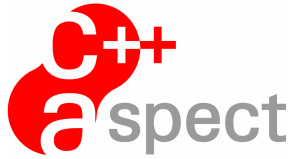
Aspect-Oriented Programming with C++ and AspectC++

AOSD 2007 Tutorial

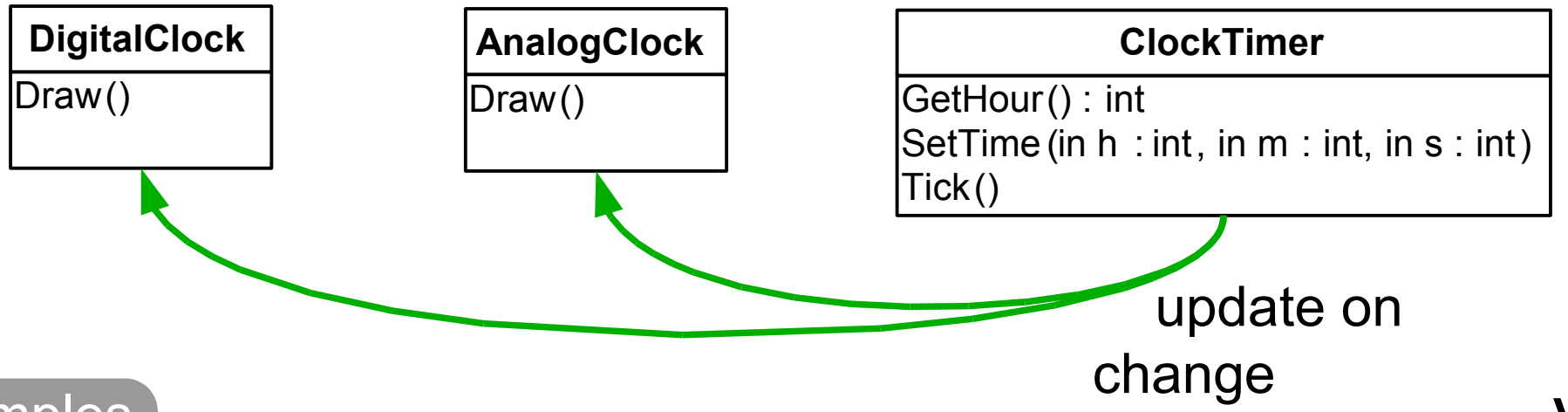
Part V – Examples



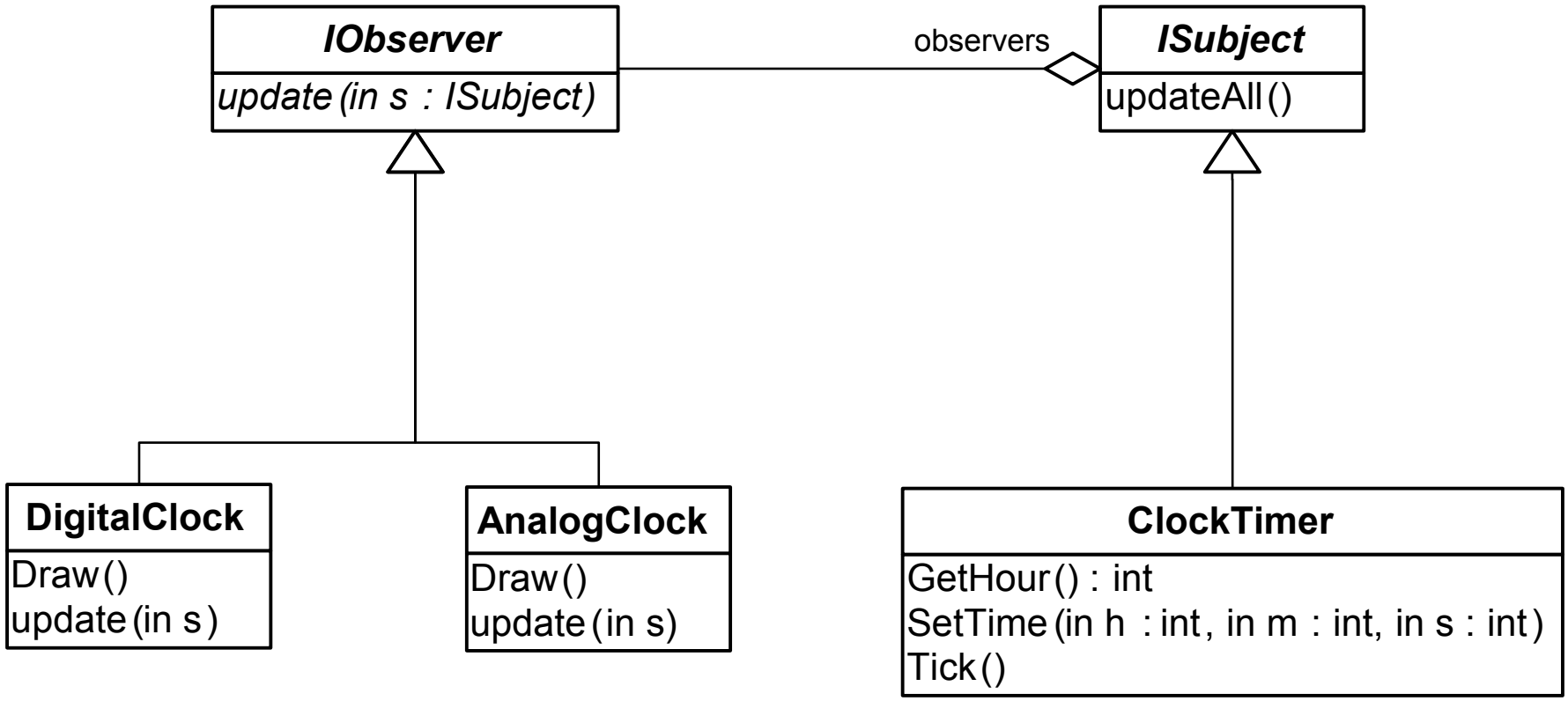
AspectC++ in Practice - Examples

- **Applying the observer protocol**
  - Example: a typical scenario for the widely used observer pattern
  - Problem: implementing observer requires several design and code transformations
- **Errorhandling in legacy code**
  - Example: a typical Win32 application
  - Problem: errorhandling often “forgotten” as too much of a bother

Observer Pattern: Scenario

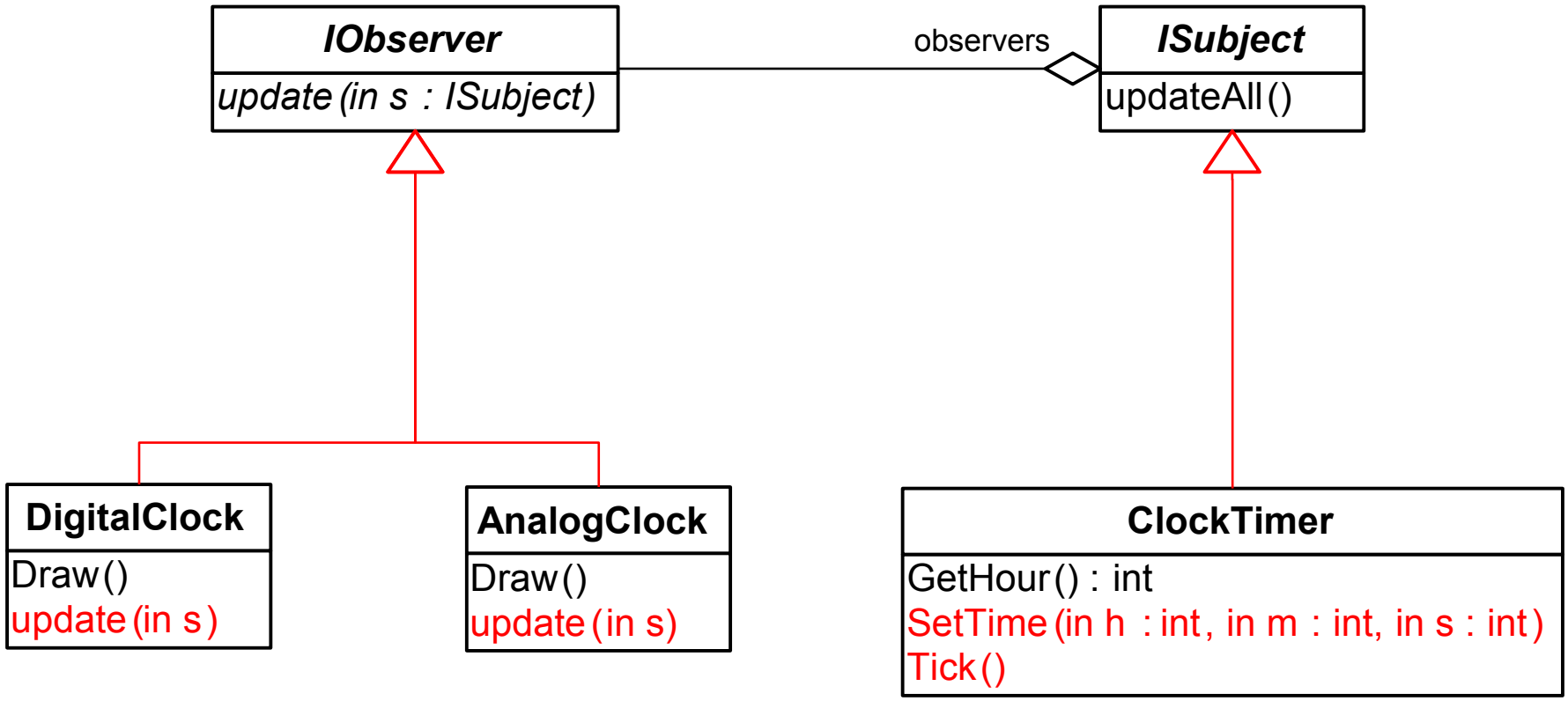


Observer Pattern: Implementation



Observer Pattern: Problem

The 'Observer Protocol' Concern...



...crosscuts the module structure

Solution: Generic Observer Aspect

```
aspect ObserverPattern {
  ...
public:
  struct ISubject {};
  struct IObserver {
    virtual void update (ISubject *) = 0;
  };

  pointcut virtual observers() = 0;
  pointcut virtual subjects() = 0;

  pointcut virtual subjectChange() =  execution( "% ...::%(...)"
                  && !"% ...::%(...) const" ) && within( subjects() );

  advice observers () : slice class : public ObserverPattern::IObserver;
  advice subjects()   : slice class : public ObserverPattern::ISubject;

  advice subjectChange() : after () {
    ISubject* subject = tjp->that();
    updateObservers( subject );
  }

  void updateObservers( ISubject* subject ) { ... }
  void addObserver( ISubject* subject, IObserver* observer ) { ... }
  void remObserver( ISubject* subject, IObserver* observer ) { ... }
};
```

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Interfaces for the subject/observer roles

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};
```

abstract pointcuts that define subjects/observers

(need to be overridden by a derived aspect)

Solution: Generic Observer Aspect

virtual pointcut defining all state-changing methods.

(Defaults to the execution of any non-const method in subjects)

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  ...
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  struct ISubject {};
  struct IObserver {
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  pointcut virtual observers() = 0;
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};
```

Introduction of the role interface as additional **baseclass** into subjects / observers

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  void remObserver( ISubject* subject, IObserver* observer ) { ... }
};
```

After advice to update observers after execution of a state-changing method

Solution: Putting Everything Together

Applying the Generic Observer Aspect to the clock example

```
aspect ClockObserver : public ObserverPattern {
  // define the participants
  pointcut subjects()   = "ClockTimer";
  pointcut observers()  = "DigitalClock"||"AnalogClock";
public:
  // define what to do in case of a notification
  advice observers() : slice class {
  public:
    void update( ObserverPattern::ISubject* s ) {
      Draw();
    }
  };
};
```

Observer Pattern: Conclusions

- Applying the observer protocol is now very easy!
  - all necessary transformations are performed by the generic aspect
  - programmer just needs to define participants and behaviour
  - multiple subject/observer relationships can be defined
- More reusable and less error-prone component code
  - observer no longer “hard coded” into the desing and code
  - no more forgotten calls to update() in subject classes
- Full source code on Tutorial CD

Errorhandling in Legacy Code: Scenario

```
LRESULT WINAPI WndProc( HWND hWnd, UINT nMsg, WPARAM wParam, LPARAM lParam ) {
  HDC dc = NULL; PAINTSTRUCT ps = {0};

  switch( nMsg ) {
    case WM_PAINT:
      dc = BeginPaint( hWnd, &ps );
      ...
      EndPaint(hWnd, &ps);
      break;
    ...
}}

int WINAPI WinMain( ... ) {
  HANDLE hConfigFile = CreateFile( "example.config", GENERIC_READ, ... );

  WNDCLASS wc = {0, WndProc, 0, 0, ... , "Example_Class"};
  RegisterClass( &wc );
  HWND hwndMain = CreateWindowEx( 0, "Example_Class", "Example", ... );
  UpdateWindow( hwndMain );

  MSG msg;
  while( GetMessage( &msg, NULL, 0, 0 ) ) {
    TranslateMessage( &msg );
    DispatchMessage( &msg );
  }
  return 0;
}
```

A typical Win32 application

Errorhandling in Legacy Code: Scenario

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LRESULT WINAPI WndProc( HWND hWnd, UINT nMsg, WPARAM wParam, LPARAM lParam ) {
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      ...
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      break;
    ...
}}

int WINAPI WinMain( ... ) {
  HANDLE hConfigFile = CreateFile( "example.config", GENERIC_READ, ... );

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  RegisterClass( &wc );
  HWND hwndMain = CreateWindowEx( 0, "Example_Class", "Example", ... );
  UpdateWindow( hwndMain );

  MSG msg;
  while( GetMessage( &msg, NULL, 0, 0 ) ) {
    TranslateMessage( &msg );
    DispatchMessage( &msg );
  }
  return 0;
}
```

These Win32 API functions may fail!

Win32 Errorhandling: Goals

- Detect failed calls of Win32 API functions
  - by giving after advice for any call to a Win32 function
- Throw a *helpful* exception in case of a failure
  - describing the exact circumstances and reason of the failure

Problem: Win32 failures are indicated by a “magic” return value

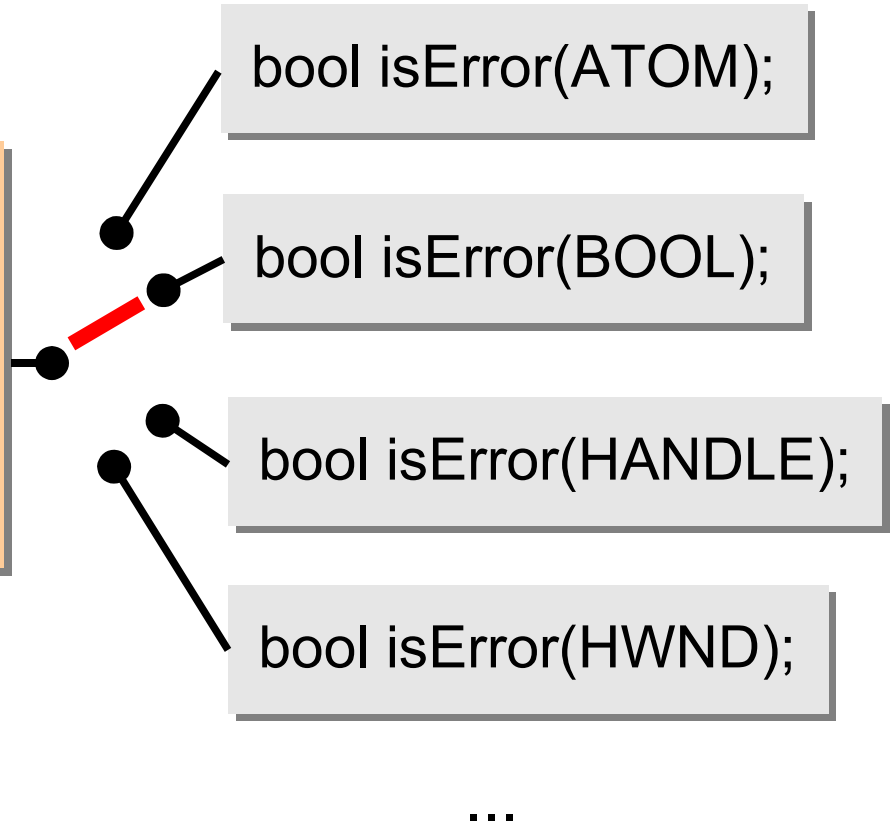
- magic value to compare against depends on the ***return type*** of the function
- error reason (`GetLastError()`) only valid in case of a failure

return type	**magic value**
BOOL	FALSE
ATOM	(ATOM) 0
HANDLE	INVALID_HANDLE_VALUE or NULL
HWND	NULL

Examples

Detecting the failure: Generic Advice

```
advice call(win32API ()) :
after () {
  if (isError (*tjp->result()))
    // throw an exception
}
```



Describing the failure: Generative Advice

```
template <int I> struct ArgPrinter {
  template <class JP> static void work (JP &tjp, ostream &s) {
    ArgPrinter<I–1>::work (tjp, s);
    s << “, “ << *tjp. template arg<I-1>();
  }
};
```

```
advice call(win32API ()) : after () {
  // throw an exception
  ostringstream s;
  DWORD code = GetLastError();
  s << “WIN32 ERROR ” << code << ...
     << win32::GetErrorText( code ) << ... <<
     << tjp->signature() << “WITH: ” << ...;
     ArgPrinter<JoinPoint::ARGS>::work (*tjp, s);

  throw win32::Exception( s.str() );
}
```

Reporting the Error

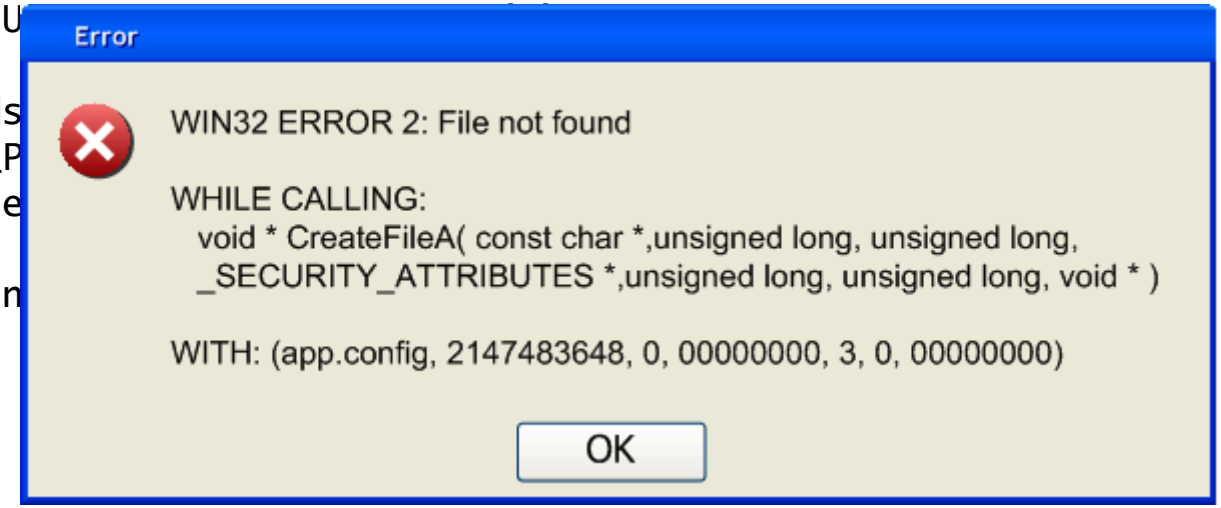
```
LRESULT WINAPI WndProc( HWND hWnd, UINT nMsg, WPARAM wParam, LPARAM lParam ) {
  HDC dc = NU

  switch( nMs
    case WM_P
      dc = Be
      ...
      EndPain
      break;
    ...
}}

int WINAPI WinMain( ... ) {
  HANDLE hConfigFile = CreateFile( "example.config", GENERIC_READ, ... );

  WNDCLASS wc = {0, WndProc, 0, 0, ... , "Example_Class"};
  RegisterClass( &wc );
  HWND hwndMain = CreateWindowEx( 0, "Example_Class", "Example", ... );
  UpdateWindow( hwndMain );

  MSG msg;
  while( GetMessage( &msg, NULL, 0, 0 ) ) {
    TranslateMessage( &msg );
    DispatchMessage( &msg );
  }
  return 0;
}
```



Errorhandling in Legacy Code: Conclusions

- Easy to apply errorhandling for Win32 applications
  - previously undetected failures are reported by exceptions
  - rich context information is provided
- Uses advanced AspectC++ techniques
  - error detection by generic advice
  - context propagation by generative advice
- Full source code on tutorial CD