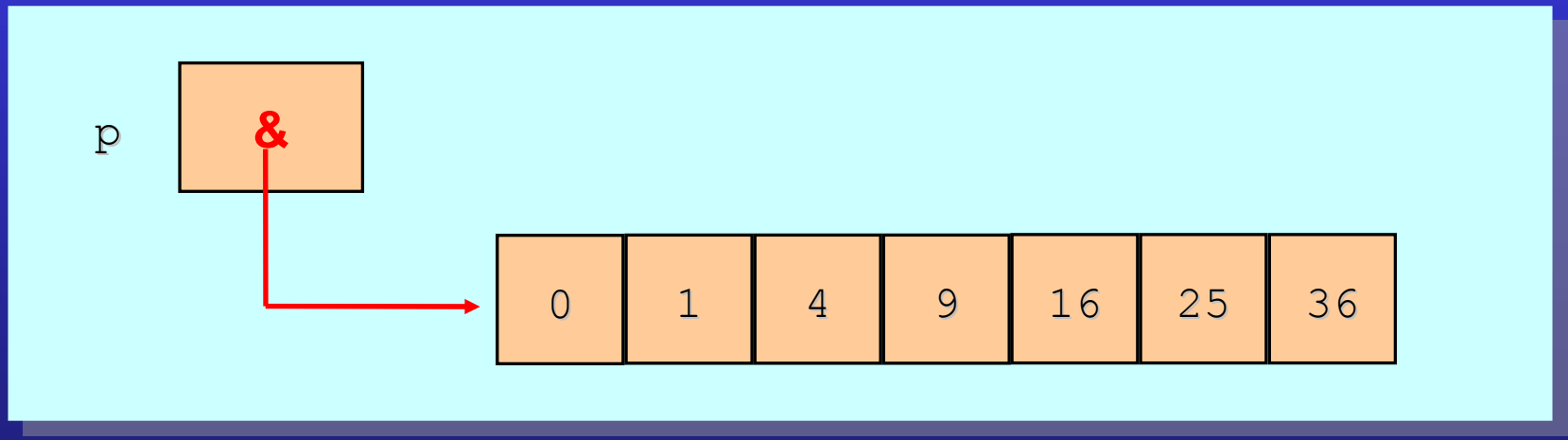
Arrays

array literal

- an aggregate initializer list can apparently be cast to an array type
  - known as a compound literal

```
int * p =
     (int []){ 0,1,4,9,16,25,36 };
```



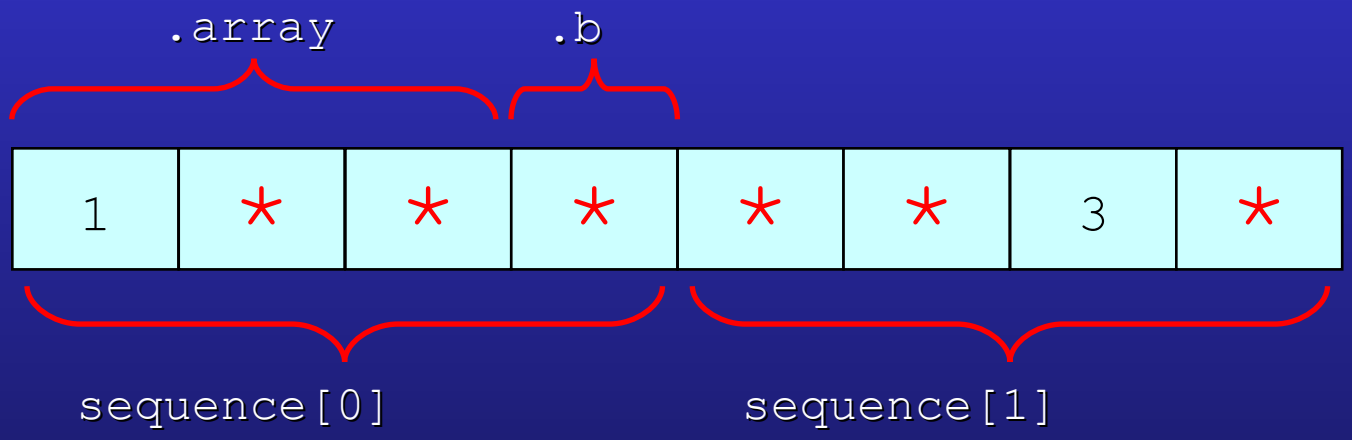
arrays and structs

- arrays and struct may contain each other
  - [int] and .identifier designators can be combined

struct containing array

```
struct s
{
    int array[3];
    int b;
};
```

```
struct s sequence[] =
    {
        [0].array = { 1 },
        [1].array[2] = 3
    };
```



* default value

- only the top-level array decays into a pointer
  - the size of sub arrays remains part of the type

```
void print(int nrows, int matrix[2][3]);
void print(int nrows, int matrix[ ][3]);
void print(int nrows, int (*matrix)[3]);
```

equivalent

```
int main(void)
{
    int grid[2][3] = {{0,1,2},{3,4,5}};
    ...
    print(2, grid);
}
```

```
void illegal(int matrix[ ][ ]) ...
```

pointer to array

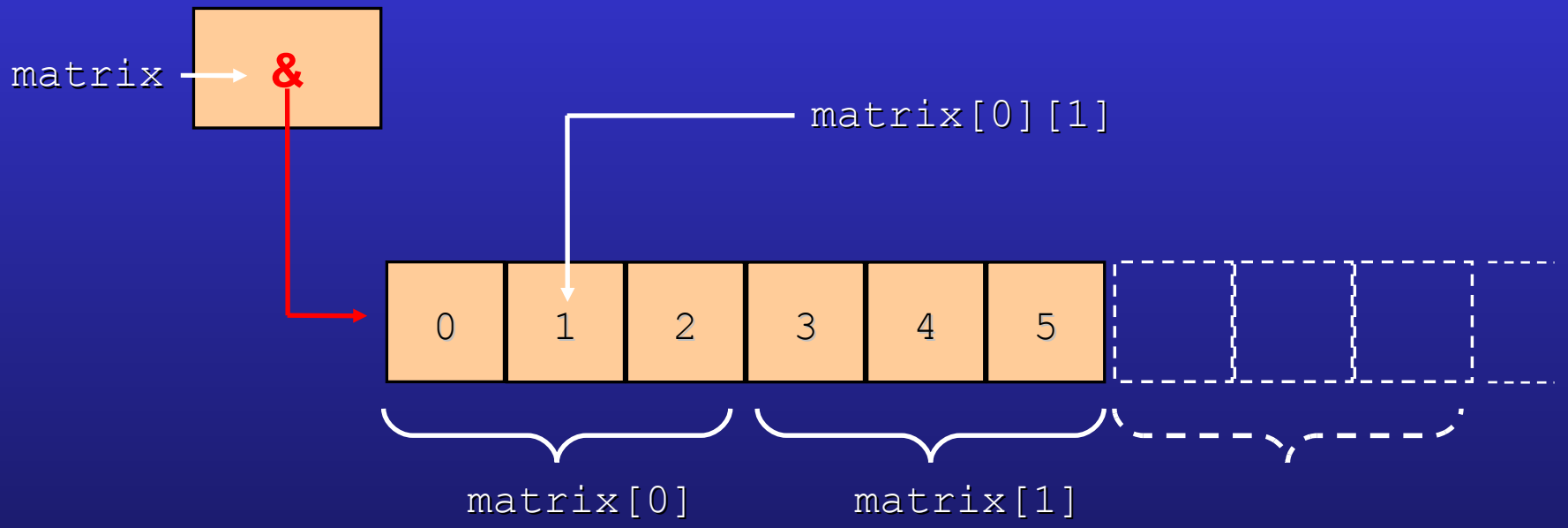
```
int (*matrix)[3]
```

```
int (*matrix)[3]

int (*matrix)[3]
```

matrix is a pointer
to zero, one, or more
array(s) of three ints

matrix points to a *single* chunk of memory



ragged arrays

- an array of pointers can mimic a 2d array
  - each pointer points to an array
  - aka Illiffe vector aka dope vector

note this is `int*ragged[2]` and not `int(*ragged)[2]`

```
void print(int nrows, int ncols, int * ragged[2]);
void print(int nrows, int ncols, int * ragged[ ]);
void print(int nrows, int ncols, int * * ragged);
```

equivalent

```
int main(void)
{
    int vec1[] = { 0, 1, 2 };
    int vec2[] = { 3, 4, 5 };
    int * grid[2] = { vec1, vec2 };

    print(2, 3, grid);
}
```

array of pointers

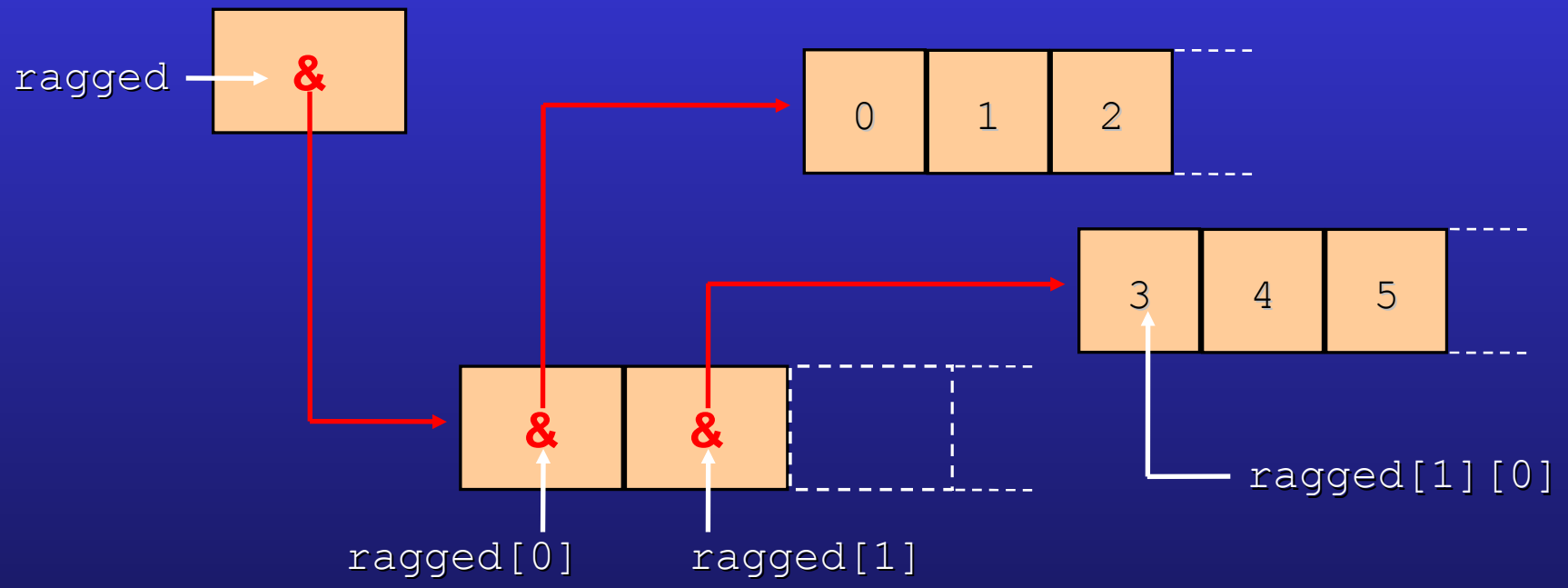
```
int * ragged[]
```

```
int * ragged[]

int * ragged[]

int * ragged[]
```

ragged is an array
of
pointers
to zero, one, or more
int(s)



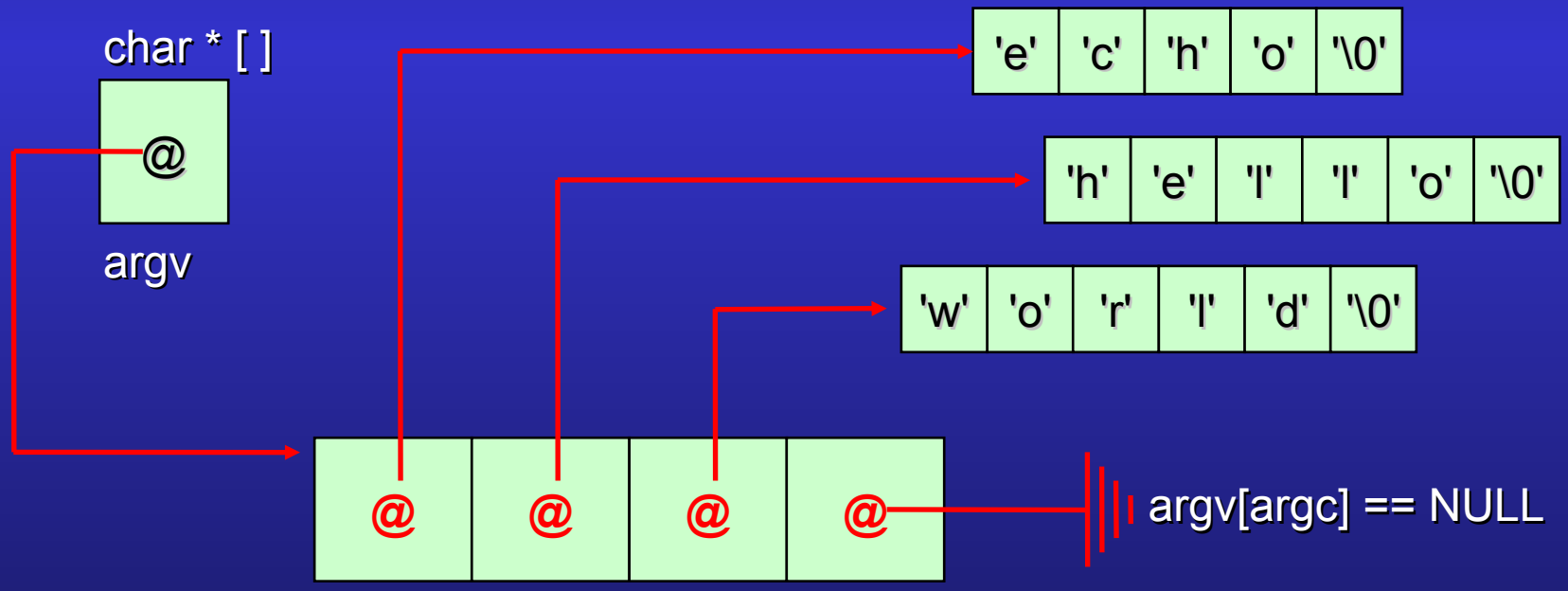
ragged array example

echo.c

```
#include <stdio.h>

int main(int argc, char * argv[])
{
    for (int at = 0; at != argc; at++)
        printf("%s ", argv[at]);
    putchar('\n');
}
```

```
>echo hello world
```



Variable length arrays

- **VLA's - four restrictions**

```
void vla(int n)
{
    int ok[n];

    static int g[n];

    extern int f[n];

    struct tag
    {
        int (*y)[n];
        int x[n];
    };
}

extern int size;
int array[size];
```

An object with static storage duration cannot have a variable length array type

An object with linkage cannot have a variable length array type

An identifier other than a simple identifier cannot have a variable length array type

A file scope identifier cannot have a variable length array type

- VLA's make multi-dimensional array parameters much more useful and reusable

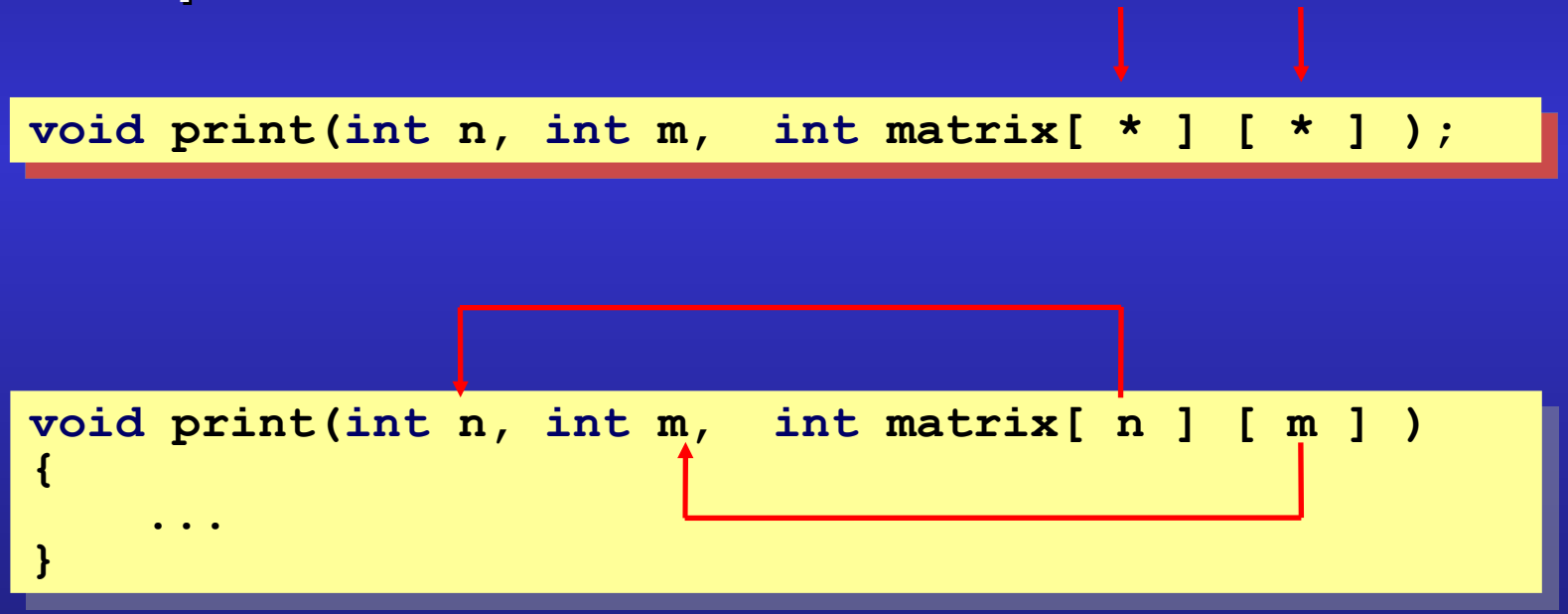
```
void print(int n, int m,  int matrix[ n ] [ m ] );
```

```
void print(int n, int m,  int matrix[ n ] [ m ] )
{
    ...
}
```

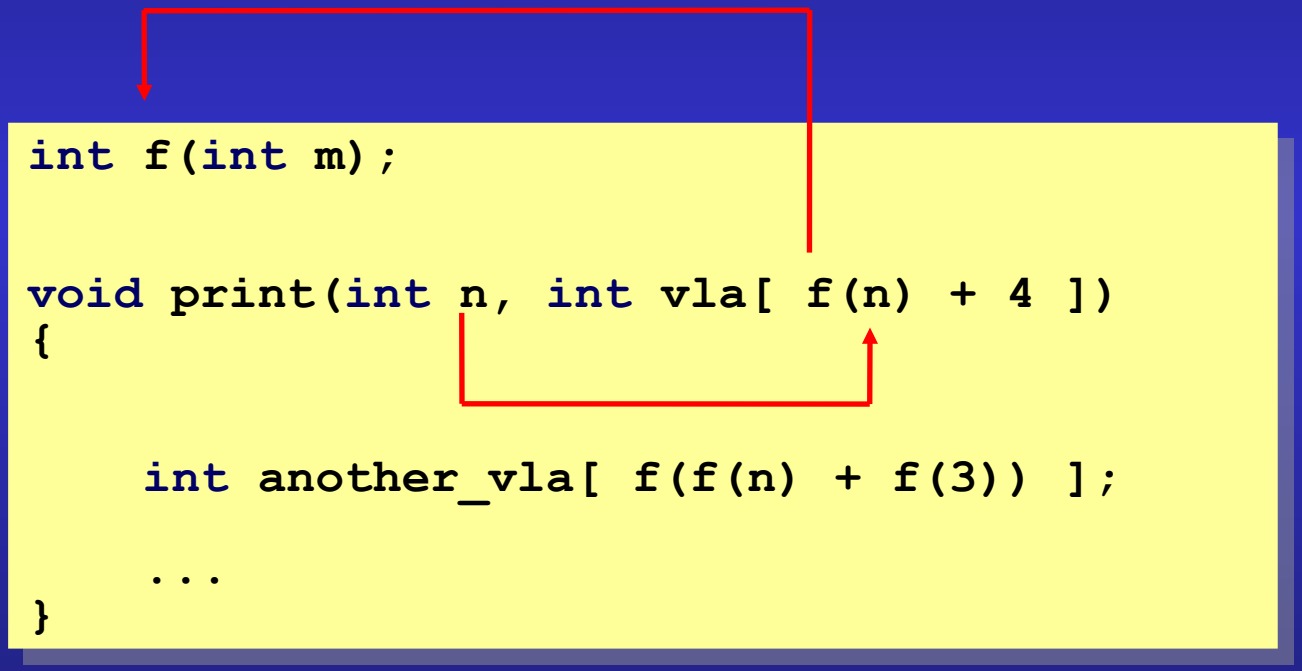
n and m must be declared before matrix

```
int main(void)
{
    int matrix[][3] = {{ 0, 1, 2 }, { 3, 4, 5 }};
    print(2, 3, matrix);
}
```

- 6.7.5.2 Array declarators
  - para 4 – If the size is * instead of being an expression, the array type is a variable length array type of unspecified size, which can only be used in declarations with function prototype scope



- 6.7.5.2 Array declarators
  - para 5 – if the size is an expression that is not an integer constant expression ... each time it is evaluated it shall have a value greater than zero.



```
int f(int m);

void print(int n, int vla[ f(n) + 4 ])
{
    int another_vla[ f(f(n) + f(3)) ];
    ...
}
```

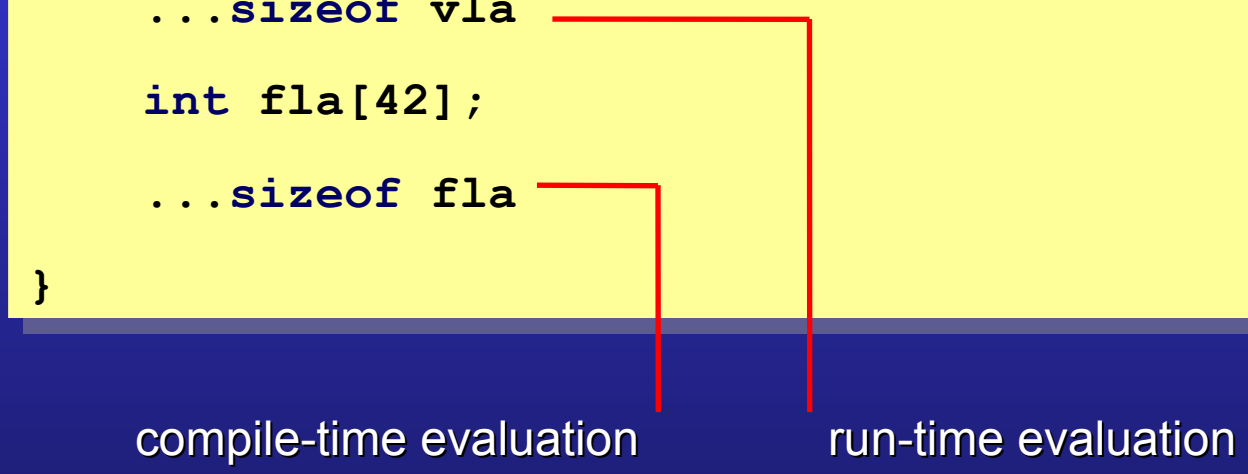
- 6.5.3.4 The sizeof operator
  - para 2 – If the type of the operand is a variable length array type, the operand is evaluated; otherwise, the operand is not evaluated and the result is an integer constant

```
void examples(int n, int vla[ f(n) ])
{
    ...sizeof vla

    int fla[42];

    ...sizeof fla

}
```

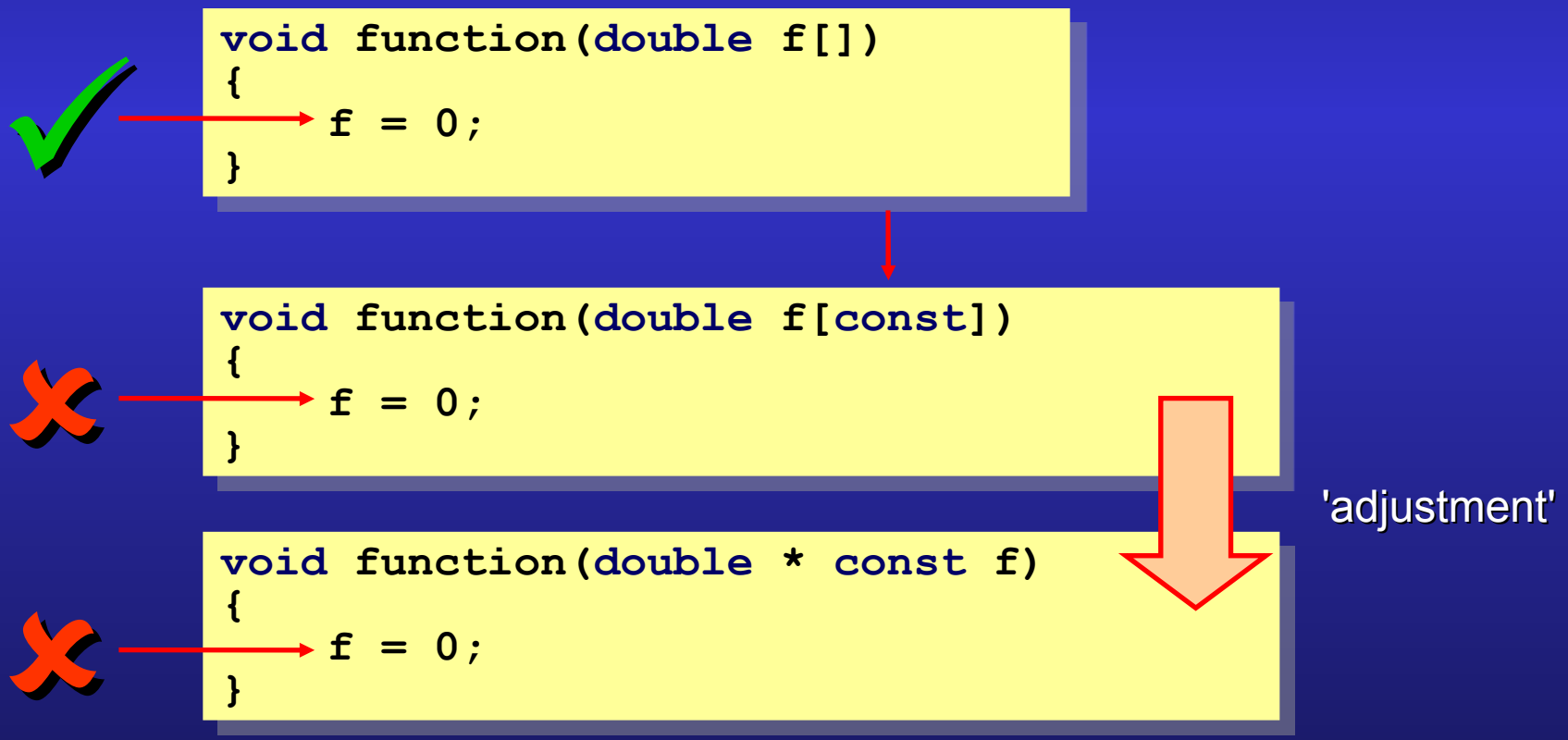


- 6.7.5.3 Function declarators
  - para 7 - If the keyword static also appears within the [and] of the array type derivation, then for each call to the function, the value of the corresponding argument ***shall*** provide access to the first element of an array with at least as many elements as specified by the size expression

```
void function(double f[static 16])
{
    ...
}
```

f is non-null and points to at least 16 doubles

- 6.7.5.3 Function declarators
  - para 7 – A declaration of as parameter as "array of type" shall be adjusted to "qualified pointer to type", where the type qualifiers (if any) are those specified within the [and] of the array type derivation



- complete arrays can be typedef'd

```
typedef int table[42];

void example(void)
{
    table t;

    printf("%zd\n", sizeof(t));

}
```

42 * sizeof(int)

typedef

- incomplete arrays can be typedef'd

```
typedef int table[];

void example(void)
{
    table t1 = { 1,2 };

    printf("%zd\n", sizeof(t1));

    table t2 = { 1,2,3,4 };

    printf("%zd\n", sizeof(t2));

}
```

2 * sizeof(int)

4 * sizeof(int)

The compound-literal feature was added in C99. It is not a cast.

Note that the memory layout for a 2d array is a single block of memory.

To understand the third function prototype for pass remember that a pointer to something uses the same syntax as a pointer to an array of something. In:

```
void print(int nrows, int (*matrix)[3]);
```

matrix is a pointer to an int[3] or to the first element in an array of int[3].

Note that argv[0] is often the name of the program itself by strictly speaking this is not required by the standard.

The keyword static affects composite type compatibility rules when used in declarators. If static is used on any declarators the effect is as if it was used on all declarators. If the sizes used on declarators differ the composite type takes the largest size.

```
void f(int x[static 10]);
void f(int x[static 5]);
void f(int x[1])
{
   // composite type is void f(int x[static 10]);
}
```

The other two type qualifiers are restrict and volatile.

The array can be an incomplete type:

```
typedef int table[];
```

This typedef's name (table) can never be completed. However, an object definition whose type specifier is the typedef name can complete the type for that object.