Design Principles and Design Patterns

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Outline

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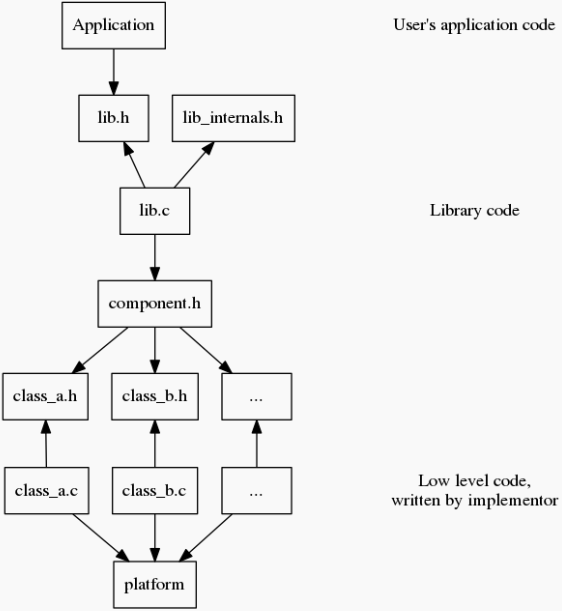
Architecture and Dependencies



Symptoms of Rotting Design

1. Rigidity
2. Fragility
3. Immobility
4. Viscosity

Rigidity

- Deficient in or devoid of flexibility
- Software for which extra effort is expended in order to make changes.
- The system is hard to change because every change forces many other changes to other parts of the system.

Rigidity

How it happens

- Code written in a procedural way
- Lack of abstractions
- Solving a generic problem with implementation specific details
- Spreading a single responsibility throughout several parts
- When components need a lot of knowledge about each other in order to function

Rigidity

```c
#include <stdint.h>

#define ADC_BITS (12)
#define ADC_DATA_SHIFT (2)
#define ADC_SIGN_CONVERSION (1)
#define RAW_ADC_BITS (15) // Sum of the above bits

#define LFSR_LENGTH (4)
#define LFSR_REPEATS (2)
#define CORRELATED_BITS (20) // ADC bits + lfsr length + log2(repeats)

typedef int16_t rpo_raw_adc_t;
typedef int24_t rpo_correlated_int_t;

#if sizeof(rpo_raw_adc_t) < (RAW_ADC_BITS / 2 + 1)
#error "rpo_raw_adc_t is too small to store ADC results"
#endif

#if sizeof(rpo_correlated_int_t) < (RAW_ADC_BITS / 2 + 1)
#error "rpo_correlated_int_t is too small to store correlated adc results"
#endif
```

Rigidity

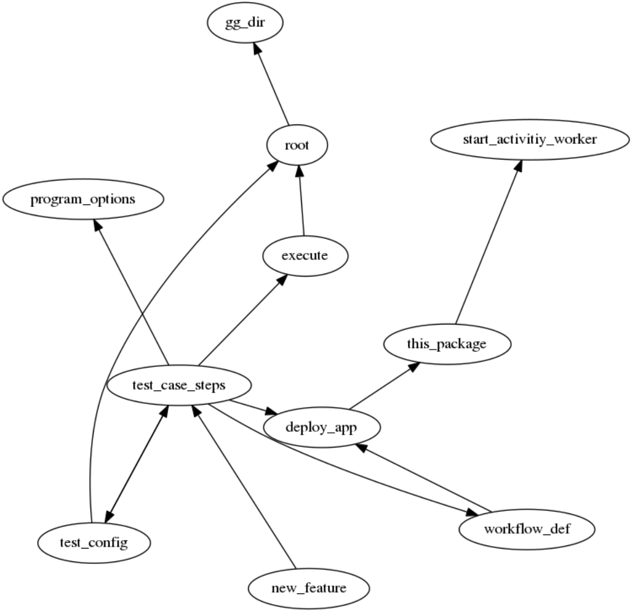
```c
#include <stdint.h>

#define ADC_BITS (14) // Changing this
#define ADC_DATA_SHIFT (2)
#define ADC_SIGN_CONVERSION (1)
#define RAW_ADC_BITS (17) // Changes this

#define LFSR_LENGTH (4)
#define LFSR_REPEATS (2)
#define CORRELATED_BITS (22) // Changes this

typedef int24_t rpo_raw_adc_t; // Changes this
typedef int24_t rpo_correlated_int_t;

#if sizeof(rpo_raw_adc_t) < (RAW_ADC_BITS / 2 + 1)
#error "rpo_raw_adc_t is too small to store ADC results"
#endif

#if sizeof(rpo_correlated_int_t) < (RAW_ADC_BITS / 2 + 1)
#error "rpo_correlated_int_t is too small to store correlated adc results"
#endif
```

Rigidity

Refactor to reduce rigidity

```
#include <stdint.h>

#define ADC_BITS (14)
#define ADC_DATA_SHIFT (2)
#define ADC_SIGN_CONVERSION (1)
#define RAW_ADC_BITS (ADC_BITS + ADC_DATA_SHIFT + ADC_SIGN_CONVERSION)
typedef_min_int(rpo_raw_adc_t, RAW_ADC_BITS);

#define LFSR_LENGTH (4)
#define LFSR_REPEATS (2)
#define CORRELATED_BITS (RAW_ADC_BITS + LFSR_LENGTH + log_2(LFSR_REPEATS))
typedef_min_int(rpo_correlated_int_t, CORRELATED_BITS);
```

Rigidity


gg_dir
root
start_activitiy_worker
program_options
execute
this_package
test_case_steps
deploy_app
workflow_def
test_config
new_feature

Rigidity

Notes:
Customer wants a feature: be able to test a new feature
Create the code to test the new feature
This requires new test case steps
Which in turn requires a new workflow to execute the new test case steps
Also new execution command
Also new test configurations
Also new command line arguments
Etc.

Rigidity

How to avoid it

- Break the code into smaller, self-contained concepts
- Solve the details and provide a problem oriented abstraction
- Solving a generic problem with implementation specific details
- Write DRY code (Don't repeat yourself)
- Define the code in logical pieces. Set boundaries and responsibilities.

Fragility

- Easily broken or destroyed
- Software for which extra risk is incurred in order to make changes.
- Changes cause the system to break in places that have no conceptual relationship to the part that was changed.

Fragility

How it happens

- Implicit dependencies
- Unmanaged shared resources
- Relying on implementation details
- Relying upon side effects of operations
- Reaching past abstraction layers
- Unmanaged complexity

Fragility

```
void sdcard_init(void) {
    spi_init(mode_0, card_cs_pin);
    fat_init();
}

void sensor_init(void) {
    spi_init(mode_0, sensor_cs_pin);
    spi_write(SENSOR_CONFIGURATION, sensor_cs_pin);
}
```

Fragility

Changing the sensor to use mode 1...

```c
void sdcard_init(void) {
    spi_init(mode_0, card_cs_pin);
    fat_init();
}

void sensor_init(void) {
    spi_init(mode_1, sensor_cs_pin); // Breaks the sd card
    spi_write(SENSOR_CONFIGURATION, sensor_cs_pin);
}
```

...Breaks the sd card (when sensor is initialized after the sd card)

Fragility

How to avoid it

- Implicit dependencies
- Law of Demeter: principle of least knowledge
- Avoid side effects, and don't rely on the side effects of other modules
- Rely on the published API
- Invent and **simplify**

Immobility

- Incapable of being moved
- Software for which extra effort is required in order to reuse.
- It is hard to disentangle the system into components that can be reused in other systems.

Immobility

How it happens

- Direct dependency on things you don't own
- Too many responsibilities

Immobility

How it happens

- Depend upon the concept, not the details
- Reduce responsibilities to solve distinct problems

Viscosity

- Having or characterized by a high resistance to flow
- Software for which extra effort is required in order to reuse.

Viscosity

Code that takes effort to maintain correctly

- Viscous Design
  - When changing, preserving the design is difficult
- Viscous Environment
  - Long builds
  - Slow Tests

Principles of Object Oriented Class Design

SOLID Principles

- **S***ingle Responsibility Principle* (SRP)
- **O***pen Closed Principle* (OCP)
- **L***iskov Substitution Principle* (LSP)
- **I***nterface Segregation Principle* (ISP)
- **D***ependency Inversion Principle* (DIP)

Single Responsibility Principle

Responsibility

- Cohesion
- Reason to change
- Axis of change

Single Responsibility Principle

```cpp
class modem
{
  public:
    void dial();
    void hangup();
    void send();
    void rcv();
}
```

Single Responsibility Principle

```
class modem
{
  public:
    void dial();   // Connection management
    void hangup(); // Connection management
    void send();
    void rcv();
}
```

Single Responsibility Principle

```
class modem
{
  public:
    void dial();
    void hangup();
    void send(); // Data Management
    void rcv();  // Data Management
}
```

Single Responsibility Principle

```
class modem_connection
{
  public:
    void dial();
    void hangup();
}

class modem_data
{
  public:
    void send();
    void rcv();
}

class modem_impl
{
  private:
    modem_connection connection;
    modem_data       data;
}
```

Single Responsibility Principle

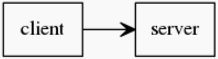
Caution:

- Too much splitting of modules can lead to an overly complicated design.
- If the code does not change in a way that the two responsibilities change at different times, then there's no need to separate.

Open Closed Principle

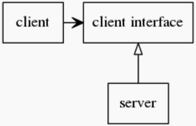
- "Open for Extension"
    - Behavior of the module can be extended through extension
- "Closed for Modification"
    - Extending the behavior requires no change in source code or binary executables.

Open Closed Principle



- Client depends on server
- Changing server requires modification of client
- Use of clients with different servers requires duplication of code

Open Closed Principle



- Enables client implementations for multiple servers

Open Closed Principle

```c
// shape.h ////////////////////////////////////////////////////////////////////
enum shape_type_t { circle, square };
struct shape_s {
    shape_type_t shape_type;
}

// circle.h ///////////////////////////////////////////////////////////////////
#include "shape.h"
struct circle_s {
    shape_type_t shape_type;
    double       radius;
    point        center;
}

void drawCircle(struct circle_s *);

// square.h ///////////////////////////////////////////////////////////////////
#include "shape.h"
struct square_s {
    shape_type_t shape_type;
    double       side;
    point        top_left;
}

void drawSquare(struct square_s *);
```

Open Closed Principle

```c
// draw_all_shapes.c ////////////////////////////////////////////////////////////

typedef struct shape_t *shape_pointer_t;

void DrawAllShapes(shape_pointer_t *shapes, int n)
{
    for (int i = 0; i < nl i++) {
        struct shape_s *s = shapes[i];
        switch (shape->shape_type) {
        case circle:
            drawCircle((struce circle_s *)shape);
            break;
        case square:
            drawSquare((struce square_s *)shape);
            break;
        }
    }
}
```

Open Closed Principle

```c
// shape.h /////////////////////////////////////////////////////////////////////
enum shape_type_t { circle, square };
void (*DrawFunction)(void *);
struct shape_s {
    DrawFunction draw;
}
void DrawShape(void *);

// shape.c /////////////////////////////////////////////////////////////////////
void DrawShape(void * shape_in){
    shape = (struct shape_s *) shape_in;
    shape.draw(shape_in);
}

// circle.h ////////////////////////////////////////////////////////////////////
struct circle_s {
    DrawFunction draw;
    double       radius;
    point        center;
}

void drawCircle(struct circle_s *);

// square.h ////////////////////////////////////////////////////////////////////
struct square_s {
    DrawFunction draw;
    double       side;
    point        top_left;
}

void drawSquare(struct square_s *);
```

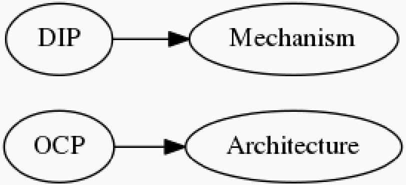
Open Closed Principle

```c
// draw_all_shapes.c ///////////////////////////////////////////////////////////

typedef struct shape_t *shape_pointer_t;

void DrawAllShapes(shape_pointer_t *shapes, int n)
{
    for (int i = 0; i < nl i++) {
        struct shape_s *shape = shapes[i];
        DrawShape(shape);
    }
}
```

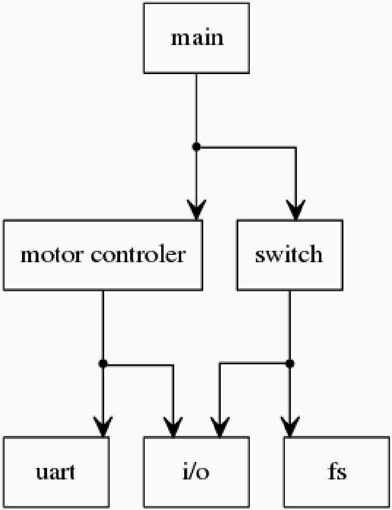
Dependency Inversion Principle

Depend upon abstractions. Do not depend upon concretions.

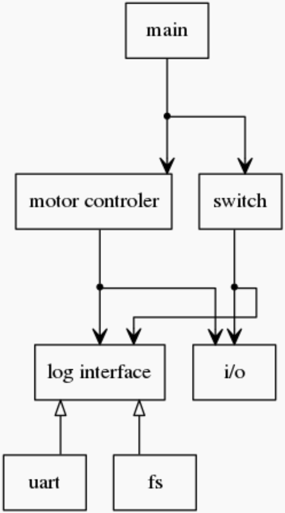
Dependency Inversion Principle



Dependency Inversion Principle



Dependency Inversion Principle



Principles of Package Architecture

Package Principles

- Package Cohesion
  - Release Reuse Equivalency Principle (REP)
  - Common Closure Principle (CCP)
  - Common Reuse Principle (CRP)
- Package Coupling
  - Acyclic Dependencies Principle (ADP)
  - Stable Dependencies Principle (SDP)
  - Stable Abstractions Principle (SAP)

Dependency Inversion Principle

Principles of Package Architecture

Principles of Package Architecture

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Questions