Records

CS 115

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Structs and unions

Title	string
Author	string
Publisher	string
Year	unsigned int
Call Number	string
Price	double

Motivation

- E.g. Catalog information in a library

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- Solution using arrays:

```
string titles[N];
string authors[N];
string publishers[N];
unsigned int publishingYears[N];
string callNumbers[N];
double Price[N];
```

- Poor choice of interface!

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```
string titles[N];
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- Poor choice of interface!
- (many arguments to pass for functions)

Use a record instead!

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```cpp
struct CatalogEntry {
  string title;
  string author;
  string publisher;
  unsigned int publishingYear;
  string callNumber;
};
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- Only 1 argument needs to be passed

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```cpp
struct CatalogEntry c;
// or, equivalently this:
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- Declare:

```cpp
struct CatalogEntry c;
// or, equivalently this:
CatalogEntry c;
```

- Initialize:

```cpp
c.title = "Peter Pan";
c.author = "J. M. Barrie";
c.publisher = "Scribner";
c.publishingYear = 1980;
c.callNumber = "B2754 1980";
```

- As with arrays

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Initializing a Record

- As with arrays

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```
CatalogEntry c = {"Peter Pan",
                  "J. M. Barrie",
                  "Scribner",
                  1980,
                  "B2754 1980"};
```

Copying a Record

```
// initialization list
CatalogEntry c = { ... };

// initialization by copying
CatalogEntry c1 = c;

// default initialization
CatalogEntry c2;
// assignment operator
c2 = c;
```

Functions operating on records

Functions operating on records

```
void printCatalogEntry(CatalogEntry c){
  cout << "Title: " << c.title << endl;
  cout << "Author: " << c.author << endl;
  cout << "Publisher: " << c.publisher << endl;
  cout << "Publishing Year: " << c.publishingYear << endl;
  cout << "Call Number: " << c.callNumber << endl;
}
```

- As usual, by default arguments are passed by value (call by value)

- For efficiency, call by reference is also supported

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```cpp
void printCatalogEntry(const CatalogEntry &c){
  cout << "Title: " << c.title << endl;
  cout << "Author: " << c.author << endl;
  cout << "Publisher: " << c.publisher << endl;
  cout << "Publishing Year: " << c.publishingYear << endl;
  cout << "Call Number: " << c.callNumber << endl;
}
```

Equality checking

- Not supported by default

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if (c1 == c2) // invalid
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```
bool CatalogEntryEquals(const CatalogEntry &c1, const CatalogEntry &c2
  return c1.title == c2.title && c1.author == c2.author &&
         c1.publisher == c2.publisher &&
         c1.publishingYear == c2.publishingYear &&
         c1.callNumber == c2.callNumber;
}
```

Complex record data structures

- Arrays of records

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```
CatalogEntry A[3];
CatalogEntry A[] = {{"Peter Pan",
                     "J. M. Barrie",
                     "Scribner",
                     1980,
                     "B2754 1980"},
                    {"C++ Primer",
                     "Stanley B. Lippman",
                     "Addison-Wesley",
                     1998,
                     "QA 76.73 C15 L57 1998"},
                    {"Anatomy of LISP",
                     "John Allen",
                     "McGraw-Hill",
                     1978,
                     "QA 76.73 L23A44"}};
```

Practise!

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- Try the exercises there
  - declare a C++ struct to represent a point in the Cartesian coordinate system
  - declare a C++ struct to represent a hexagon
  - declare a C++ struct to represent a circle

- Can put arrays as fields of records

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Arrays inside of records

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```cpp
const int MAX_NAMES = 100;

struct FullName {
  string name_component[MAX_NAMES];
  int name_count;
};
```

Multi-Dimensional Arrays in Records

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```cpp
const int SCREEN_HEIGHT = 768, SCREEN_WIDTH = 1024;
struct Screen{
  char screen_array[SCREEN_HEIGHT][SCREEN_WIDTH];
};

...

Screen my_screen;
for (int i = 0; i < SCREEN_HEIGHT; i++){
 my_screen.screen_array[i][0] = '*';
 }
```

Mix and Match

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```cpp
#include <iostream>
using namespace std;
struct str1 {
  int a[2];
  int b;
};

void func1(str1 A[ ]){
  A[0].a[0] = 10;
  A[0].a[1] = 20;
  A[0].b = 30;
}

int main( ) {
  str1 A[3] = {{{1,0},2}, {{3,0},4},{{0,0},9}};
  func1(A);

  std::cout << A[0].b<<"\n";
  std::cout << A[0].a[1]<<"\n";
}
```

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  std::cout << A[0].b<<"\n";
  std::cout << A[0].a[1]<<"\n";
}
```

- What will the ouput be?

Enumerations

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```cpp
enum day {
  Friday = 99,//
  Saturday,//
  Sunday = 90,//
  ...,
  Thursday //
};

day d;
d = Thursday;

if (d == Saturday  d == Sunday)
  cout << "Enjoy the weekend!" ;

cout << d+1 ;
```

Enumerations

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enum day {
  Friday = 99,//
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  ...,
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day d;
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- User-defined data type that consists of integral constants

Enumerations

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- User-defined data type that consists of integral constants
- What will the output be?

Variant records

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```cpp
union Coordinates {
  int a,
      double b,
      char c
};

Coordinates x;

x.a = 5;
cout << x.a; // works, prints 5

x.b = 416.905; // destroys the value of x.a
x.c = 'p';     // destroys the value of x.a and x.b
cout << x.a;   // invalid!
cout << x.b;   // invalid!
cout << x.c;   // works, prints p
```

Example

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```
enum CatalogEntryType {
  BookEntry, //
  DVDEntry //
};

struct BookSpecificInfo {
  unsigned int pages;
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enum CatalogEntryType {
  BookEntry, //
  DVDEntry //
};

struct BookSpecificInfo {
  unsigned int pages;
};
```

```
struct DVDSpecificInfo {
  unsigned int discs;
  unsigned int minutes;
};

union CatalogEntryVariantPart {
  BookSpecificInfo book;
  DVDSpecificInfo dvd;
};
```

```
struct CatalogEntry {
  string title;
  string author;
  string publisher;
  unsigned int publishingYear;
  string callNumber;
  CatalogEntryType tag;
  CatalogEntryVariantPart variant;
};
```

```cpp
void printCatalogEntry(const CatalogEntry& c) {
  cout << "Title: " << c.title << endl;
  ...
    cout << "Call Number: " << c.callNumber << endl;
  switch (c.tag) {
  case BookEntry:
    cout << "Pages: " << c.variant.book.pages << endl;
    break;
  case DVDEntry:
    cout << "Discs: " << c.variant.dvd.discs << endl;
    cout << "Minutes: " << c.variant.dvd.minutes << endl;
    break;
  }
}
```

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Prof's Aside

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- Other languages have safe combinations of tags and unions
  - enum in Rust and Swift
  - Sealed Classes in Java/Kotlin
  - Algebraic datatypes in functional languages (CS 350)

Anonymous declaration of records and variant-records

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```
union CatalogEntryVariantPart {
  BookSpecificInfo book;
  DVDSpecificInfo dvd;
};
```

- Could have actually declared them in-line:

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union CatalogEntryVariantPart {
  BookSpecificInfo book;
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};
```

- Could have actually declared them in-line:

```
union CatalogEntryVariantPart {
  struct BookSpecificInfo { unsigned int pages; } book;
  struct DVDSpecificInfo { unsigned int discs, minutes; } dvd;
};
```

- Can also anonymize:

Anonymous declaration of records and variant-records

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union CatalogEntryVariantPart {
  struct { unsigned int pages; } book;
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Anonymous declaration of records and variant-records

- In fact, we could have done the same with the union

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  string title;
  string author;
  string publisher;
  unsigned int publishingYear;
  string callNumber;
  CatalogEntryType tag;
  union {
    struct { unsigned int pages; } book;
    struct { unsigned int discs, minutes; } dvd;
  } variant;
};
```