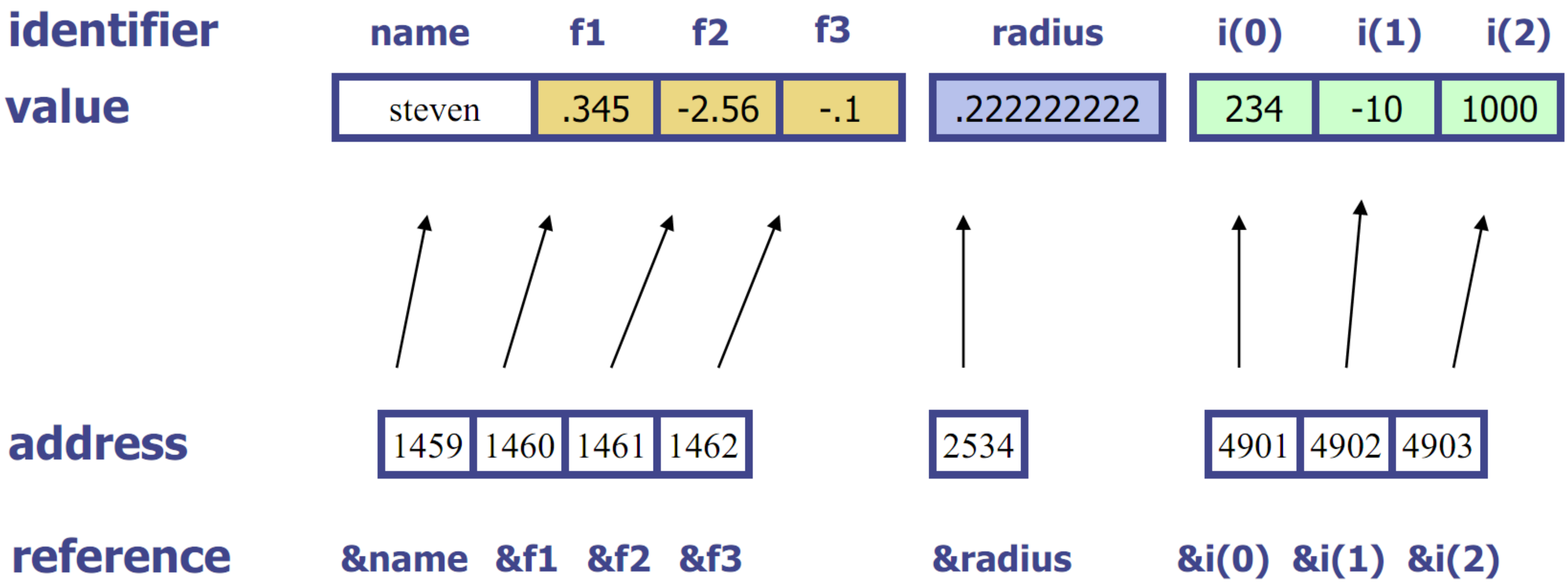
CSE 165/ENGR 140 Intro to Object Orient Program

Lecture 4 – C in C++

Data types: pointers and references

- Pointers are variables containing a memory address
- Every variable, object, and function has an address
- References are introduced in C++ as a new way to work with the address of a variable
  - Avoids the sometime heavy syntax needed to work with pointers, and allowing the same kind of functionality
- Contrary to pointers, references are always valid
  - pointer can be “null” or be of void type (void* pt), references cannot
  - Can’t be changed to reference a different variable

Memory: address and value



identifier	name	f1	f2	f3	radius	i(0)	i(1)	i(2)
value	steven	.345	-2.56	-.1	.222222222	234	-10	1000
address	1459	1460	1461	1462	2534	4901	4902	4903
reference	&name	&f1	&f2	&f3	&radius	&i(0)	&i(1)	&i(2)

Reference and De-reference

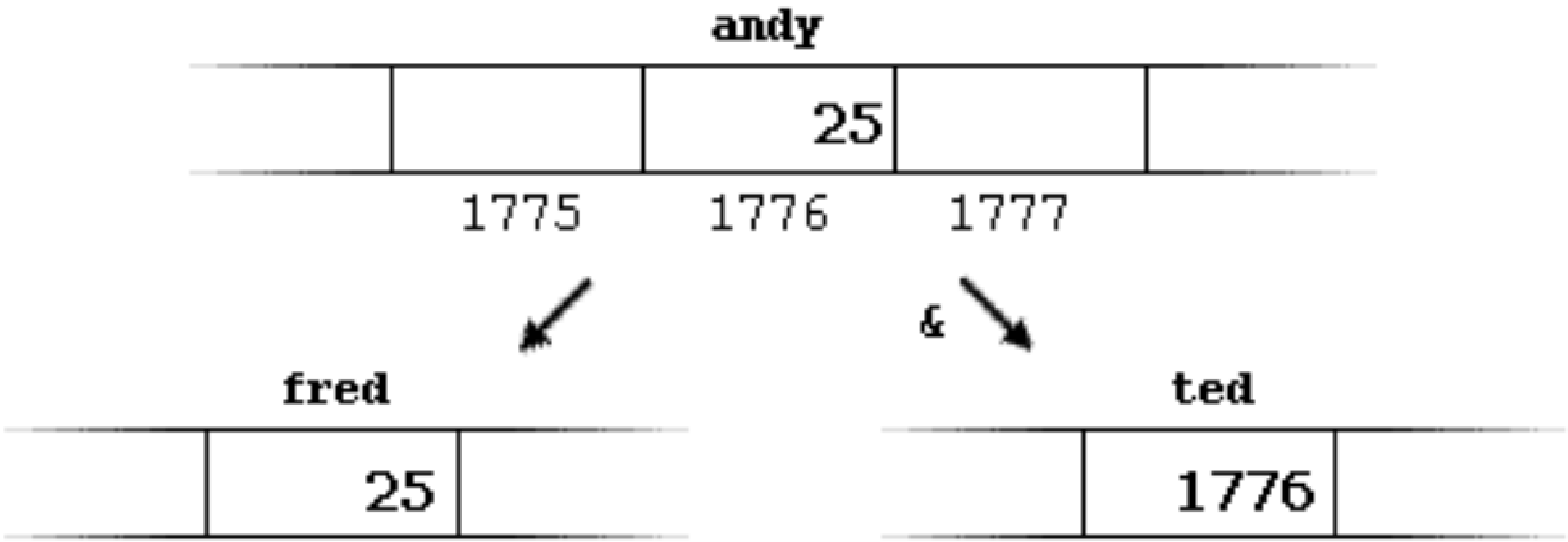
type&	reference declaration	
type*	pointer declaration	
&	reference operator:	"address of"
*	dereference operator:	"value pointed by"

Equivalent to:

&:	Address of	John	is 52 Main Street
*:	Value at	52 Main Street	is John

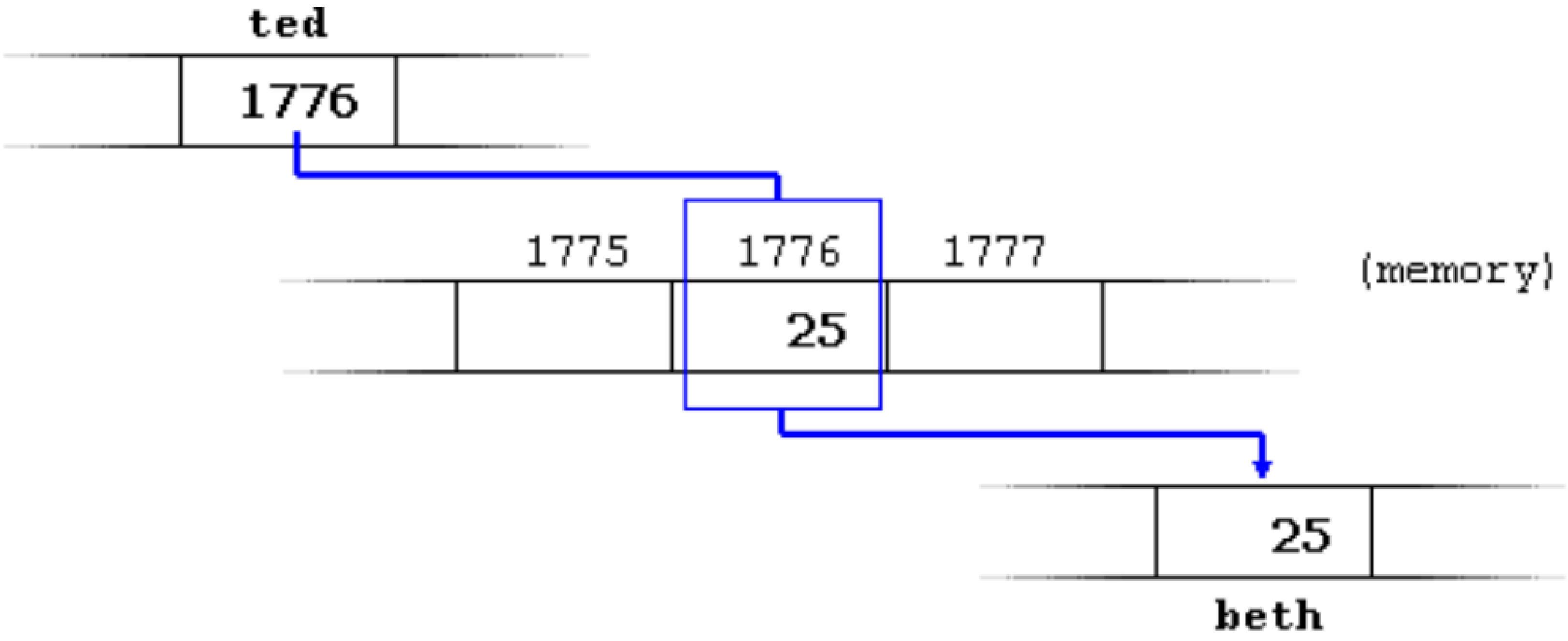
Reference operator

andy = 25; // andy contains 25
fred = andy;   // fred contains the value of andy (25)
ted = &andy; // ted contains the address of andy (1776)



De-reference operator

```
beth = ted;     // beth equal to ted ( 1776 )
beth = *ted;    // beth equal to value pointed by ted (25)
```



Variables of pointer type

- Declaration:
  - type * name;
  - type* name;
  - type *name;

- Examples:
  - int * address;   // address is a pointer of type int
  - char *p_ch;   // p_ch is a pointer of type char
  - float* p;   // p is a pointer of type float

Pointer initialization

- int number = 1000;
- int* p_number = &number;
- cout << p_number
- cout << *p_number

Variables and pointers

- Declaration:
  - type * name1, * name2; // declares 2 pointers type*
  - type * name1, name2;   // declares 1 pointer type and 1 variable of type
- Definition:
  - int *p_i; int i, j;
  - i = 10;
  - p_i = &i;
  - *p_i = 20;
  - p_i = &j;
  - *p_i = 10;

Reference example

```cpp
#include <iostream>
using namespace std;

int dog, cat, bird, fish;

void f(int pet)
{
   cout << "pet id number: " << pet << endl;
}

int main()
{
   int i, j, k;
   cout << "f(): " << (long)&f << endl;
   cout << "dog: " << (long)&dog << endl;
   cout << "cat: " << (long)&cat << endl;
   cout << "bird: " << (long)&bird << endl;
   cout << "fish: " << (long)&fish << endl;
   cout << "i: " << (long)&i << endl;
   cout << "j: " << (long)&j << endl;
   cout << "k: " << (long)&k << endl;
}
```

```
Result:
f(): 4198736
dog: 4323632
cat: 4323636
bird: 4323640
fish: 4323644
i: 6684160
j: 6684156
k: 6684152
```

Reference examples

```cpp
//: C03:PassReference.cpp
#include <iostream>
using namespace std;
void f ( int& r ) // Accepting reference
{
  cout << "r = " << r << endl;
  cout << "&r = " << &r << endl;
  r = 5;
  cout << "r = " << r << endl;
}

int main()
{
  int x = 47;
  cout << "x = " << x << endl;
  cout << "&x = " << &x << endl;
  f(x); // Looks like pass-by-value, but is actually
pass by reference
  cout << "x = " << x << endl;
}
```

Result:

```
x = 47
&x = 0065FE00
r = 47
&r = 0065FE00
r = 5
x = 5
```

Wake up

- https://youtu.be/hVr1YI6x-eQ

Pointers vs References

- A pointer is a variable that stores the address of another variable
  - Can be null
  - Can be changed
  - Uses *
- References refers to another variable
  - Another name of an existing variable
  - Cannot be null
  - Cannot be changed
  - Uses &

Types: operators

- Mathematical operators:
  - addition (+), subtraction (-), division (/), multiplication (*)
    - integer division truncates the result (it doesn’t round)
  - modulus (%; remainder from integer division)
    - cannot be used with floating-point numbers
  - Assignment operators: +=, -=, *=, /=, etc
- Logical operators
  - **and** (&&), **or** (||) produce *true* or *false*
  - in C and C++ a statement is *true* if it has a non-zero value, and *false* if it has a value of zero
  - Negation operator not (!)
  - == comparison operator
    - different from assignment op. (=) !

Types: operators

- Bitwise operators
  - bitwise and (&)
    - 1 if both input bits are 1; otherwise 0
  - bitwise or (|)
    - 1 if either input bits are 1; 0 only if both are 0
  - bitwise exclusive or, or xor (^)
    - 1 if an input bit is one, but not both; otherwise 0
  - bitwise not (~)
    - unary operator that inverts the input bit
- Shift operators
  - left-shift operator (<<) and right-shift operator (>>)
    - Also valid: <<= and >>=
  - One bit is always lost in a shift operation
- Ternary operator "? :" (a? b:c)

Types: casting

- Types can be converted by C-like type-casts in parenthesis.

```
//: C03:FunctionCallCast.cpp
int main() {
  float a = float(200);
  // This is equivalent to:
  float b = (float)200;
}
```

- In C++ we should use:
  - **static_cast**: simple casts for type conversion
  - **const_cast**: to cast away the constness of variables
  - **reinterpret_cast**: to cast an object to something completely different
  - **dynamic_cast**: type-safe cast with run-time checking, can be used only with pointers and references to objects (will discuss it with inheritance)

Types: static_cast

```
//: C03:static_cast.cpp
void func(int) {}

int main() {
  int i = 0x7fff; // Max pos value = 32767
  long l;
  float f;
  // 1a) Typical castless conversions:
  l = i;
  f = i; // may generate a warning

  // 1b) C-style type casts:
  l = (long)i;
  f = (float)i; // no warning

  // 1c) C++ way:
  l = static_cast<long>(i);
  f = static_cast<float>(i);
```

Types: static_cast

```
//: C03:static_cast.cpp (continuation)

// 2a) Automatic narrowing conversions:
i = f; // May lose digits (will generate a warning)

// 2b) Says "I know," eliminates warnings:
i = (int)(l); // C style
i = (int)(f); // C style

// 2c) C++ way:
i = static_cast<int>(l); // C++ style
i = static_cast<int>(f); // C++ style
char c = static_cast<char>(i);

// 3a) Forcing a conversion from void* :
void* vp = &i;
// 3b) Old way produces a “dangerous” conversion:
float* fp = (float*)vp;
// 3c) The new way is equally dangerous:
fp = static_cast<float*>(vp);
// etc
}
```

Types: const_cast

```
//: C03:const_cast.cpp
int main() {
//1) const values should not be modified:
const int i = 0;

//2) But we can get a pointer to them and later modify them…:
int* j = (int*)&i;         // Deprecated form
j  = const_cast<int*>(&i); // Preferred
*j = 1;
//3) Can't do simultaneous additional casting:
//! long* l = const_cast<long*>(&i); // Error
}
```

Types: reinterpret_cast

```
//: C03:reinterpret_cast.cpp
#include <iostream>
using namespace std;
const int sz = 100;

struct X { int a[sz]; };

void print(X* x) {
  for ( int i = 0; i < sz; i++)  cout << x->a[i] << ' ';
  cout << endl << "--------------------" << endl;
}

int main() {
  X x;
  print(&x);
  int* xp = reinterpret_cast<int*>(&x); // Cast to integer
  for ( int* i = xp; i < xp + sz; i++ )
        *i = 0;

  // Can't use xp as an X* unless you cast it back:
  print(reinterpret_cast<X*>(xp));
}
```

Types: reinterpret_cast

```
class BaseClass { ... };

class Class1 : public BaseClass {...}; // BaseClass “derives” Class1

class Class2 {...} ; // BaseClass does not derive Class2

BaseClass  *pb; // pointer to BaseClass
Class1     *p1; // pointer to Class1

p1 = static_cast<Class1*>(pb); // Ok as long as we know pb can point to Class1
p1 = (Class1*)(pb); // C-style also ok, same as static_cast<>

Class2     *p2; // pointer to Class2
p2 = static_cast<Class2*>(pb); // Compiler error, can't convert
p2 = (Class2*)(pb);            // No compiler error…
                               // Same as reiterpret_cast<>

p2 = reinterpret_cast<Class2*>(pb); // No compiler error.
```

A reinterpret_cast<> can only be justified in rare situations. When you use a reinterpret_cast<> you tell the compiler that you need an unusual type of casting and that you know what you are doing…