Other data types

Type aliases (typedef / using)

A type alias is a different name by which a type can be identified. In C++, any valid type can be aliased so that it can be referred to with a different identifier.

In C++, there are two syntaxes for creating such type aliases: The first, inherited from the C language, uses the `typedef` keyword:

```
typedef existing_type new_type_name ;
```

where `existing_type` is any type, either fundamental or compound, and `new_type_name` is an identifier with the new name given to the type.

For example:

```
1 typedef char C;
2 typedef unsigned int WORD;
3 typedef char * pChar;
4 typedef char field [50];
```

This defines four type aliases: `C`, `WORD`, `pChar`, and `field` as `char`, `unsigned int`, `char*` and `char[50]`, respectively. Once these aliases are defined, they can be used in any declaration just like any other valid type:

```
1 C mychar, anotherchar, *ptc1;
2 WORD myword;
3 pChar ptc2;
4 field name;
```

More recently, a second syntax to define type aliases was introduced in the C++ language:

```
using new_type_name = existing_type ;
```

For example, the same type aliases as above could be defined as:

```
1 using C = char;
2 using WORD = unsigned int;
3 using pChar = char *;
4 using field = char [50];
```

Both aliases defined with `typedef` and aliases defined with `using` are semantically equivalent. The only difference being that `typedef` has certain limitations in the realm of templates that `using` has not. Therefore, `using` is more generic, although `typedef` has a longer history and is probably more common in existing code.

Note that neither `typedef` nor `using` create new distinct data types. They only create synonyms of existing types. That means that the type of `myword` above, declared with type `WORD`, can as well be considered of type `unsigned int`; it does not really matter, since both are actually referring to the same type.

Type aliases can be used to reduce the length of long or confusing type names, but they are most useful as tools to abstract programs from the underlying types they use. For example, by using an alias of `int` to refer to a particular kind of parameter instead of using `int` directly, it allows for the type to be easily replaced by `long` (or some other type) in a later version, without having to change every instance where it is used.

Unions

Unions allow one portion of memory to be accessed as different data types. Its declaration and use is similar to the one of structures, but its functionality is totally different:

```
union type_name {
  member_type1 member_name1;
  member_type2 member_name2;
  member_type3 member_name3;
  .
  .
} object_names;
```

This creates a new union type, identified by `type_name`, in which all its member elements occupy the same physical space in memory. The size of this type is the one of the largest member element. For example:

```
union mytypes_t {
  char c;
  int i;
  float f;
} mytypes;
```

declares an object (`mytypes`) with three members:

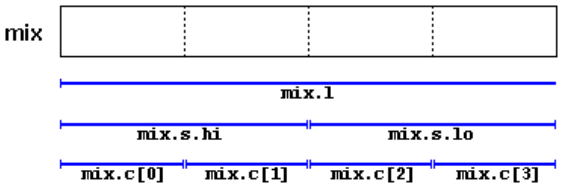
```
mytypes.c
mytypes.i
mytypes.f
```

Each of these members is of a different data type. But since all of them are referring to the same location in memory, the modification of one of the members will affect the value of all of them. It is not possible to store different values in them in a way that each is independent of the others.

One of the uses of a union is to be able to access a value either in its entirety or as an array or structure of smaller elements. For example:

```
union mix_t {
  int l;
  struct {
    short hi;
    short lo;
    } s;
  char c[4];
} mix;
```

If we assume that the system where this program runs has an `int` type with a size of 4 bytes, and a `short` type of 2 bytes, the union defined above allows the access to the same group of 4 bytes: `mix.l`, `mix.s` and `mix.c`, and which we can use according to how we want to access these bytes: as if they were a single value of type `int`, or as if they were two values of type `short`, or as an array of `char` elements, respectively. The example mixes types, arrays, and structures in the union to demonstrate different ways to access the data. For a little-endian system, this union could be represented as:



The exact alignment and order of the members of a union in memory depends on the system, with the possibility of creating portability issues.

Anonymous unions

When unions are members of a class (or structure), they can be declared with no name. In this case, they become *anonymous unions*, and its members are directly accessible from objects by their member names. For example, see the differences between these two structure declarations:

structure with regular union	structure with anonymous union

`struct book1_t {`
`  char title[50];`
`  char author[50];`
`  union {`
`  float dollars;`
`  int yen;`
`  } price;`
`} book1;`
	`struct book2_t {`
	`  char title[50];`
	`  char author[50];`
	`  union {`
	`  float dollars;`
	`  int yen;`
	`  };`
	`} book2;`

The only difference between the two types is that in the first one, the member union has a name (`price`), while in the second it has not. This affects the way to access members `dollars` and `yen` of an object of this type. For an object of the first type (with a regular union), it would be:

```
book1.price.dollars
book1.price.yen
```

whereas for an object of the second type (which has an anonymous union), it would be:

```
book2.dollars
book2.yen
```

Again, remember that because it is a member union (not a member structure), the members `dollars` and `yen` actually

share the same memory location, so they cannot be used to store two different values simultaneously. The `price` can be set in `dollars` or in `yen`, but not in both simultaneously.

Enumerated types (enum)

Enumerated types are types that are defined with a set of custom identifiers, known as *enumerators*, as possible values. Objects of these *enumerated types* can take any of these enumerators as value.

Their syntax is:

```
enum type_name {
  value1,
  value2,
  value3,
  .
  .
} object_names;
```

This creates the type `type_name`, which can take any of `value1`, `value2`, `value3`, ... as value. Objects (variables) of this type can directly be instantiated as `object_names`.

For example, a new type of variable called `colors_t` could be defined to store colors with the following declaration:

```
enum colors_t {black, blue, green, cyan, red, purple, yellow, white};
```

Notice that this declaration includes no other type, neither fundamental nor compound, in its definition. To say it another way, somehow, this creates a whole new data type from scratch without basing it on any other existing type. The possible values that variables of this new type `color_t` may take are the enumerators listed within braces. For example, once the `colors_t` enumerated type is declared, the following expressions will be valid:

```
1 colors_t mycolor;
2
3 mycolor = blue;
4 if (mycolor == green) mycolor = red;
```

Values of *enumerated types* declared with `enum` are implicitly convertible to the integer type `int`, and vice versa. In fact, the elements of such an `enum` are always assigned an integer numerical equivalent internally, of which they become an alias. If it is not specified otherwise, the integer value equivalent to the first possible value is `0`, the equivalent to the second is `1`, to the third is `2`, and so on... Therefore, in the data type `colors_t` defined above, `black` would be equivalent to `0`, `blue` would be equivalent to `1`, `green` to `2`, and so on...

A specific integer value can be specified for any of the possible values in the enumerated type. And if the constant value that follows it is itself not given its own value, it is automatically assumed to be the same value plus one. For example:

```
1 enum months_t { january=1, february, march, april,
2                 may, june, july, august,
3                 september, october, november, december} y2k;
```

In this case, the variable `y2k` of the enumerated type `months_t` can contain any of the 12 possible values that go from `january` to `december` and that are equivalent to the values between `1` and `12` (not between `0` and `11`, since `january` has been made equal to `1`).

Because enumerated types declared with `enum` are implicitly convertible to `int`, and each of the enumerator values is actually of type `int`, there is no way to distinguish `1` from `january` - they are the exact same value of the same type. The reasons for this are historical and are inheritance of the C language.

Enumerated types with enum class

But, in C++, it is possible to create real `enum` types that are neither implicitly convertible to `int` and that neither have enumerator values of type `int`, but of the `enum` type itself, thus preserving type safety. They are declared with `enum class` (or `enum struct`) instead of just `enum`:

```
enum class Colors {black, blue, green, cyan, red, purple, yellow, white};
```

Each of the enumerator values of an `enum class` type needs to be scoped into its type (this is actually also possible with `enum` types, but it is only optional). For example:

```
1 Colors mycolor;
2
3 mycolor = Colors::blue;
4 if (mycolor == Colors::green) mycolor = Colors::red;
```

Enumerated types declared with `enum class` also have more control over their underlying type; it may be any integral data type, such as `char`, `short` or `unsigned int`, which essentially serves to determine the size of the type. This is specified by a colon and the underlying type following the enumerated type. For example:

```
enum class EyeColor : char {blue, green, brown};
```

Here, `Eyecolor` is a distinct type with the same size of a `char` (1 byte).

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