Embedded Software

Abstract Object-Oriented OS APIs

Agenda

- What is an API and why use it?
- What is an OS API?
- Concrete examples using OS API
- Guidelines for writing event based thread oriented programs

API and OS API - What and Why?

What is an API?

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- Why use an API?
  - Encapsulation – the API may hide some of the system
  - Abstraction – only the system interface is revealed
  - Simplification – the API may restrict access to the system

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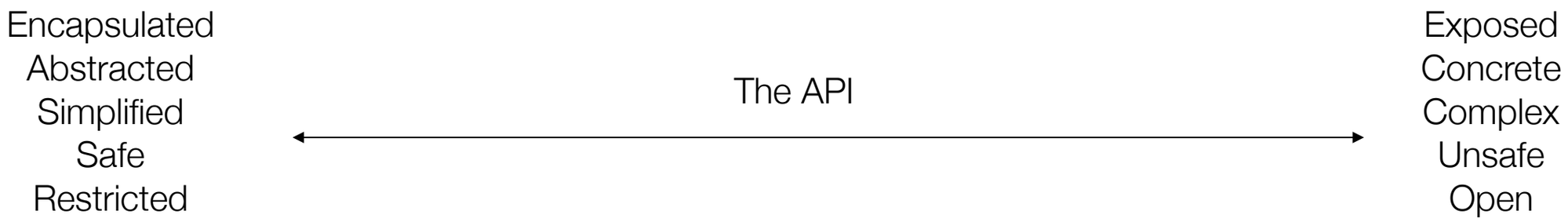

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The OS API

- Operating systems have extensive APIs to access OS resources
  - Threads, semaphores, timers, pipes…
  - Example: Thread creation

```
//win32
HANDLE CreateThread(…);
```

```
//POSIX - Linux
void* pthread_create(…);
```

```
//VxWorks
void* pthread_create(…);
```

The abstract OS API

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- Why is the native OS' API not enough for us
  - why further abstract it?

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Why would we ever want to switch the OS itself?

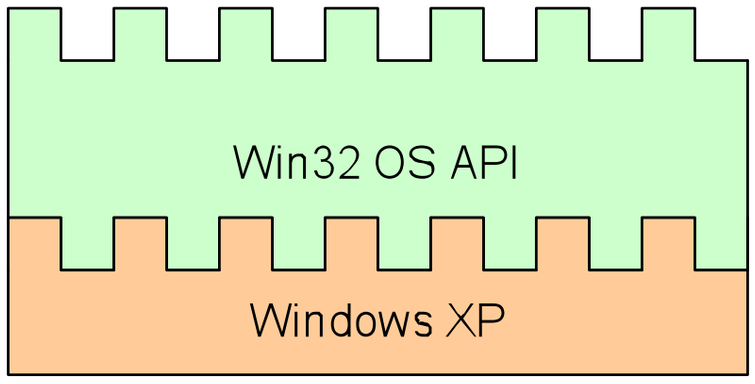
Grp 2 & 2 - 3mins

Your input....

Concrete example - Article on OSAL

- *An Operating System Abstraction Layer for Portable Applications in Wireless Sensor Networks* (for the Mantis OS and FreeRTOS)
  - Why?
    - Faster development due to increase in portability
      - New platforms demand "*only*" implementation of OSAL (and drivers)
    - Support for different OS's deployed on different platforms
    - Same API used again and again - Only one API to learn
  - How?
    - Thin layer introduced between Application layer and OS layer

The abstract OS API



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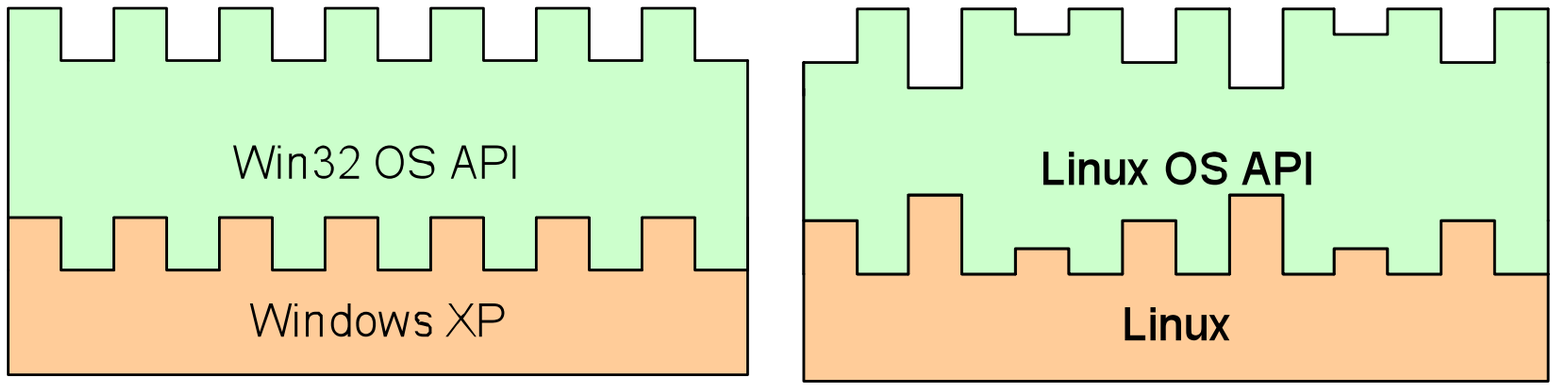

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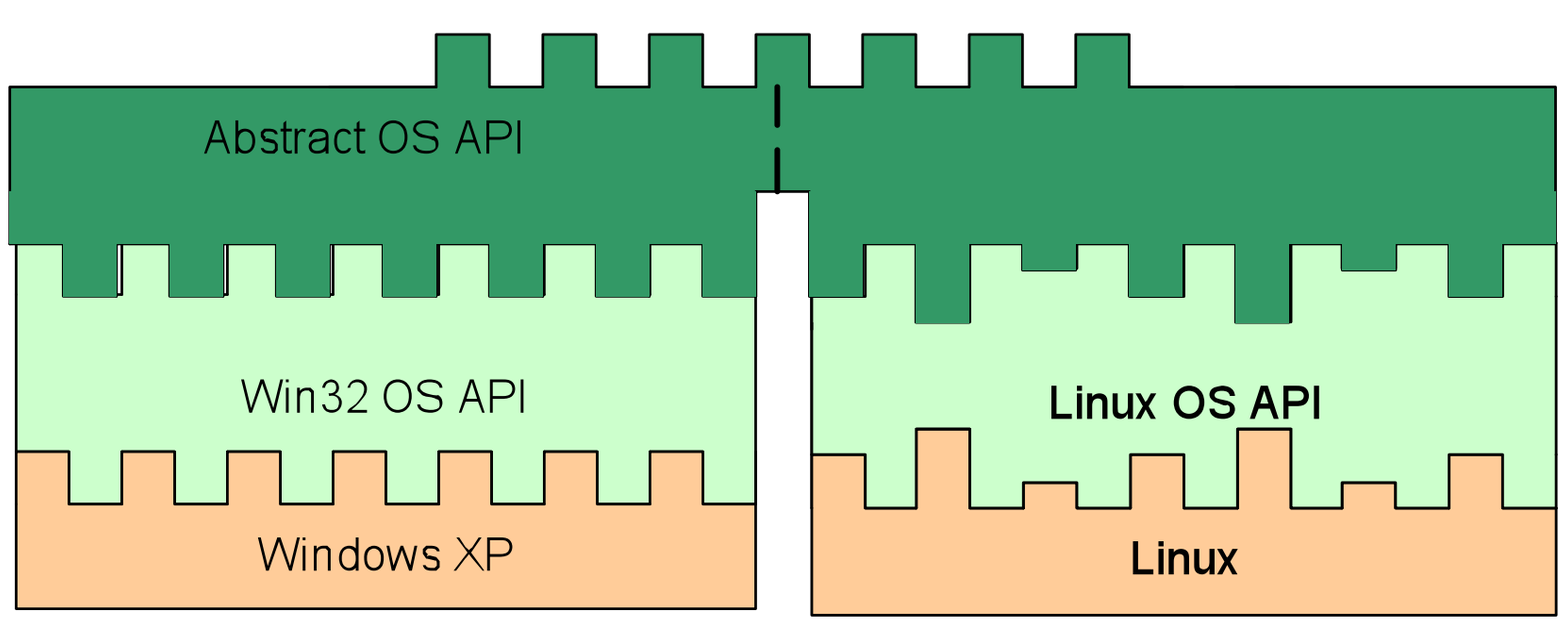

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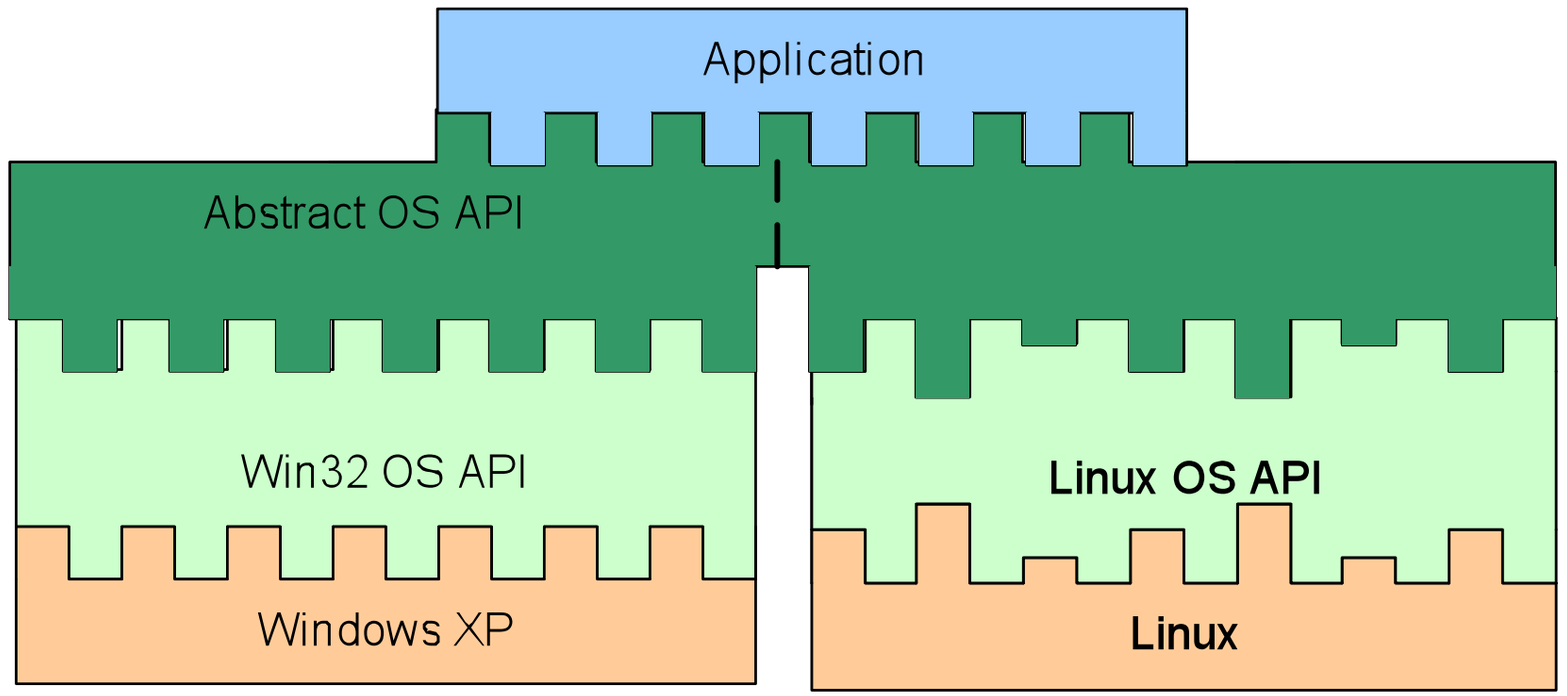
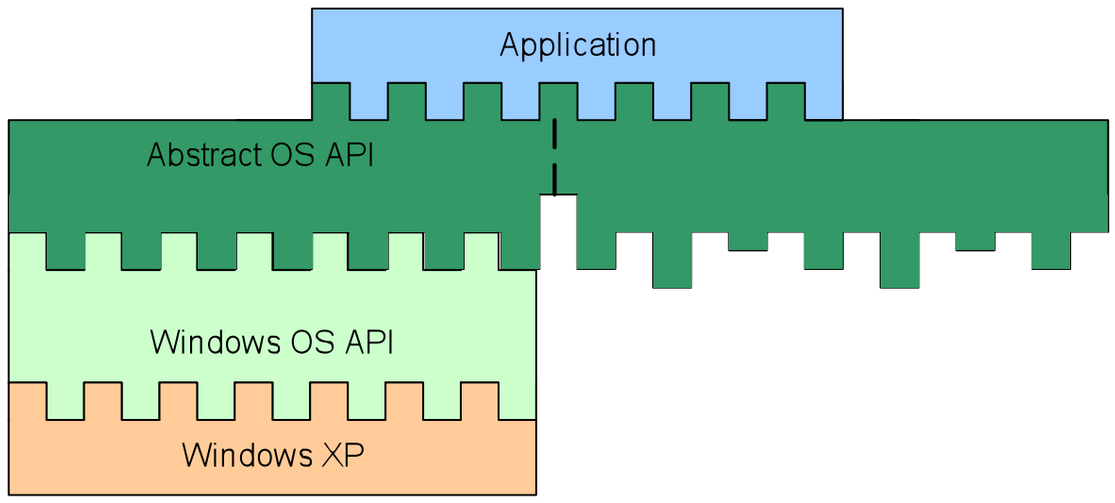


Abstract OS API: Cross-development

- Develop the system for the host platform
  - Debug the system until no errors are left
  - Use stubs for real-life peripherals (GoF Strategy)



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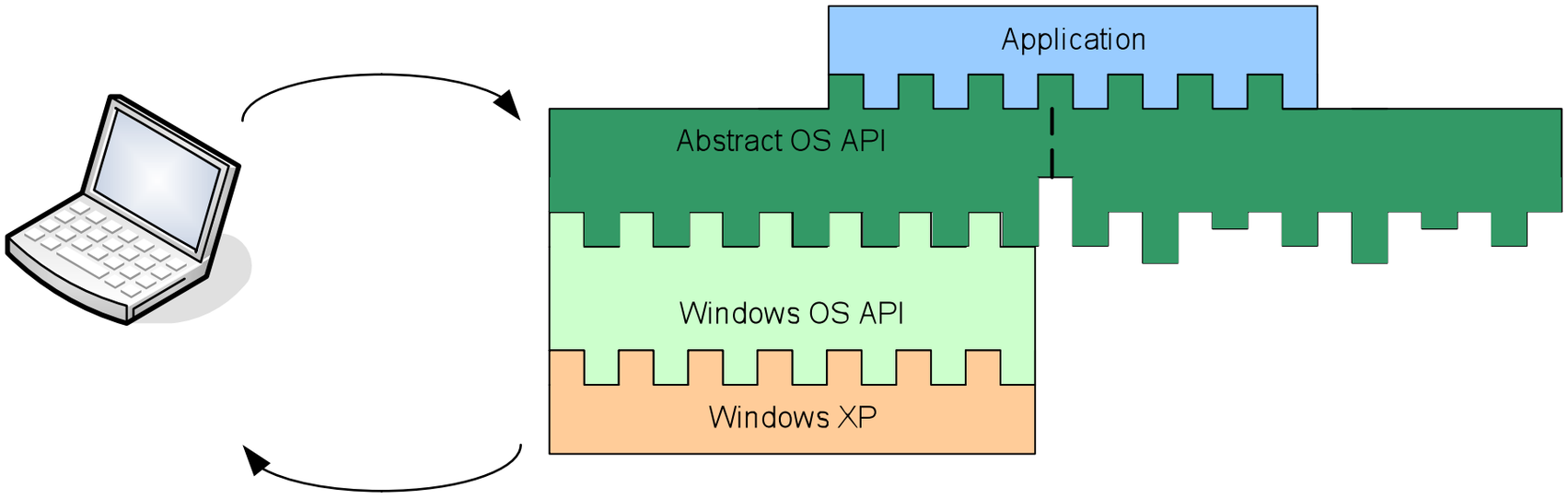

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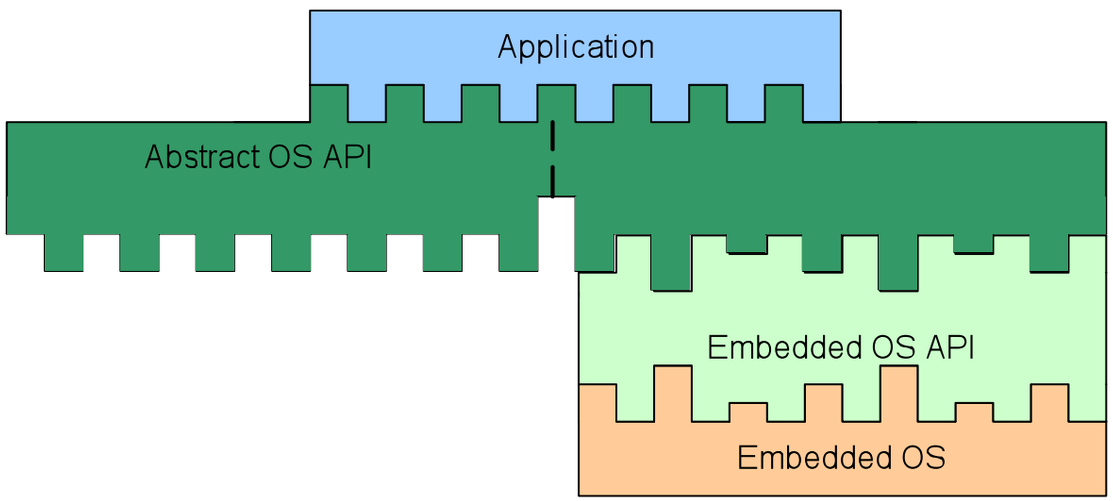
Abstract OS API: Cross-development

- Develop the system for the host platform
  - Debug the system until no errors are left
  - Use stubs for real-life peripherals (GoF Strategy)
- Now develop the same system for target platform
  - Little or no change to application
  - Now debug target-specific problems (timing, real peripherals, etc.)



An abstract object-oriented OS API

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- Why should the abstract OS API be object oriented?
  - Easier to work with (if you're used to objects)
  - Cleaner code
  - Decreases the representational gap between design and implementation

An abstract object-oriented OS API

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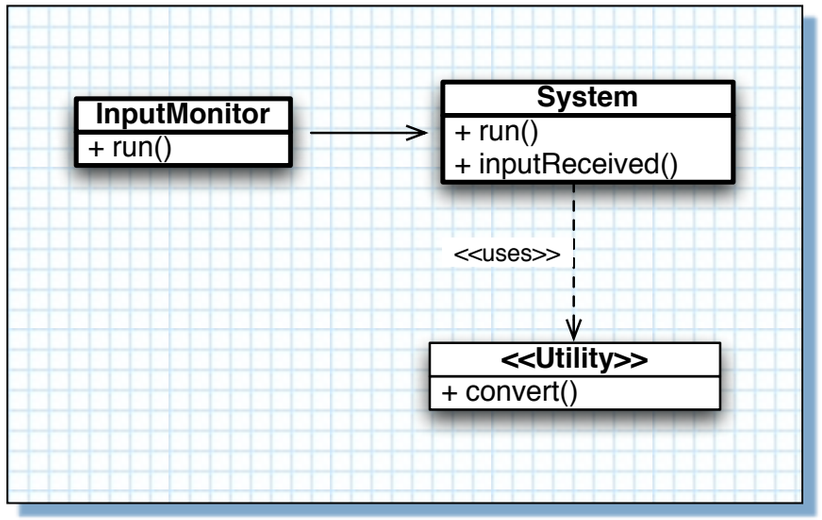
  - Decreases the representational gap between design and implementation

- The representational gap
  - The ”distance in representation” between the design and implementation of your application

The representational gap



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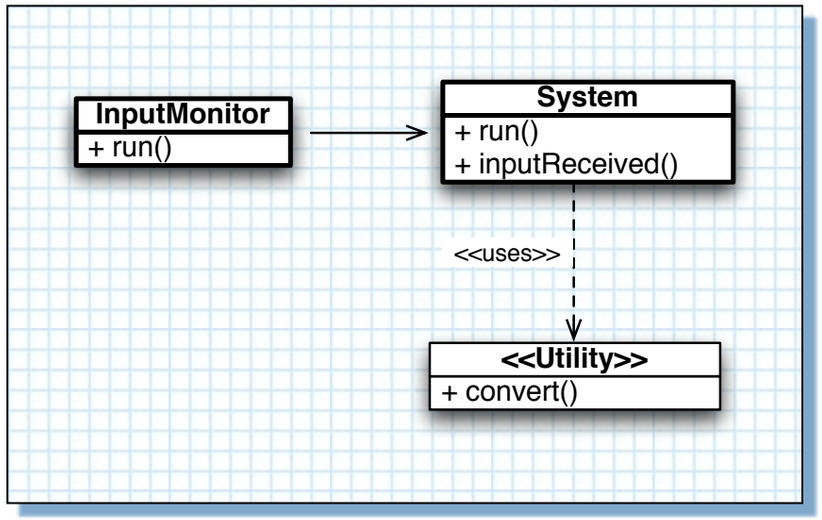
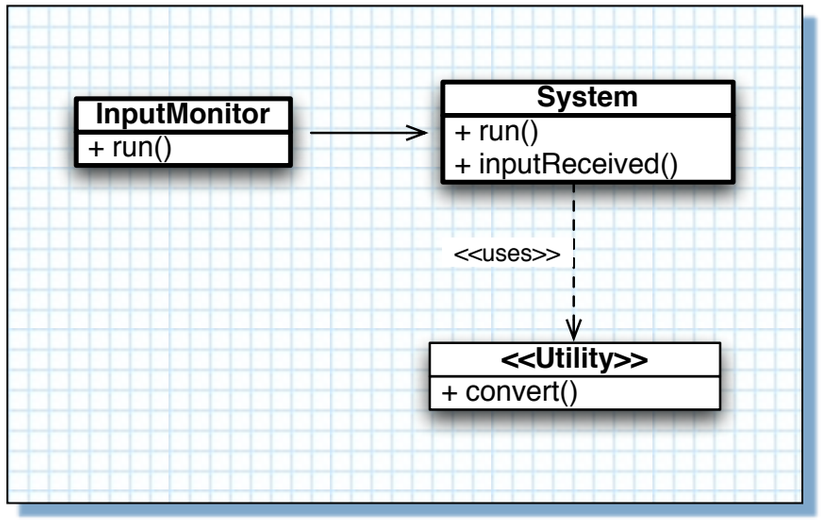



```
// system.h
class System : public Thread
{
public:
    enum { ID_INPUT };
    System() : mq_(MAX_QUEUE_SIZE) {}
    inputReceived(InputMsg* msg);
    MsgQueue mq_;
    ...
};

// system.cpp
void System::run()
{
    unsigned long id;
    Message* msg = mq_.receive(id);
    switch (id) {
            case ID_INPUT:
                        inputReceived(static_cast<InputMsg*> (msg));
                    break;
            default:
                    break;
    }
    delete msg;
}

void System::inputReceived(InputMsg* msg)
{
    convInput = convert(msg->value_);
}
```

The representational gap




```
// inputmonitor.h
class InputMonitor
{
public:
    InputMonitor(MsgQueue* sysMsgQueue);
    ...
};


// inputmonitor.cpp
...
InputMonitor::inputReady()
{
    value = gpio_read_16bit(0x22);
    ...
    sysMsgQueue_->send(System::ID_INPUT, inputMsg);
}
```

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// system.h
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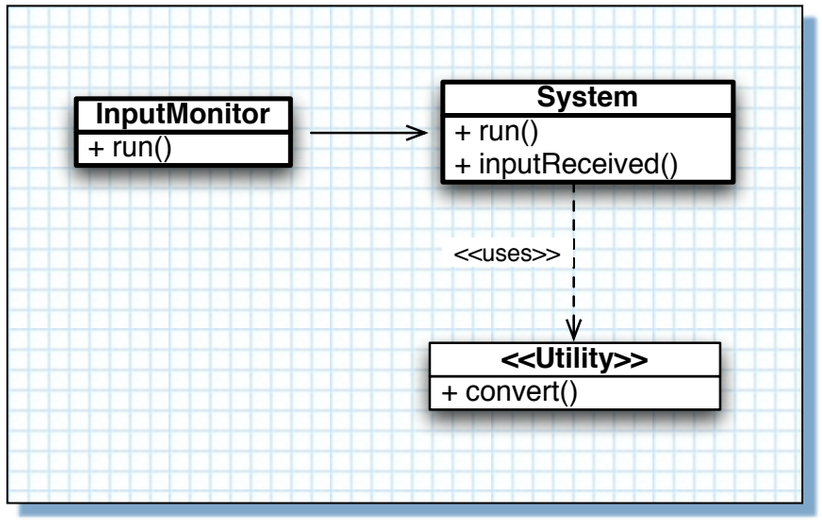


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InputMonitor::inputReady()
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    sysMsgQueue_->send(System::ID_INPUT, inputMsg);
}
```

```
// main.cpp
void main()
{
    System sys;
    InputMonitor inputMonitor(sys.getMsgQueue());
    sys.start();
    inputMonitor.start();

    while(true) sleep(1000);
}
```

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// system.h
class System : public Thread
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Usage & Guidelines

OO OS Api - Example

- Simple example
  - `MyThread` inherits and implements function *run* from `Thread`
  - `osapi::Mutex` is part of `MyThread` and is default appropriately initialized
  - `MyThread` is created on the stack in function `main()`
    - Started via `start()`
    - Waited upon via `join()`

```
class MyThread : public osapi::Thread
{
public:
    MyThread() : running_(true) {}
    virtual void run()
    {
        while (running_) {
            m_.lock();
            // Do stuff
            m_.unlock();
            // Do stuff
        }
    }
private:
    bool          running_;
    osapi::Mutex m_;
};
```

```
int main(int argc, char *argv[])
{
    MyThread myt;
    myt.start();

    myt.join();
}
```

Typical task structure in event-based system

```
void MyThread::run()
{
   // get message from message queue
   while(running_)
   {
        switch (on state) {
            case ST_IDLE:

                switch (on event) {
                    case ID_MSG:
                        // Handle event.
                        break;
                    default:
                        break;
                }

                break;
            default:
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Perform setup here that does not belong in constructor

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Handle each ”type” of message separately

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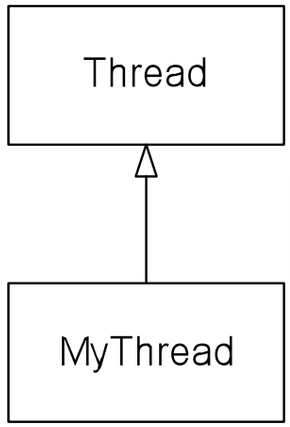


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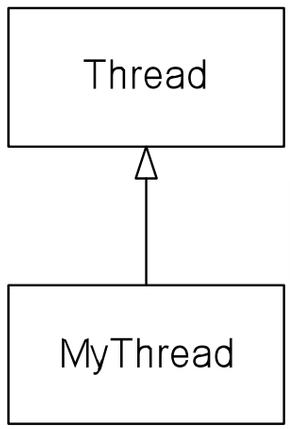


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Perform setup here that does not belong in constructor

Get a message, e.g. msgQueue->receive()

Switch on state, each state has separate handlers

Handle each ”type” of message separately

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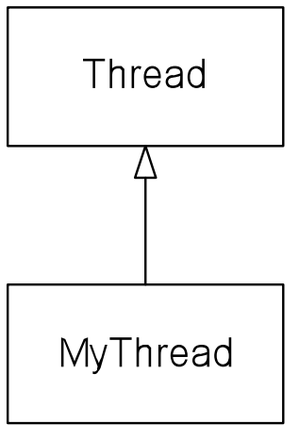
OS Api used with MsgQueues

- Thread class using the MsgQueue concept




```
class MyThread : public osapi::Thread
{
public:
    enum MsgID {
        ID_MSG,
        ID_TERMINATE
    }
    // Other functions
    MyThread();
private:
    void handleMsg(unsigned int id, osapi::Message* msg);
    virtual void run();

    enum State {
        ST_IDLE,
        ST_RUNNING
    };

    osapi::MsgQueue mq_;
    State           st_;
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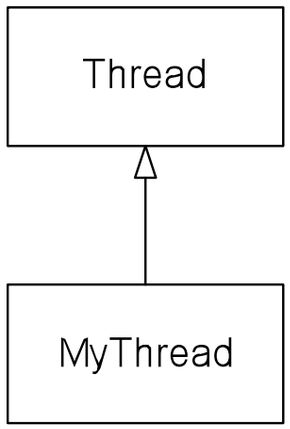

Messages that can be received = Class Interface

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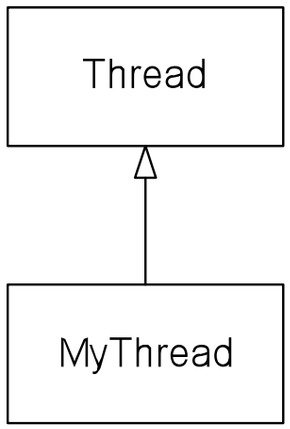

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Thread function and message handler

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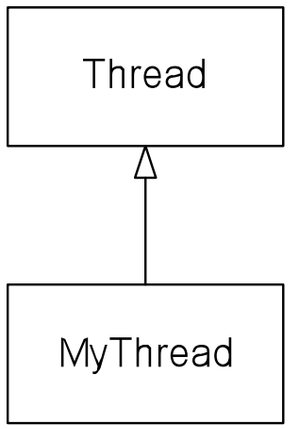

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Thread states

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Typical task structure in event-based system

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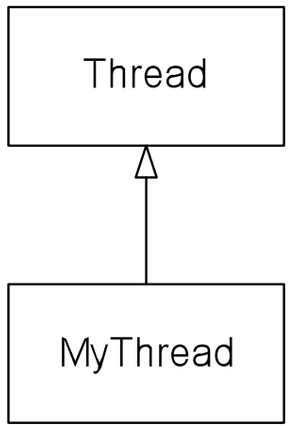


```
void MyThread::run()
{
    // Initial one-time setup
    while (running_) {
        {
            // Wait for message (e.g. mail)
            unsigned int id;
            osapi::Message* msg = mq_.receive(id);
            handleMsg(id, msg);
            delete msg;
        }
    }
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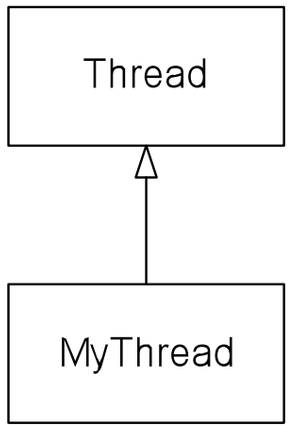
```

Thread loop

Typical task structure in event-based system

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        }
    }
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```

Thread loop

```
void MyThread::handleMsg(unsigned int id,
                         osapi::Message* msg)
{
    switch (state) {
        case ST_IDLE:
            handleMsgStateIdle(id, msg);
            break;
        default:
            break;
    }
}
```

Switch on state and handle it

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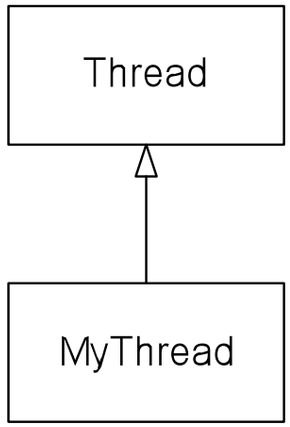


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    }
}
```

Thread loop

```
void MyThread::handleMsg(unsigned int id,
                         osapi::Message* msg)
{
    switch (state) {
        case ST_IDLE:
            handleMsgStateIdle(id, msg);
            break;
        default:
            break;
    }
}
```

Switch on state and handle it

Switch on event and handle it

```
void MyThread::handleMsgStIdle(unsigned int id,
                               osapi::Message* msg)
{
    switch(event)
    {
        case ID_MSG:
            // handle firstType-messages
            handleStIdleIdMsg(msg);
            break;

        case ID_TERMINATE:
            // handle secondType-messages
            break;

            ...

        default:
            // signal an error
            break;
    }

}
```

The abstract OO OS API

- The OS API includes the following resources:
  - An abstract Thread class
  - sleep
  - A Timer class (for timeouts)
  - A Time class (simple time arithmetic)
  - Semaphore class (counting)
  - Mutex class
  - Conditional class
  - A ScopedLock class
  - A Completion class
  - A Log System
  - A Message Queue class
- Use (or extend) this to build generic, object-oriented applications