Pointers

In this section of notes you will learn about another type of variable that stores addresses rather than data

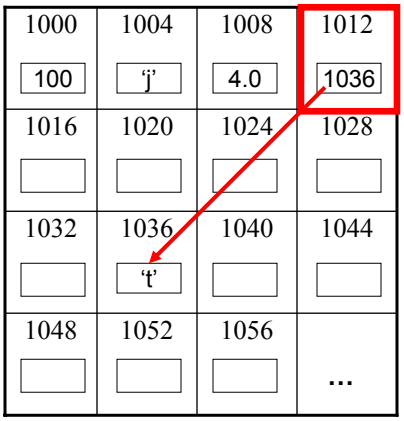
Memory: What You Know

- Memory is similar to a series of slots each of which can store a single piece of information

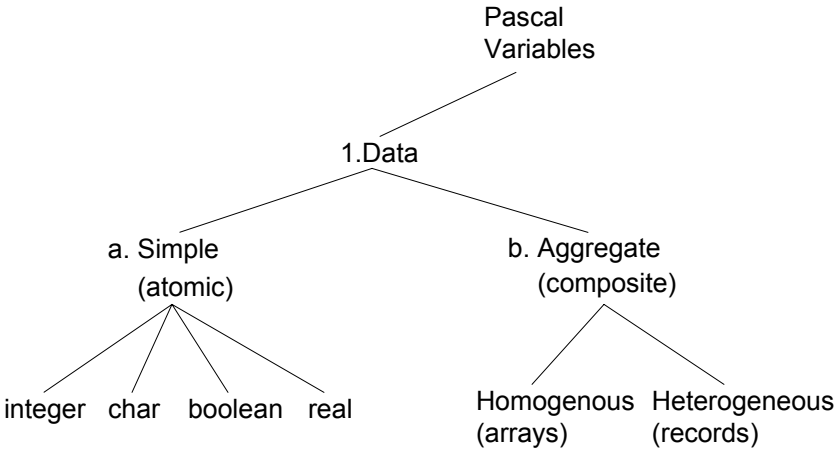
1000	1004	1008	1012
100	'j'	4.0	
1016	1020	1024	1028
1032	1036	1040	1044
1048	1052	1056	
			...

Memory: What You Will Learn

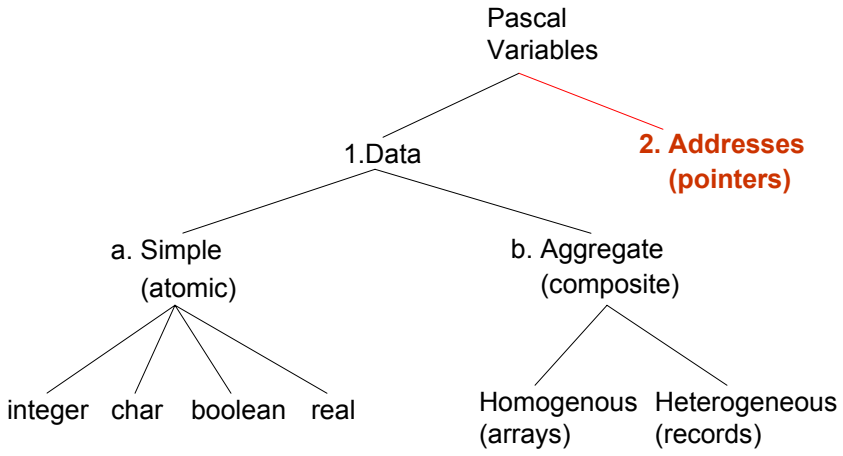
•Memory can also contain the address of another slot



Types Of Variables



Types Of Variables



Declaration Of Pointer Variables

Format:

```
type
    type name = ^ type pointed to[1];
        :                :
begin
    var pointer name : type name;
```

Example:

```
type
    IntegerPointer = ^integer;
        :                :
begin
    var numPtr1 : IntegerPointer;
```

1 An alternative is to use the "at-sign" @ instead of the "up-arrow" ^ to declare a pointer variable (*not recommended*)

Allocating Memory For Pointers

Static vs. dynamic memory

- Arrays

Allocating dynamic memory

- Reserving some dynamic memory and having the pointer point to it.

Format

new (*pointer name*);

Example

new (numPtr1);

De-Allocating Memory For Pointers

De-allocating memory

- Returning back the dynamically allocated memory

Format

dispose (*pointer name*);

Example

dispose (numPtr1);

De-Allocating Memory For Pointers: Followup

- Should also be followed by having the pointer no longer point to the memory that has just been de-allocated

Format:

pointer name := NIL;

Example

numPtr1 := NIL;

Using Pointers

Important! Are you dealing with the pointer or what the pointer is pointing to (allocated memory)?

- Pointer name

- Pointer name ^ (de-reference pointer)

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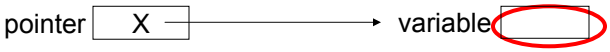


Accessing Pointers

Format:

(Pointer)

pointer name

(Memory pointed to)

pointer name ^

Example:

(Pointer)

```
writeln(numPtr2);
```

(Memory pointed to)

```
writeln(numPtr1^);
```

Accessing Pointers

Format:

(Pointer)

pointer name

(Memory pointed to)

pointer name ^

Example:

(Pointer)

writeln(numPtr1);

(Memory pointed to)

writeln(numPtr1^);

Using Pointers : Allowable Operations

Assignment :=

Relational

- Equality =
- Inequality <>

Using Pointers : Assignment

Format:

(Pointer)

pointer name := *pointer name*;

(Memory pointed to)

pointer name ^ := *expression*;

Example:

(Pointer)

numPtr1 := numPtr2;

(Memory pointed to)

numPtr1^ := 100;

Using Pointers : Allowable Operations (Equality)

Format:

(Pointer)

if (*pointer name 1* = *pointer name 2*) then

(Memory pointed to)

if (*pointer name 1*^ = *pointer name 2*^) then

Example:

(Pointer)

if (numPtr1 = numPtr2) then

(Memory pointed to)

if (numPtr1^ = numPtr2^) then

Using Pointers : Allowable Operations (Inequality)

Format:

(Pointer)

if (*pointer name 1 <> pointer name 2*) then

(Memory pointed to)

if (*pointer name 1^ <> pointer name 2^*) then

Example:

(Pointer)

if (numPtr1 <> numPtr2) then

(Memory pointed to)

if (numPtr1^ <> numPtr2^) then

Pointers : First Example

A full version of this example can be found in Unix under:
/home/231/examples/pointers/pointer1.p

```
program pointer1 (output);
type
  IntegerPointer = ^integer;
begin
  var num      : integer;
  var temp     : integer;
  var numPtr1 : IntegerPointer;
  var numPtr2 : IntegerPointer;
  writeln('Example 1');
  num := 10;
  new(numPtr1);
  new(numPtr2);
  numPtr1^ := 100;
  numPtr2^ := 100;
```

Pointers : First Example (2)

```
writeln('num = ':11, num:3);
writeln('numPtr1^ = ':11, numPtr1^:3);
writeln('numPtr2^ = ':11, numPtr2^:3);
if (numPtr1 = numPtr2) then
    writeln('Same memory')
else
    writeln('Separate memory');
if (numPtr1 ^= numPtr2^) then
    writeln('Same data')
else
  writeln('Different data');

(* Not allowed *)
(*writeln('numPtr1=',numPtr1); *)
```


Pointers: First Example (3)

```
writeln('Example 2');
temp := num;
num := numPtr1^;
writeln('num = ':11, num:3);
writeln('numPtr1^ = ':11, numPtr1^:3);
writeln;

writeln('Example 3');
numPtr1^ := num;
num := 2;
writeln('num = ':11, num:3);
writeln('numPtr1^ = ':11, numPtr1^:3);
writeln;
```

Pointers: First Example (4)

```
  writeln('Example 4');
  numPtr2 ^ := 66;
  numPtr1 := numPtr2;
  if (numPtr1 = numPtr2) then
     writeln('Same memory')
  else
     writeln('Separate memory');
  numPtr2^ := 33;
  writeln('numPtr1^ = ':11, numPtr1^);
  writeln('numPtr2^ = ':11, numPtr2^);
  dispose(numPtr1);
  dispose(numPtr2);
  numPtr1 := NIL;
  numPtr2 := NIL;
end.
```


Pointers As Value Parameters

Need to define a type for the pointer first!

Example (defining type)

```
type
  CharPointer = ^char;
```

Format (passing pointer):

procedure *procedure name* (*pointer name (1)* : *type of pointer (1*);
pointer name (2) : *type of pointer (2)*;
: **:**
pointer name (n) : *type of pointer (n)*);

function *function name* (*pointer name (1)* : *type of pointer (1*);
pointer name (2) : *type of pointer (2)*;
: **:**
pointer name (n) : *type of pointer (n)*);

Pointers As Value Parameters (2)

Example (passing pointer):

```
procedure proc1 (charPtr : CharPointer);
```


Pointers As Variable Parameters

Need to define a type for the pointer first!

Example (defining type)

```
type
  CharPointer = ^char;
```

Format (passing pointer):

procedure *procedure name* (var *pointer name (1)* : *type of pointer (1*);
var *pointer name (2)* : *type of pointer (2)*;
: **:**
var *pointer name (n)* : *type of pointer (n)*);

Example (Passing pointer):

```
procedure proc2 (var charPtr : CharPointer);
```

Pointers: Second Example

A full version of this program can be found in Unix under:
/home/231/examples/pointers/pointer2.p

```
program pointer2 (output);
type
  CharPointer = ^char;

procedure proc1 (charPtr : CharPointer);
var
  temp    : CharPointer;
begin
  writeln;
  writeln(‘Proc1');
  new(temp);
  temp^ := 'A';
  charPtr := temp;
  writeln('temp^ = ', temp^);
  writeln('charPtr^ = ', charPtr^);
end;
```

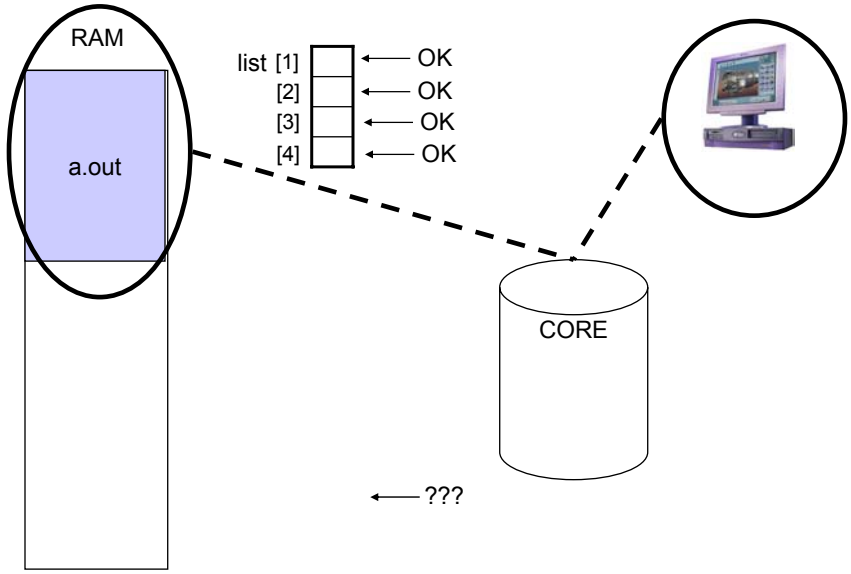

Pointers: Second Example (2)

```
procedure proc2 (var charPtr : CharPointer);
var
  temp : CharPointer;
begin
  writeln;
  writeln(‘Proc2');
  new(temp);
  temp^ := 'A';
  charPtr := temp;
  writeln('temp^ = ', temp^);
  writeln('charPtr^ = ', charPtr^);
end;
```

Pointers: Second Example (4)

```
begin                   (* Main program *)
  var charPtr : CharPointer;
  new (charPtr);
  charPtr^ := 'a';
  writeln;
  writeln(‘Main program.');
  writeln('charPtr^ = ', charPtr^);
  proc1(charPtr);
  writeln('After proc1');
  writeln('charPtr^ = ', charPtr^);
  proc2(charPtr);
  writeln('After proc2');
  writeln('charPtr^ = ', charPtr^);
  writeln;
end.                    (* End of main program *)
```


What You Know: How Segmentation Faults Are Caused By Indexing Beyond The Array Bounds



What You Will Learn: How Segmentation Faults (Possibly Bus Errors) Can Be Caused By Incorrect Pointer Dereferencing

A full version of this program can be found in Unix under:
/home/231/examples/pointers/pointer3.p

```
program pointer3 (output);

type
  IntegerPointer = ^ integer;

begin
  var numPtr1 : IntegerPointer;
  writeln('1');
  numPtr1^ := 100;
  writeln('2');
  numPtr1 := NIL;
  writeln('3');
  numPtr1^ := 100;
end.
```


You Should Now Know

- How to declare new types that are pointers to data
- How to declare variables that are pointers
- The difference between static and dynamically allocated memory
- How to dynamically allocate memory
- How to de-allocate memory
- Why and when to set pointers to NIL
- How to access a pointer and how to access what the pointer points to
- How to assign values to a pointer and how to assign values to what the pointer points to
- What operations can be performed on pointers and how does each one work
- How to pass pointers as value and variable parameters
- How incorrect pointer usage results in problems with memory accesses