int array[3] = {1, 2, 3};
    int *p1;
    int (*p2)[3];

    p1 = array;
    p2 = &array;

    printf("%p %p\n", p1 + 0, p2 + 0);
    printf("%p %p\n", p1 + 1, p2 + 1);
    printf("%p %p\n", p1 + 2, p2 + 2);

    return 0;
}
```



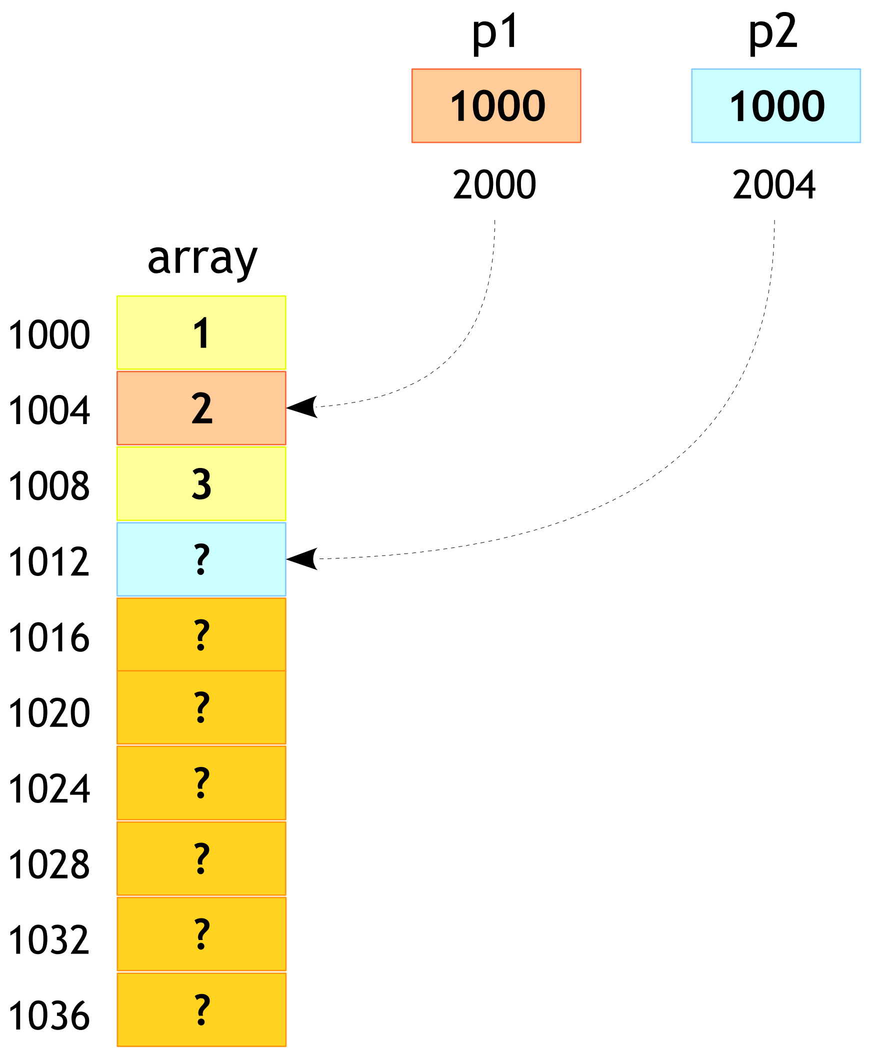
	array
1000	1
1004	2
1008	3
1012	?
1016	?
1020	?
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Pointer to an Array

012_example.c

```c
int main()
{
    int array[3] = {1, 2, 3};
    int *p1;
    int (*p2)[3];

    p1 = array;
    p2 = &array;

    printf(“%p %p\n”, p1 + 0, p2 + 0);
    printf(“%p %p\n”, p1 + 1, p2 + 1);
    printf(“%p %p\n”, p1 + 2, p2 + 2);

    return 0;
}
```



p1	p2
1000	1000
2000	2004

array

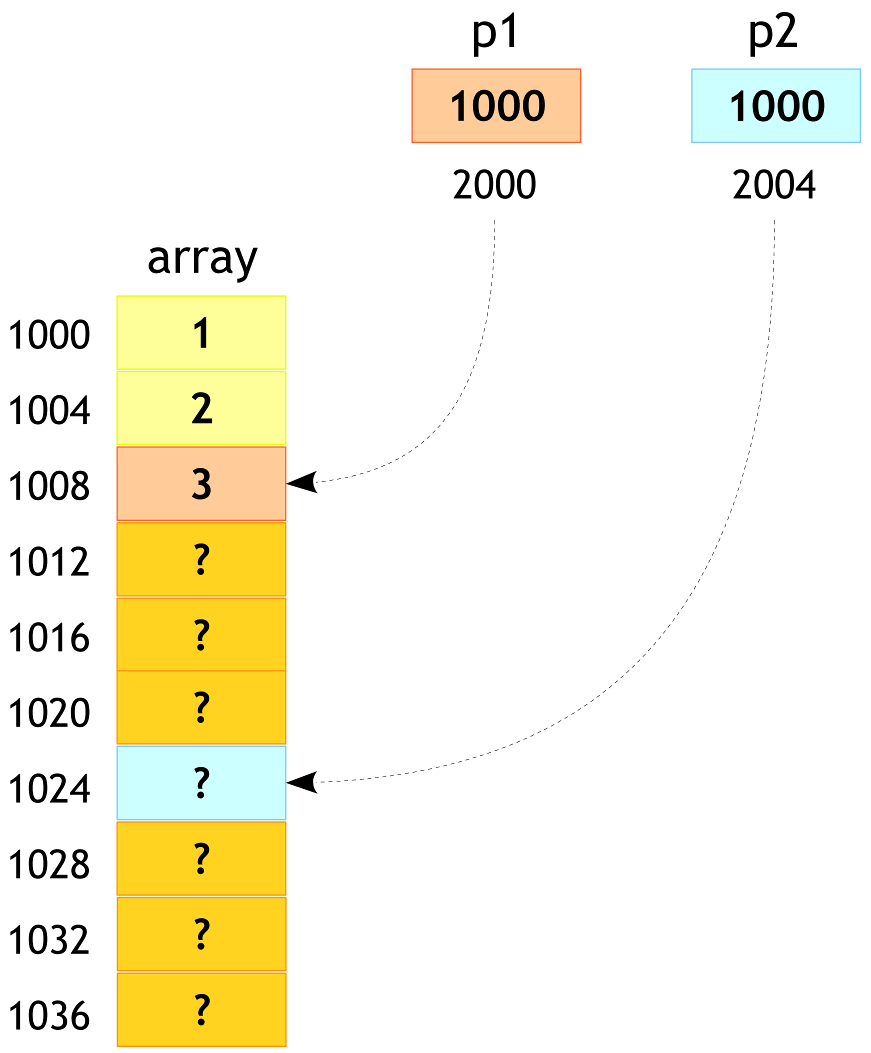
1000	1
1004	2
1008	3
1012	?
1016	?
1020	?
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Pointer to an Array

012_example.c

```
int main()
{
     int array[3] = {1, 2, 3};
     int *p1;
     int (*p2)[3];

     p1 = array;
     p2 = &array;

     printf(“%p %p\n”, p1 + 0, p2 + 0);
     printf(“%p %p\n”, p1 + 1, p2 + 1);
     printf(“%p %p\n”, p1 + 2, p2 + 2);

     return 0;
}
```



	p1	p2
value	1000	1000
address	2000	2004

	array
1000	1
1004	2
1008	3
1012	?
1016	?
1020	?
1024	?
1028	?
1032	?
1036	?

Pointers – Pointer to an Array

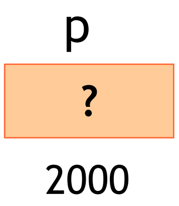
- So as a conclution we can say the
  - Pointer arithmetic on 1D array is based on the size of datatype
  - Pointer arithmetic on 2D array is based on the size of datatype and size of 1D array
- Still one question remains is what is real use of this syntax if can do p[i][j]?
  - In case of dynamic memory allocation as shown in next slide

Advanced C

Pointers – Pointer to an Array

013_example.c

```
int main()
{
    int (*p)[3];

    p = malloc(sizeof(*p) * 3);

    (*(p + 0))[0] = 1;
    (*(p + 1))[1] = 2;
    (*(p + 2))[2] = 3;

    printf(“%d\n”, p[0][0]);
    printf(“%d\n”, p[1][1]);
    printf(“%d\n”, p[2][2]);

    return 0;
}
```



p

?

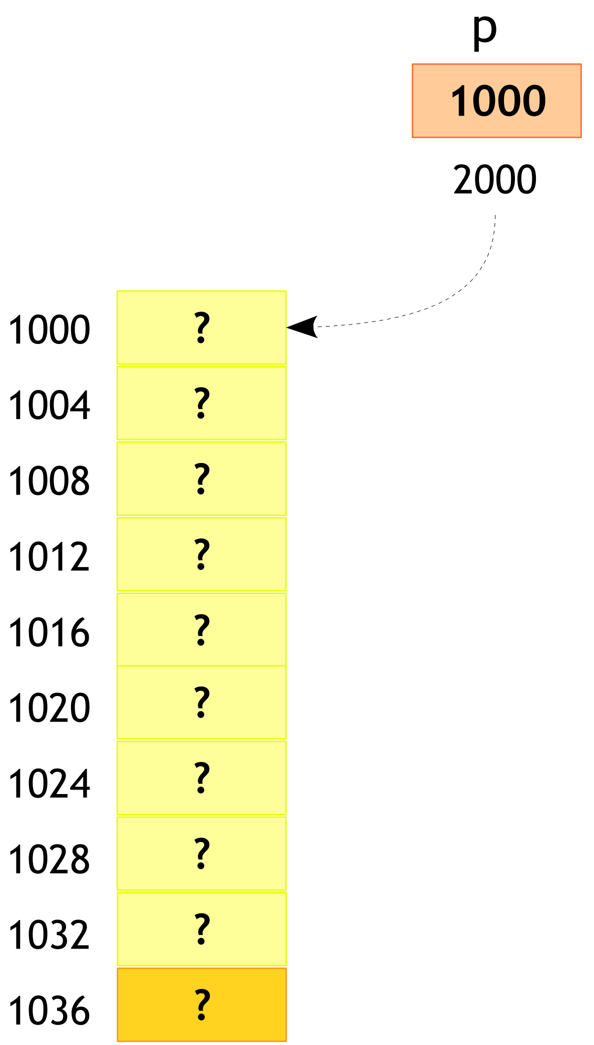
2000

Advanced C

Pointers – Pointer to an Array

013_example.c

```
int main()
{
    int (*p)[3];

    p = malloc(sizeof(*p) * 3);

    (*(p + 0))[0] = 1;
    (*(p + 1))[1] = 2;
    (*(p + 2))[2] = 3;

    printf(“%d\n”, p[0][0]);
    printf(“%d\n”, p[1][1]);
    printf(“%d\n”, p[2][2]);

    return 0;
}
```



p

1000

2000

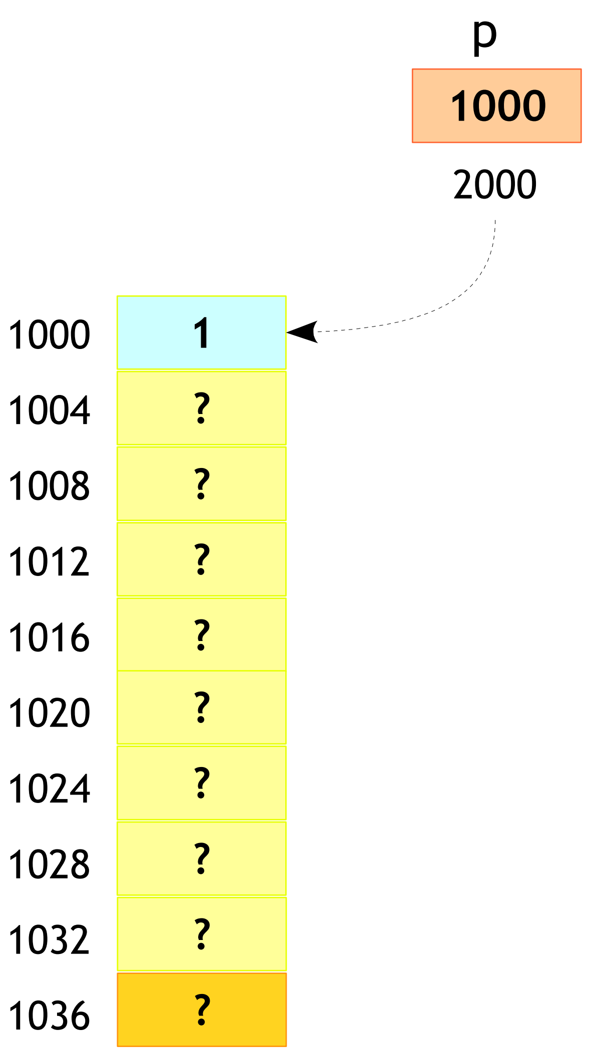
1000	?
1004	?
1008	?
1012	?
1016	?
1020	?
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Pointer to an Array

013_example.c

```c
int main()
{
    int (*p)[3];

    p = malloc(sizeof(*p) * 3);

    (*(p + 0))[0] = 1;
    (*(p + 1))[1] = 2;
    (*(p + 2))[2] = 3;

    printf(“%d\n”, p[0][0]);
    printf(“%d\n”, p[1][1]);
    printf(“%d\n”, p[2][2]);

    return 0;
}
```



p

1000

2000

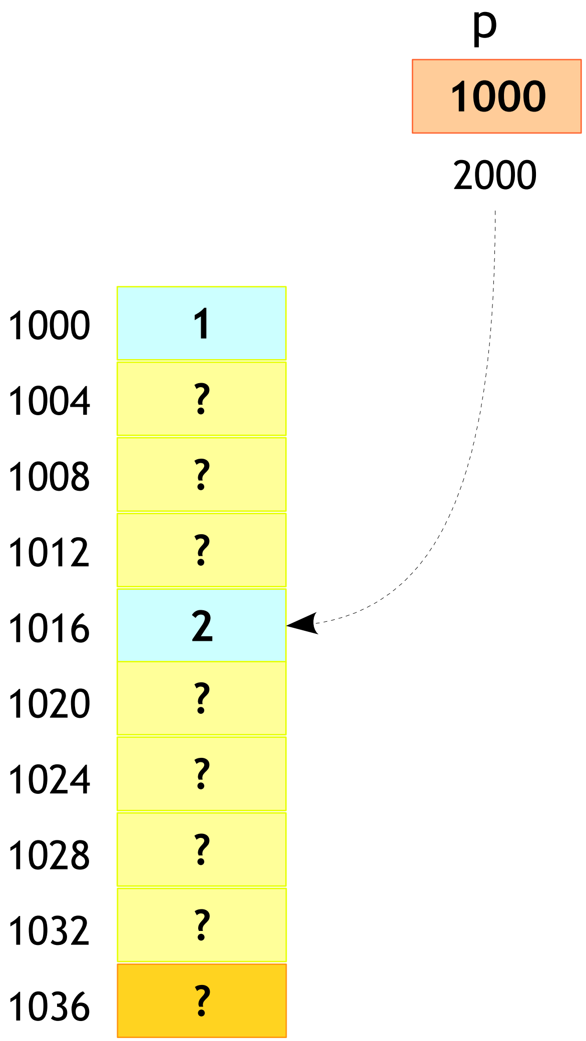
1000	1
1004	?
1008	?
1012	?
1016	?
1020	?
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Pointer to an Array

013_example.c

```
int main()
{
     int (*p)[3];

     p = malloc(sizeof(*p) * 3);

     (*(p + 0))[0] = 1;
     (*(p + 1))[1] = 2;
     (*(p + 2))[2] = 3;

     printf("%d\n", p[0][0]);
     printf("%d\n", p[1][1]);
     printf("%d\n", p[2][2]);

     return 0;
}
```



p

1000

2000

1000 1

1004 ?

1008 ?

1012 ?

1016 2

1020 ?

1024 ?

1028 ?

1032 ?

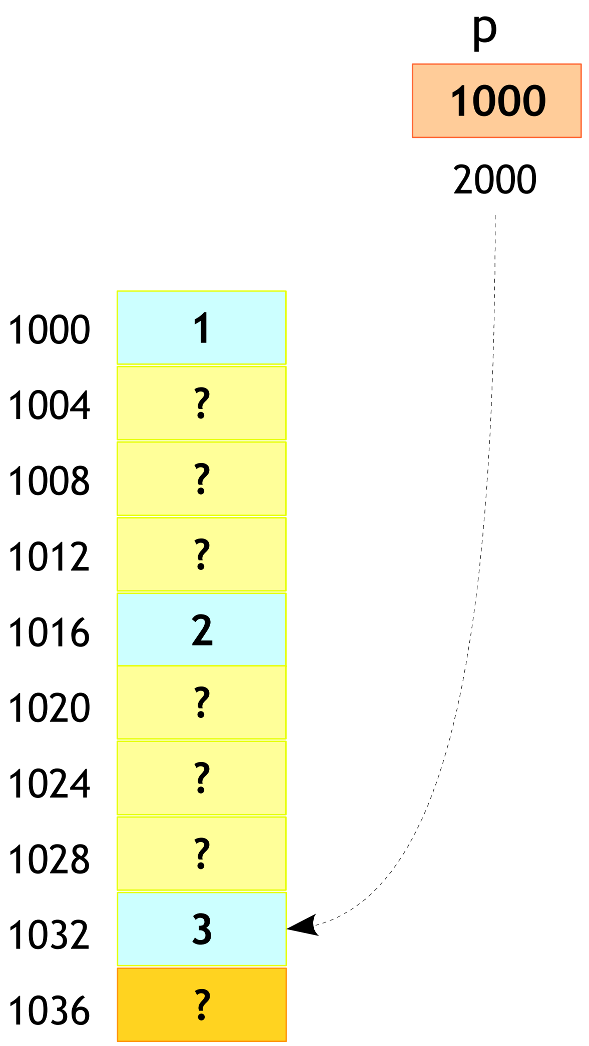
1036 ?

Advanced C

Pointers – Pointer to an Array

013_example.c

```
int main()
{
    int (*p)[3];

    p = malloc(sizeof(*p) * 3);

    (*(p + 0))[0] = 1;
    (*(p + 1))[1] = 2;
    (*(p + 2))[2] = 3;

    printf(“%d\n”, p[0][0]);
    printf(“%d\n”, p[1][1]);
    printf(“%d\n”, p[2][2]);

    return 0;
}
```

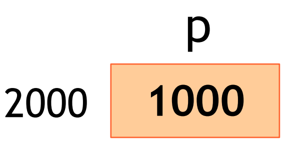


Advanced C

Pointers – Pointer to an 2D Array

014_example.c

```c
int main()
{
    int (*p)[3];
    int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

    p = a;

    return 0;
}
```



p

2000

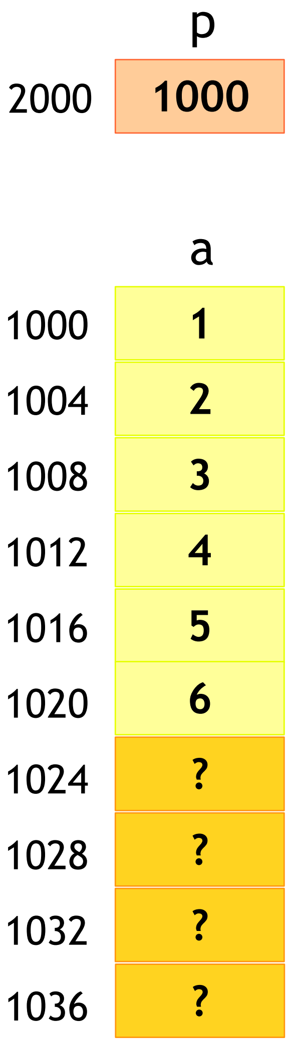
1000

Advanced C

Pointers – Pointer to an 2D Array

014_example.c

```c
int main()
{
    int (*p)[3];
    int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

    p = a;

    return 0;
}
```



p

2000	1000

a

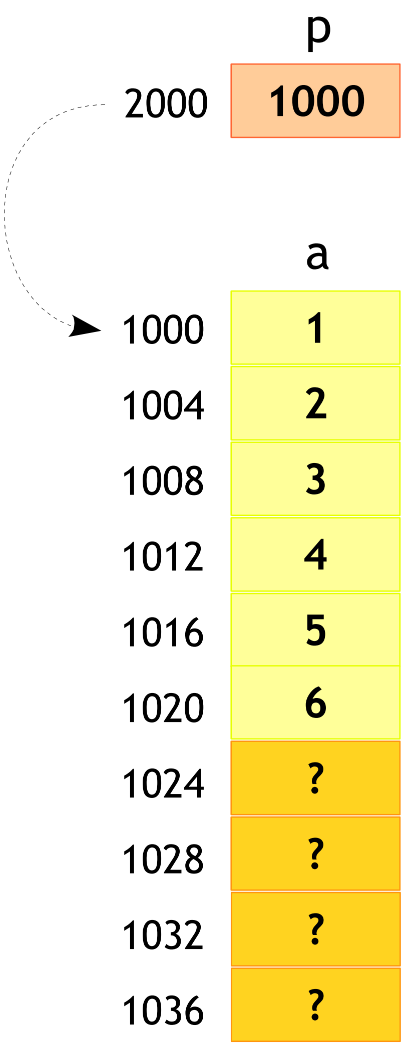
1000	1
1004	2
1008	3
1012	4
1016	5
1020	6
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Pointer to an 2D Array

014_example.c

```
int main()
{
    int (*p)[3];
    int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

    p = a;

    return 0;
}
```



p

2000	1000

a

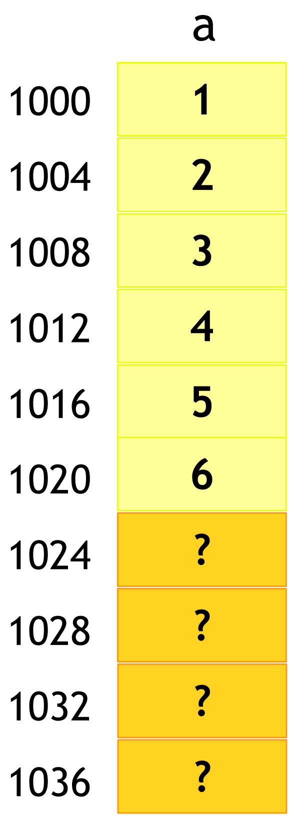
1000	1
1004	2
1008	3
1012	4
1016	5
1020	6
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Passing 2D array to function

015_example.c

```c
#include <stdio.h>

void print_array(int p[2][3])
{
    int i, j;

    for (i = 0; i < 2; i++)
    {
        for (j = 0; j < 3; j++)
        {
            printf("%d\n", p[i][j]);
        }
    }
}

int main()
{
    int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

    print_array(a);

    return 0;
}
```



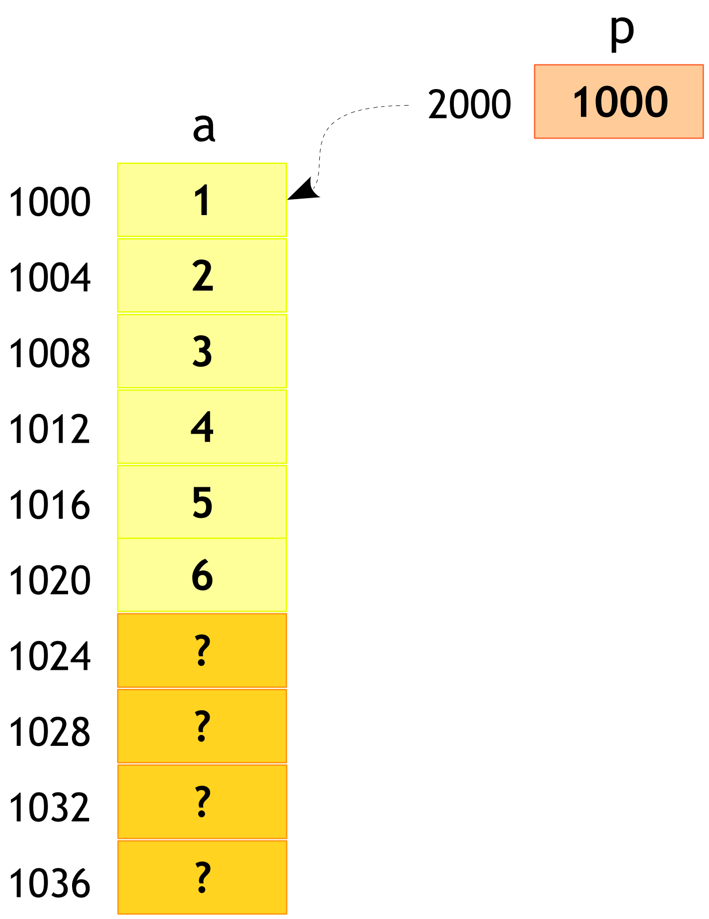
	a
1000	1
1004	2
1008	3
1012	4
1016	5
1020	6
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Passing 2D array to function

015_example.c

```c
#include <stdio.h>

void print_array(int p[2][3])
{
     int i, j;

     for (i = 0; i < 2; i++)
     {
          for (j = 0; j < 3; j++)
          {
               printf("%d\n", p[i][j]);
          }
     }
}

int main()
{
     int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

     print_array(a);

     return 0;
}
```



	a
1000	1
1004	2
1008	3
1012	4
1016	5
1020	6
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Passing 2D array to function

016_example.c

```
#include <stdio.h>

void print_array(int (*p)[3])
{
    int i, j;

    for (i = 0; i < 2; i++)
    {
        for (j = 0; j < 3; j++)
        {
            printf("%d\n", p[i][j]);
        }
    }
}

int main()
{
    int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

    print_array(a);

    return 0;
}
```

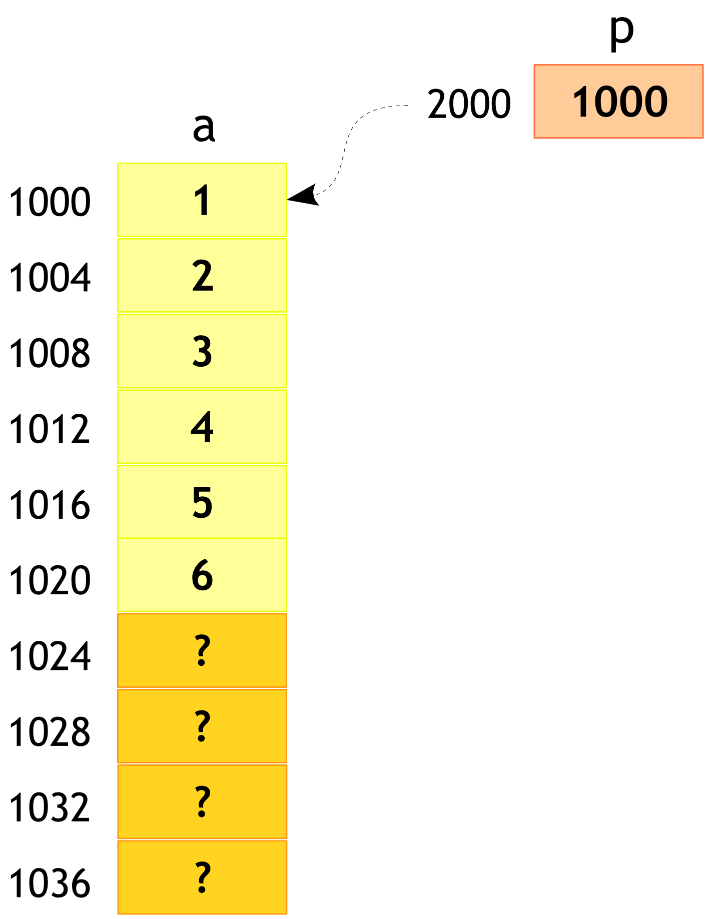
	a
1000	1
1004	2
1008	3
1012	4
1016	5
1020	6
1024	?
1028	?
1032	?
1036	?

Advanced C

Pointers – Passing 2D array to function

016_example.c

```
#include <stdio.h>

void print_array(int (*p)[3])
{
    int i, j;

    for (i = 0; i < 2; i++)
    {
        for (j = 0; j < 3; j++)
        {
            printf("%d\n", p[i][j]);
        }
    }
}

int main()
{
    int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

    print_array(a);

    return 0;
}
```



Advanced C

Pointers – Passing 2D array to function

017_example.c

```c
#include <stdio.h>

void print_array(int row, int col, int (*p)[col])
{
     int i, j;

     for (i = 0; i < row; i++)
     {
          for (j = 0; j < col; j++)
          {
               printf(“%d\n”, p[i][j]);
          }
     }
}

int main()
{
     int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

     print_array(2, 3, a);

     return 0;
}
```

Advanced C

Pointers – Passing 2D array to function

018_example.c

```
#include <stdio.h>

void print_array(int row, int col, int *p)
{
    int i, j;

    for (i = 0; i < row; i++)
    {
        for (j = 0; j < col; j++)
        {
            printf(“%d\n”, *((p + i * col) + j));
        }
    }
}

int main()
{
    int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

    print_array(2, 3, (int *) a);

    return 0;
}
```

Advanced C

Pointers – 2D Array Creations

- Each Dimension could be Static or Dynamic
- Possible combination of creation could be
  - BS: Both Static (Rectangular)
  - FSSD: First Static, Second Dynamic
  - FDSS: First Dynamic, Second Static
  - BD: Both Dynamic

Advanced C

Pointers – 2D Array Creations - BS

018_example.c

```c
#include <stdio.h>

int main()
{
    int a[2][3] = {{1, 2, 3}, {4, 5, 6}};

    return 0;
}
```

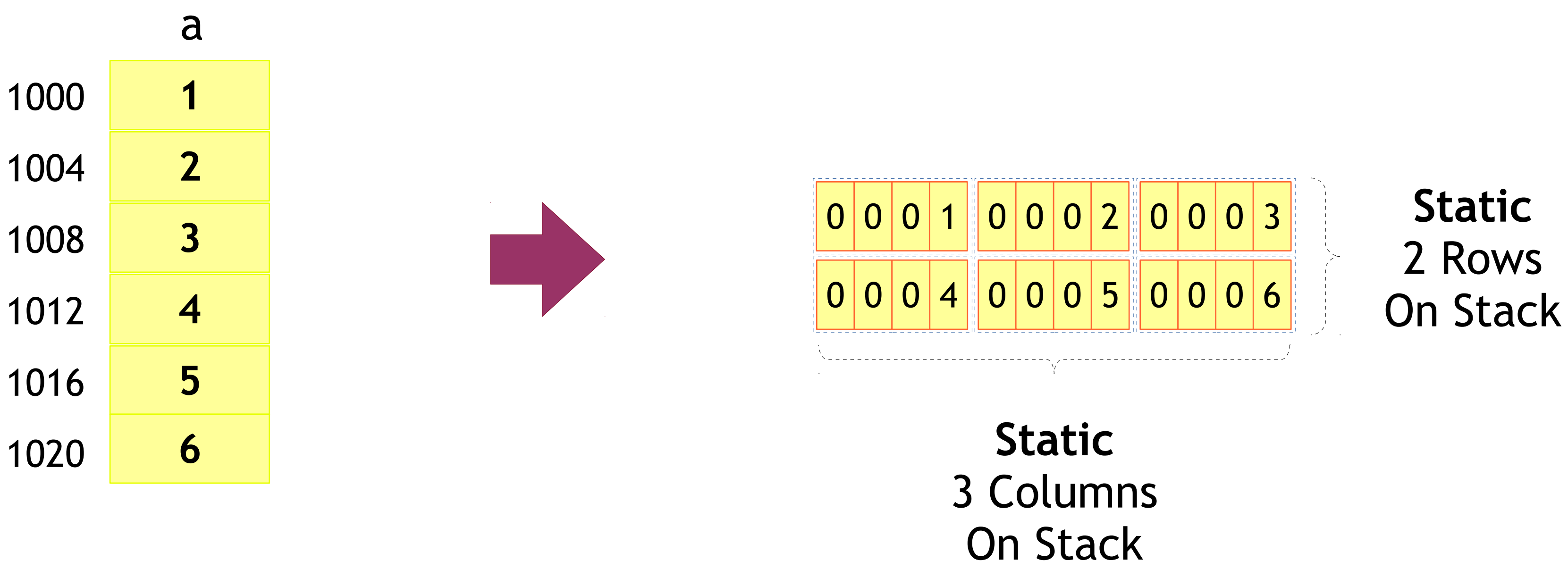
- Both Static (BS)
- Called as an rectangular array
- Total size is

  2 * 3 * sizeof(datatype)

  2 * 3 * 4 = 24 Bytes
- The memory representation can be as shown in next slide

Advanced C

Pointers – 2D Array Creations - BS



a

1000	**1**
1004	**2**
1008	**3**
1012	**4**
1016	**5**
1020	**6**

0 0 0 1	0 0 0 2	0 0 0 3
0 0 0 4	0 0 0 5	0 0 0 6

Static
2 Rows
On Stack

Static
3 Columns
On Stack

Advanced C

Pointers – 2D Array Creations - FSSD

019_example.c

```
#include <stdio.h>
#include <stdlib.h>

int main()
{
    int *a[2];

    for ( i = 0; i < 2; i++)
    {
        a[i] = malloc(3 * sizeof(int));
    }

    return 0;
}
```

- First Static and Second Dynamic (FSSD)
- Mix of Rectangular & Ragged
- Total size is

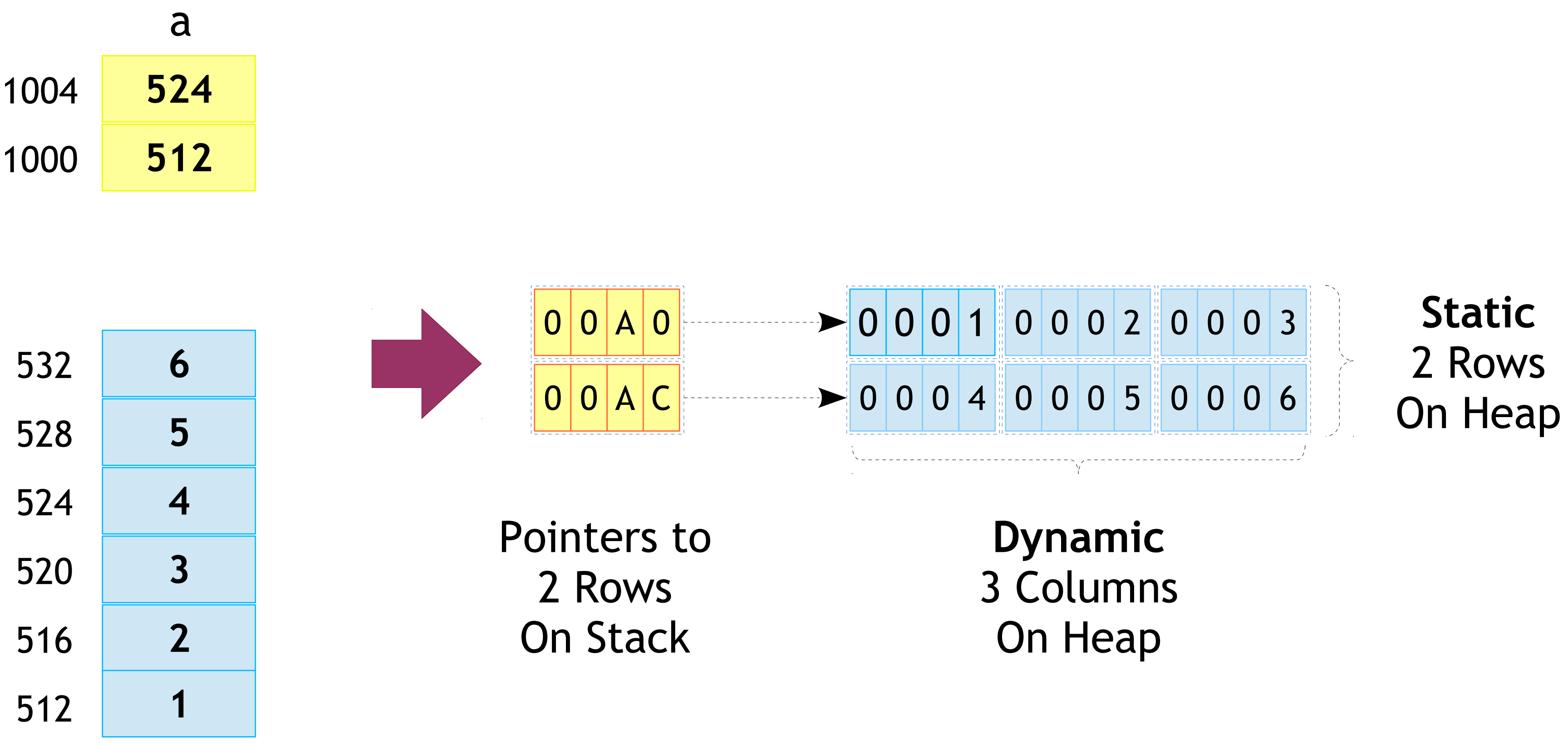
  2 * sizeof(datatype *) +

  2 * 3 * sizeof(datatype)

  2 * 4 + 2 * 3 * 4 = 32 Bytes
- The memory representation can be as shown in next slide

Advanced C

Pointers – 2D Array Creations - FSSD



a

1004 524

1000 512

532 6

528 5

524 4

520 3

516 2

512 1

0 0 A 0

0 0 A C

0 0 0 1 0 0 0 2 0 0 0 3

0 0 0 4 0 0 0 5 0 0 0 6

Static
2 Rows
On Heap

Pointers to
2 Rows
On Stack

Dynamic
3 Columns
On Heap

Advanced C

Pointers – 2D Array Creations - FDSS

020_example.c

```c
#include <stdio.h>
#include <stdlib.h>

int main()
{
    int (*a)[3];

    a = malloc(2 * sizeof(int [3]));

    return 0;
}
```

- First Dynamic and Second Static (FDSS)
- Total size is

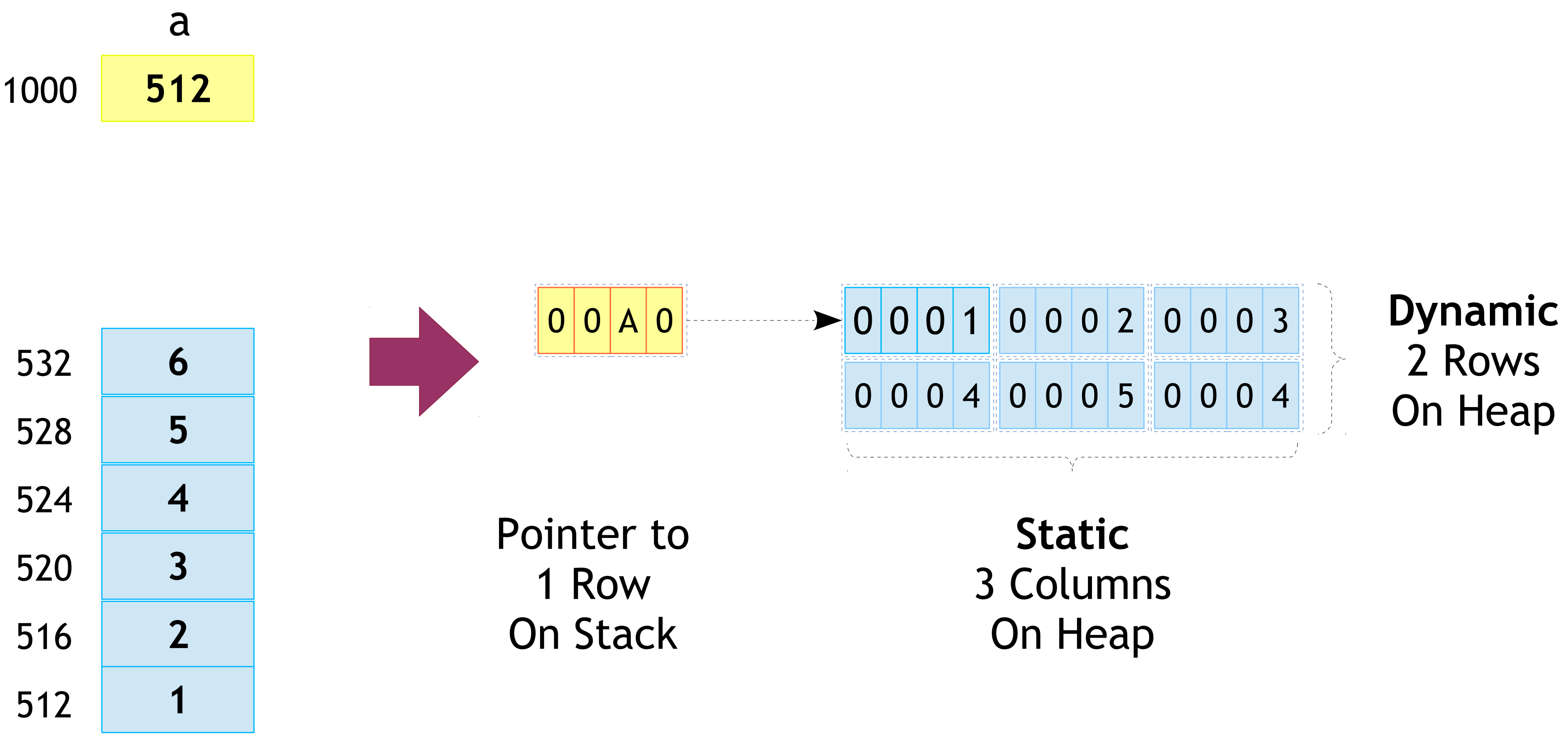
  sizeof(datatype *) +

  2 * 3 * sizeof(datatype)

  4 + 2 * 3 * 4 = 28 Bytes
- The memory representation can be as shown in next slide

Advanced C

Pointers – 2D Array Creations - FDSS



a

1000 512

532 6

528 5

524 4

520 3

516 2

512 1

0 0 A 0

0 0 0 1 0 0 0 2 0 0 0 3

0 0 0 4 0 0 0 5 0 0 0 4

Pointer to
1 Row
On Stack

Static
3 Columns
On Heap

Dynamic
2 Rows
On Heap

Advanced C

Pointers – 2D Array Creations - BD

021_example.c

```c
#include <stdio.h>
#include <stdlib.h>

int main()
{
    int **a;
    int i;

    a = malloc(2 * sizeof(int *));

    for (i = 0; i < 2; i++)
    {
        a[i] = malloc(3 * sizeof(int));
    }

    return 0;
}
```

- Both Dynamic (BD)
- Total size is

  sizeof(datatype **) +

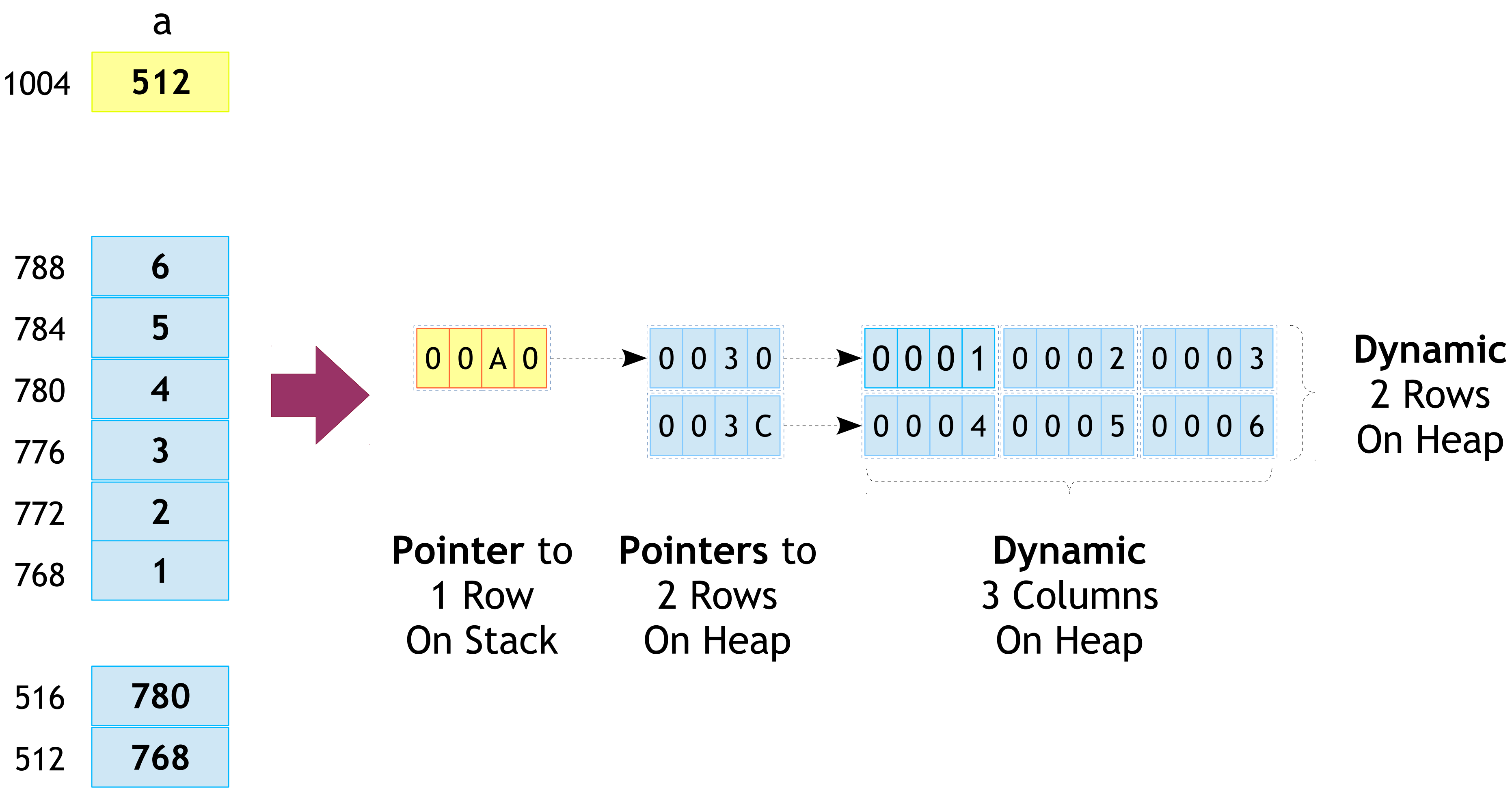
  2 * sizeof(datatype *) +

  2 * 3 * sizeof(datatype)

  4 + 2 * 4 + 2 * 3 * 4 = 28 Bytes
- The memory representation can be as shown in next slide

Advanced C

Pointers – 2D Array Creations - BD



a

1004	512

788	6
784	5
780	4
776	3
772	2
768	1

516	780
512	768

0	0	A	0

0	0	3	0
0	0	3	C

0	0	0	1	0	0	0	2	0	0	0	3
0	0	0	4	0	0	0	5	0	0	0	6

Dynamic
2 Rows
On Heap

Pointer to
1 Row
On Stack

Pointers to
2 Rows
On Heap

Dynamic
3 Columns
On Heap