



## Module 29

Instructors: Abir  
Das and  
Sourangshu  
Bhattacharya

Binding: Exercise

Exercise 1

Exercise 2

Staff Salary  
Processing

C Solution

Engineer +  
Manager

Engineer +  
Manager + Director

Advantages and  
Disadvantages

Module Summary

# Module 29: Programming in C++

## Polymorphism: Part 4: Staff Salary Processing using C

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Slides taken from NPTEL course on Programming in Modern C++

by **Prof. Partha Pratim Das**



# Module Objectives

- Understand design with ISA related concepts
- Understand the problems with C design

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# Module Outline

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Module Summary

## 1 Binding: Exercise

- Exercise 1
- Exercise 2

## 2 Staff Salary Processing

- C Solution
  - Engineer + Manager
  - Engineer + Manager + Director
  - Advantages and Disadvantages

## 3 Module Summary



# Binding: Exercise 1

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Module Summary

// Class Definitions

```
class A { public:
    virtual void f(int) { }
    virtual void g(double) { }
    int h(A *) { }
};

class B: public A { public:
    void f(int) { }
    virtual int h(B *) { }
};

class C: public B { public:
    void g(double) { }
    int h(B *) { }
};
```

// Application Codes

```
A a;
B b;
C c;

A *pA;
B *pB;
```

Invocation	Initialization		
	pA = &a;	pA = &b;	pA = &c;
pA->f(2);			
pA->g(3.2);			
pA->h(&a);			
pA->h(&b);			



# Binding: Exercise 1: Solution

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class B: public A { public:
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class C: public B { public:
    void g(double) { }
    int h(B *) { }
};
```

// Application Codes

```
A a;
B b;
C c;

A *pA;
B *pB;
```

Invocation	Initialization		
	pA = &a;	pA = &b;	pA = &c;
pA->f(2);	A::f	B::f	B::f
pA->g(3.2);	A::g	A::g	C::g
pA->h(&a);	A::h	A::h	A::h
pA->h(&b);	A::h	A::h	A::h



# Binding: Exercise 2

// Class Definitions

```
class A { public:
    virtual void f(int) { }
    virtual void g(double) { }
    int h(A *) { }
};

class B: public A { public:
    void f(int) { }
    virtual int h(B *) { }
};

class C: public B { public:
    void g(double) { }
    int h(B *) { }
};
```

// Application Codes

```
A a;
B b;
C c;

A *pA;
B *pB;
```

Invocation	Initialization		
	pB = &a;	pB = &b;	pB = &c;
pB->f(2);			
pB->g(3.2);			
pB->h(&a);			
pB->h(&b);			



# Binding: Exercise 2: Solution

// Class Definitions

```
class A { public:
    virtual void f(int) { }
    virtual void g(double) { }
    int h(A *) { }
};

class B: public A { public:
    void f(int) { }
    virtual int h(B *) { }
};

class C: public B { public:
    void g(double) { }
    int h(B *) { }
};
```

// Application Codes

```
A a;
B b;
C c;

A *pA;
B *pB;
```

Invocation	Initialization		
	pB = &a;	pB = &b;	pB = &c;
pB->f(2);	<b>Error</b> <b>Downcast</b> <b>(A *) to</b> <b>(B *)</b>	B::f	B::f
pB->g(3.2);		A::g	C::g
pB->h(&a);		<b>No conversion (A *) to (B *)</b>	
pB->h(&b);		B::h	C::h



# Staff Salary Processing: Problem Statement

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## Staff Salary Processing

C Solution

Engineer +  
Manager

Engineer +  
Manager + Director  
Advantages and  
Disadvantages

Module Summary

- An organization needs to develop a salary processing application for its staff
- At present it has an engineering division only where **Engineers** and **Managers** work. Every **Engineer** reports to some **Manager**. Every **Manager** can also work like an **Engineer**
- The logic for processing salary for **Engineers** and **Managers** are different as they have different salary heads
- In future, it may add **Directors** to the team. Then every **Manager** will report to some **Director**. Every **Director** could also work like a **Manager**
- The logic for processing salary for **Directors** will also be distinct
- Further, in future it may open other divisions, like Sales division, and expand the workforce
- **Make a suitable extensible design**





# C Solution: Function Switch: Engineer + Manager

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Staff Salary  
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## C Solution

Engineer +  
Manager

Engineer +  
Manager + Director

Advantages and  
Disadvantages

Module Summary

- How to represent **Engineers** and **Managers**?
  - Collection of **structs**
- How to initialize objects?
  - Initialization functions
- How to have a collection of mixed objects?
  - Array of **union**
- How to model variations in salary processing algorithms?
  - **struct**-specific functions
- How to invoke the correct algorithm for a correct employee type?
  - Function Switch
  - Function Pointers



# C Solution: Function Switch: Engineer + Manager

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Engineer +  
Manager + Director

Advantages and  
Disadvantages

Module Summary

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

typedef enum E_TYPE { Er, Mgr } E_TYPE; // Tag for type of staff

typedef struct Engineer { char *name_; } Engineer;
Engineer *InitEngineer(const char *name) {
    Engineer *e = (Engineer *)malloc(sizeof(Engineer));
    e->name_ = strdup(name); return e;
}
void ProcessSalaryEngineer(Engineer *e) { printf("%s: Process Salary for Engineer\n", e->name_); }

typedef struct Manager { char *name_; Engineer *reports_[10]; } Manager;
Manager *InitManager(const char *name) {
    Manager *m = (Manager *)malloc(sizeof(Manager));
    m->name_ = strdup(name); return m;
}
void ProcessSalaryManager(Manager *m) { printf("%s: Process Salary for Manager\n", m->name_); }

typedef struct Staff { // Aggregation of staffs
    E_TYPE type_;
    union { Engineer *pE; Manager *pM; };
} Staff;
```



# C Solution: Function Switch: Engineer + Manager

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C Solution

Engineer +  
Manager

Engineer +  
Manager + Director

Advantages and  
Disadvantages

Module Summary

```
int main() {
    Staff allStaff[10];
    allStaff[0].type_ = Er;  allStaff[0].pE = InitEngineer("Rohit");
    allStaff[1].type_ = Mgr; allStaff[1].pM = InitManager("Kamala");
    allStaff[2].type_ = Mgr; allStaff[2].pM = InitManager("Rajib");
    allStaff[3].type_ = Er;  allStaff[3].pE = InitEngineer("Kavita");
    allStaff[4].type_ = Er;  allStaff[4].pE = InitEngineer("Shambhu");

    for (int i = 0; i < 5; ++i) {
        E_TYPE t = allStaff[i].type_;
        if (t == Er)
            ProcessSalaryEngineer(allStaff[i].pE);
        else if (t == Mgr)
            ProcessSalaryManager(allStaff[i].pM);
        else
            printf("Invalid Staff Type\n");
    }
}
```

Rohit: Process Salary for Engineer  
Kamala: Process Salary for Manager  
Rajib: Process Salary for Manager  
Kavita: Process Salary for Engineer  
Shambhu: Process Salary for Engineer



# C Solution: Function Switch: Engineer + Manager + Director

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Manager + Director

Advantages and  
Disadvantages

Module Summary

- How to represent **Engineers**, **Managers**, and **Directors**?
  - Collection of **structs**
- How to initialize objects?
  - Initialization functions
- How to have a collection of mixed objects?
  - Array of **union**
- How to model variations in salary processing algorithms?
  - **struct**-specific functions
- How to invoke the correct algorithm for a correct employee type?
  - Function switch
  - Function pointers



# C Solution: Function Switch: Engineer + Manager + Director

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
typedef enum E_TYPE { Er, Mgr, Dir } E_TYPE;

typedef struct Engineer { char *name_; } Engineer;
Engineer *InitEngineer(const char *name) { Engineer *e = (Engineer *)malloc(sizeof(Engineer));
    e->name_ = strdup(name); return e;
}
void ProcessSalaryEngineer(Engineer *e) { printf("%s: Process Salary for Engineer\n", e->name_); }

typedef struct Manager { char *name_; Engineer *reports_[10]; } Manager;
Manager *InitManager(const char *name) { Manager *m = (Manager *)malloc(sizeof(Manager));
    m->name_ = strdup(name); return m;
}
void ProcessSalaryManager(Manager *m) { printf("%s: Process Salary for Manager\n", m->name_); }

typedef struct Director { char *name_; Manager *reports_[10]; } Director;
Director *InitDirector(const char *name) { Director *d = (Director *)malloc(sizeof(Director));
    d->name_ = strdup(name); return d;
}
void ProcessSalaryDirector(Director *d) { printf("%s: Process Salary for Director\n", d->name_); }

typedef struct Staff { E_TYPE type_; union { Engineer *pE; Manager *pM; Director *pD; };
} Staff;
```



# C Solution: Function Switch: Engineer + Manager + Director

```
int main() { Staff allStaff[10];
    allStaff[0].type_ = Er; allStaff[0].pE = InitEngineer("Rohit");
    allStaff[1].type_ = Mgr; allStaff[1].pM = InitManager("Kamala");
    allStaff[2].type_ = Mgr; allStaff[2].pM = InitManager("Rajib");
    allStaff[3].type_ = Er; allStaff[3].pE = InitEngineer("Kavita");
    allStaff[4].type_ = Er; allStaff[4].pE = InitEngineer("Shambhu");
    allStaff[5].type_ = Dir; allStaff[5].pD = InitDirector("Ranjana");

    for (int i = 0; i < 6; ++i) { E_TYPE t = allStaff[i].type_;
        if (t == Er)
            ProcessSalaryEngineer(allStaff[i].pE);
        else if (t == Mgr)
            ProcessSalaryManager(allStaff[i].pM);
        else if (t == Dir)
            ProcessSalaryDirector(allStaff[i].pD);
        else
            printf("Invalid Staff Type\n");
    }
}
```

Rohit: Process Salary for Engineer  
Kamala: Process Salary for Manager  
Rajib: Process Salary for Manager  
Kavita: Process Salary for Engineer  
Shambhu: Process Salary for Engineer  
Ranjana: Process Salary for Director



# C Solution: Function Switch: Engineer + Manager + Director

*Instead of if-else chain, we can use switch to explicitly switch on the type of employee*

```
int main() { Staff allStaff[10];
    allStaff[0].type_ = Er;  allStaff[0].pE = InitEngineer("Rohit");
    allStaff[1].type_ = Mgr; allStaff[1].pM = InitManager("Kamala");
    allStaff[2].type_ = Mgr; allStaff[2].pM = InitManager("Rajib");
    allStaff[3].type_ = Er;  allStaff[3].pE = InitEngineer("Kavita");
    allStaff[4].type_ = Er;  allStaff[4].pE = InitEngineer("Shambhu");
    allStaff[5].type_ = Dir; allStaff[5].pD = InitDirector("Ranjana");

    for (int i = 0; i < 6; ++i) { E_TYPE t = allStaff[i].type_;
        switch (t) {
            case Er:  ProcessSalaryEngineer(allStaff[i].pE); break;
            case Mgr: ProcessSalaryManager(allStaff[i].pM); break;
            case Dir: ProcessSalaryDirector(allStaff[i].pD); break;
            default:  printf("Invalid Staff Type\n"); break;
        }
    }
}
```

Rohit: Process Salary for Engineer  
Kamala: Process Salary for Manager  
Rajib: Process Salary for Manager  
Kavita: Process Salary for Engineer  
Shambhu: Process Salary for Engineer  
Ranjana: Process Salary for Director



# C Solution: Advantages and Disadvantages

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Module Summary

- **Advantages**

- Solution exists!
- Code is well structured – has patterns

- **Disadvantages**

- Employee data has scope for better organization
  - ▷ No encapsulation for data
  - ▷ Duplication of fields across types of employees – possible to mix up types for them (say, `char *` and `string`)
  - ▷ Employee objects are created and initialized dynamically through `Init...` functions. How to release the memory?
- Types of objects are managed explicitly by `E.Type`:
  - ▷ Difficult to extend the design – addition of a new type needs to:
    - Add new type code to `enum E.Type`
    - Add a new pointer field in `struct Staff` for the new type
    - Add a new case (`if-else` or `case`) based on the new type
  - ▷ Error prone – developer has to decide to call the right processing function for every type (`ProcessSalaryManager` for `Mgr` etc.)

- **Recommendation**

- Use classes for encapsulation on a hierarchy





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Module Summary

- Practiced exercise with binding – various mixed cases
- Started designing for a staff salary problem and worked out C solutions