Programming Language Concepts

Dr. Imran

Lecture 2

Programming Language Concepts
Variables, Names and Bindings

VARIABLES

- Variables are identifiers which represent some unknown, or variable-value.
- A variable is named storage (some memory address’s contents)

```
x = a + b;
Speed_Limit = 90;
```

TYPE <Variable Name> ;

Examples:

int marks; **double Pi**; **char grade;**

Programming Language Concepts
Variables, Names and Bindings

VARIABLES

- Variable names are case sensitive in C++.

<u>Variable valid names (C/C++)</u>

- Start with a letter
- Contains letters
- Contains digits
- Contains undersocre

Programming Language Concepts
Variables, Names and Bindings

VARIABLES

- Variable names are case sensitive in C++.

Variable valid names (JavaScript)

- Start with a **letter**, an **underscore** or a **dollar** sign
- Cannot contain **spaces**.
- Cannot be the same as **reserve keywords**.
- By convention, JavaScript variable names are written in **camelCase**.
- Names should be **descriptive** that indicate their content and usage e.g. **sellingPrice** and **costPrice** instead of **x** and **y**.
- JavaScript variables do not have **set types**.

Programming Language Concepts
Variables, Names and Bindings

VARIABLE NAMES

- Variable Names or Identifiers are essential in programming languages - we use them to identify the virtual entities that we manipulate in programs.

Choose meaningful names
- Don’t use abbreviations and acronyms: mtbf, TLA, myw, nbv

Don't use overly long names
- **Ok:**

  partial_sum
  element_count
  staple_partition

- **Too long (valid but not good practice):**

  remaining_free_slots_in_the_symbol_table

Programming Language Concepts
Variables, Names and Bindings

VARIABLE NAMES

- When we declare a variable, what happens ?
  - Memory allocation
    - How much memory? (*data type*)

- Memory associated with a name (variable name)
- The allocated space has a unique **address**

int Marks; →

Marks

`%$^%$%$*^%`

FE07

Programming Language Concepts
Variables, Names and Bindings

VARIABLES

- Variables are reference to a memory location whose contents may change. names are case sensitive in C++.
- Now generalized as "a placeholder for a value of some possibly complex type"
- e.g. in functional languages variables can store closures of arbitrary higher-order types like ((int → int) → int). This is a semantic concept not only memory location.
- Some languages allow you to access the memory location information like in C/C++ .

Programming Language Concepts
Variables, Names and Bindings

VARIABLES/MEMORY ADDRESSES

When a variable is declared, a specific memory is assigned to that variable based on its type and the variable's data is stored there

```
int a = 100;
```

In example above a variable a is declared as a integer and a memory slot of 4 bytes is assigned to the variable a.

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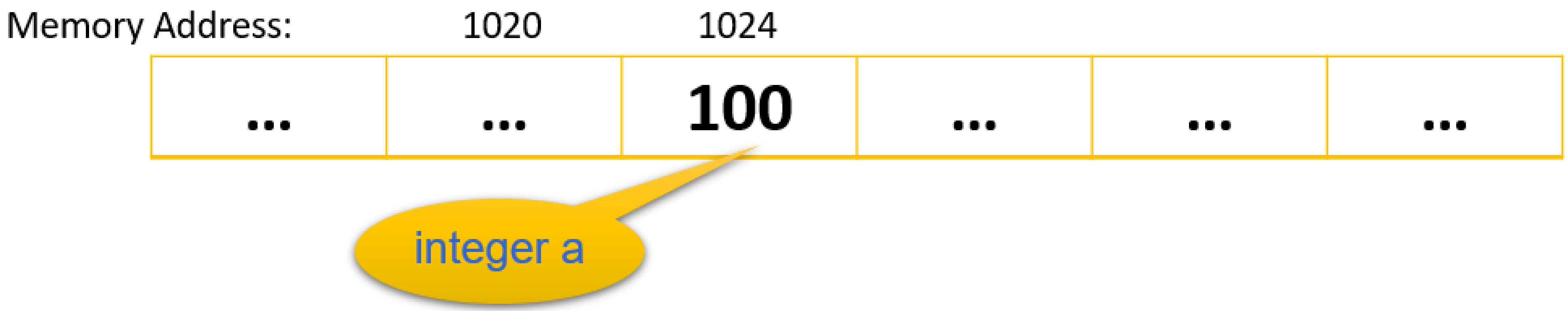
Variables, Names and Bindings

VARIABLES/MEMORY ADDRESSES

Each variable is assigned a memory slot (the size depends on the data type) and the variable's data is stored there

int a = 100;

Variable a's value 100 is stored at location 1024 as shown below:



Programming Language Concepts
Variables, Names and Bindings

- **Variables/Memory Addresses**

A variable holds a value and that value is stored at a specific location in memory.

The memory assigned to a variable has a memory address. That memory address can be accessed using **ampersand &** operator.

```
#include <iostream>
using namespace std;
int main()
{ int var1 = 3;
int var2 = 15;
int var3 = 29;
cout<<&var1<<endl;
cout<<&var2<<endl;
cout<<&var3<<endl;
return 0; }
```

Output

```
0x7fff5fbff8ac
0x7fff5fbff8a8
0x7fff5fbff8a4
```

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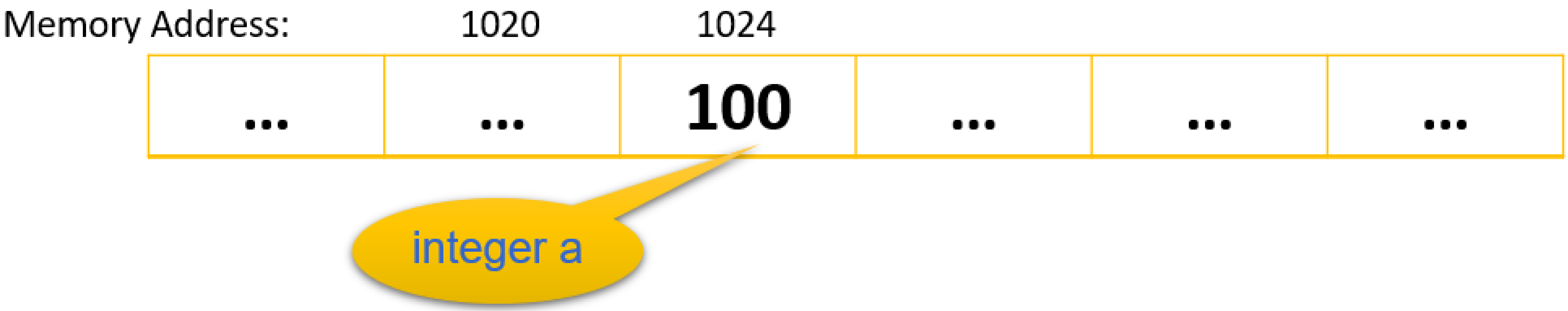
Variables, Names and Bindings

VARIABLES/MEMORY ADDRESSES

Address Operator

- The ‘*address of*’ operator (&) gives the memory address of the variable.

```
int a = 100;          //get the value
cout << a;            //prints the value 100
cout << &a;           //get the memory address and prints 1024
```



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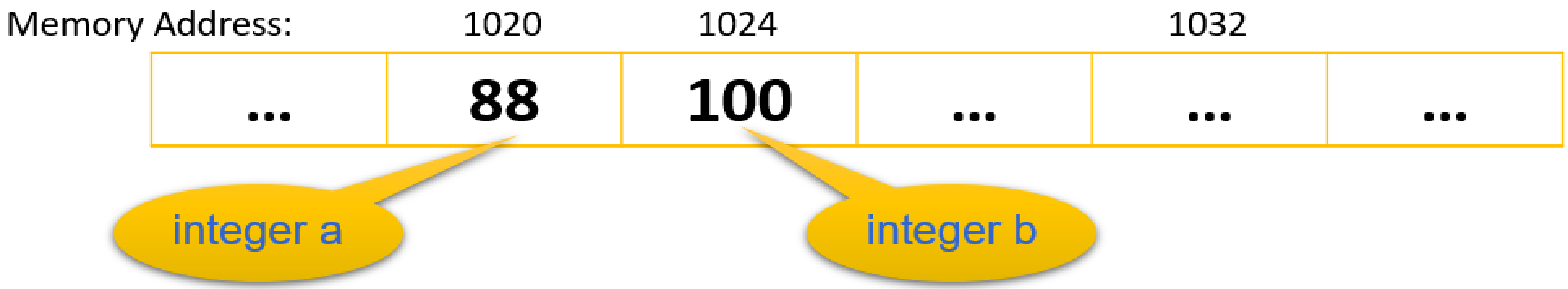
Variables, Names and Bindings

VARIABLES/MEMORY ADDRESSES

Address Operator

```
int a, b;
a = 88;                        //get the value of a
b = 100;                       //get the value of b
cout << “The address of a is = ”<< &a << endl;       //prints the address 1020
cout << “The address of b is = ”<< &b << endl;       //prints the address 1024
```



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Variables, Names and Bindings

VARIABLES

A variable typically has six attributes associated with it.

- A **name**
- An **address** (aka an L-Value, i.e. the left-hand side of an assignment)
- A **value** (aka an R-Value, i.e. the right-hand side of an assignment)
- A **type**
- An **extent**
- A **scope**

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Variables, Names and Bindings

VARIABLE TYPES

There are typically four types of variables.

Static Variables or Global Variables

- A variable bound to a memory location at initialization time.
- e.g. Static class variables in Java are static variables

Stack Dynamic Variables

- Memory is allocated from a runtime stack and bound when a declaration is executed and deallocated when the procedure block it is contained in returns.
- e.g. Local variables in a method declaration

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Variables, Names and Bindings

VARIABLE TYPES

There are typically four types of variables.

Static Variables or Global Variables

```
class Student {
public:
static int noOfStudents;
};
int Student::noOfStudents;
int main() {
Student aStudent;
aStudent.noOfStudents = 1;
Student::noOfStudents = 1;
}
```

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VARIABLE TYPES

There are typically four types of variables.

Accessing Static Variables or Global Variables

To access a static data member there are two ways

Access like a normal data member

Access using a scope resolution operator "::"

```
Student aStudent;
aStudent.noOfStudents = 1;
Student::noOfStudents = 1;
```

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Variables, Names and Bindings

VARIABLE TYPES

There are typically four types of variables.

Explicit Heap-Dynamic Variables

- Nameless abstract memory locations that are allocated/deallocated by explicit runtime commands by the programmer.
- e.g. malloc/free in C, new/delete in C++, all objects in Java using new()

Implicit Heap-Dynamic Variables

- Memory in heap is allocated when variables are assigned to values. It is deallocated and reallocated with re-assignment. Error prone and inefficient.
- Used in ALGOL 68, LISP, C and JavaScript (for arrays).

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Variables, Names and Bindings

BINDING TYPES

There are two types of bindings.

Static Type Binding

Two approaches to static type binding are:

- Type Declaration
- Type Inference

Type Declaration

- Most commonly used approach (used in Algol, Pascal, Ada, Cobol, C/C++, Java)
- A variable is introduced with an explicit type and possibly an initial value.

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Variables, Names and Bindings

BINDING TYPES

There are two types of bindings.

Static Type Binding

Types determined at compile time
And doesn't change during runtime
(e.g. Java)

- Two approaches to static type binding are:
- Type Declaration
- Type Inference

Type Inference

- No types in variable declarations; the type is inferred from the usage of the variable or by following a fixed naming scheme.
- Primitive type inference (arguably another form of explicit declaration) - e.g. in Fortran I, J, K, L, M and N are Integer types, otherwise Real assumed. In Perl $p is a number or a string, @p an array, %p a hash.

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BINDING TYPES

There are two types of bindings.

Dynamic Type Binding

Dynamic binding typically occurs as a variable is assigned a value at runtime.

- A variables type binding can change during execution simply by assigning to it a value of a different type.
- Commonly used in scripting languages such as JavaScript, Lua, Perl, PHP, Python, Ruby
- Efficiency implications (both time and space) due to runtime type checking
- Arguably advantages in readability and coding convenience.

Programming Language Concepts

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Lecture 3

Programming Language Concepts
Variables, Names and Bindings

EXTENT

- The **extent (or lifetime)** of a variable refers to the periods of execution time for which it is bound to a particular location storing a meaningful value

- Extent is a semantic concept and depends on the execution model.

Programming Language Concepts
Variables, Names and Bindings

EXTENT

Different kinds of variables have different extents:

Static variables

- Have an extent of whole program execution
- They are created even when there is no object of a class
- They remain in memory even when all objects of a class are destroyed

Programming Language Concepts
Variables, Names and Bindings

EXTENT

Different kinds of variables have different extents:

- **Stack-dynamic variables** have an extent of a particular stack frame or procedure call
- **Explicit heap-dynamic variables** have an extent from explicit allocation to explicit deallocation (cf. garbage collection and memory leak)
- **Implicit heap-dynamic variables** have an extent from implicit allocation to implicit deallocation (values may persist in memory but addresses are freed)

Programming Language Concepts
Variables, Names and Bindings

SCOPE

- The scope of a variable is the part of the code in which it can be referenced.
- Alternatively, it is the part of a program where a variable’s name is meaningful.
- A variable’s scope affects its extent. A no-longer referenceable value may be considered as a meaningless value. Garbage collectors are based on this principle.
- Local variables are declared within a program block; the block is the scope of the variable.
- Static variables have whole program scope, except where they are temporarily hidden by a locally scoped variable with the same name.

Programming Language Concepts
Variables, Names and Bindings

SCOPE

Scope in ECMAScript

```
// Global scope
var printOne = 1;
function one(){
alert(a);
}
one()
outputs ‘1’
```

Programming Language Concepts

Variables, Names and Bindings

SCOPE

Scope in ECMAScript

```
// Local scope
function two(a){
alert(a);
}
two(2)
outputs '2'
```

```
// Local scope
function three(){
var a = 3;
alert(a);
}
three()
outputs '3'
```

Programming Language Concepts
Variables, Names and Bindings

SCOPE

Scope in ECMAScript

```
// No block scope
function four(){
    if true {
        var a = 4;
    }
    alert(a);
}
four()
outputs ‘4’
```

Programming Language Concepts
Variables, Names and Bindings

SCOPE

Scope in C++

Global Variable

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

// global variable
int global = 5;

// main function
int main()
{
    // local variable with same
    // name as that of global variable
    int global = 2;

    cout << global << endl;
}
```

Local variable

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Variables, Names and Bindings

SCOPE

Scope in C++

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

void func()
{
    // this variable is local to the
    // function func() and cannot be
    // accessed outside this function
    int age=18;
}

int main()
{
    cout<<"Age is: "<<age;

    return 0;
}
```

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Variables, Names and Bindings

SCOPE

Scope in C++

```
using namespace std;

void func()
{
    // this variable is local to the
    // function func() and cannot be
    // accessed outside this function
    int age=18;
    cout<<age;
}

int main()
{
    cout<<"Age is: ";
    func();

    return 0;
}
```

Programming Language Concepts
Variables, Names and Bindings

SCOPE

Scope in C++

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

// global variable
int global = 5;

// global variable accessed from
// within a function
void display()
{
    cout<<global<<endl;
}

// main function
int main()
{
    display();

    // changing value of global
    // variable from main function
    global = 10;
    display();
}
```

Programming Language Concepts
Variables, Names and Bindings

SCOPE

Scope in C++

```
using namespace std;

// Global x
int x = 0;

int main()
{
  // Local x
  int x = 10;
  cout << "Value of global x is " << ::x;
  cout<< "\nValue of local x is " << x;
  return 0;
}
```