Thread synchronization

Part 1

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C# threading pt. 1

Concurrent access to shared resources
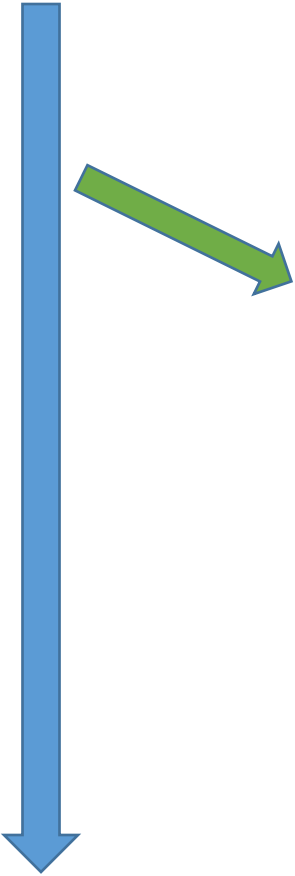
Locking

Deadlock

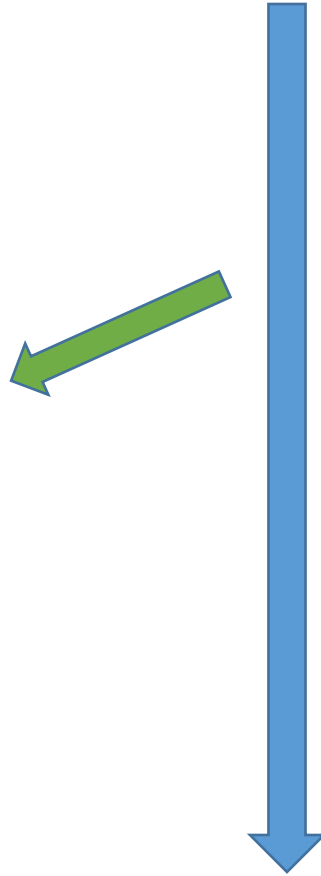Updating MAUI GUIs

But first...

Solve exercise 1k

and when done, skip ahead or get a cup of coffee

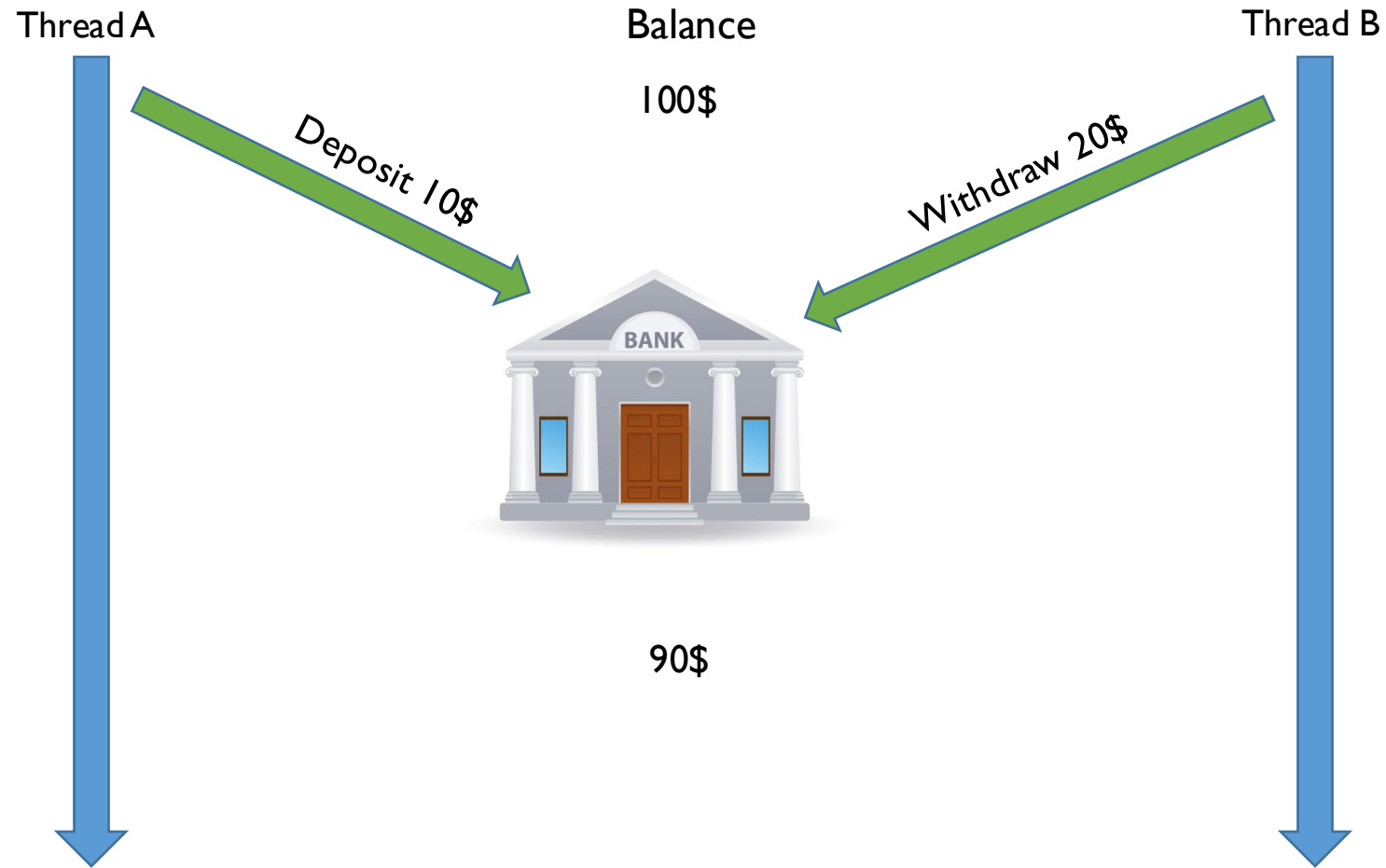# Concurrent access to shared resources

Thread A

Thread B

We often need synchronization, when threads share a resource.

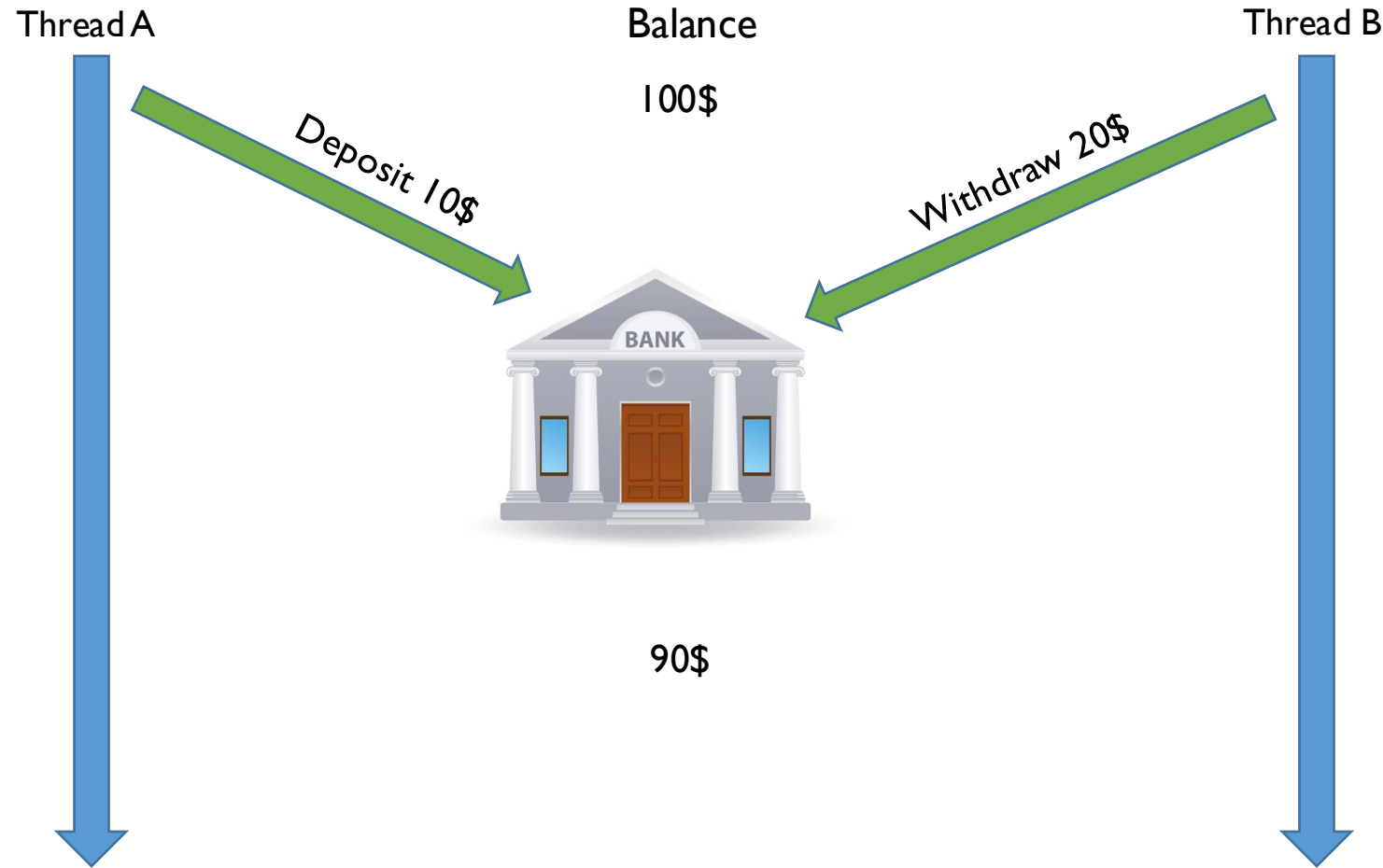# The bank account

Thread A

Balance

100$

Deposit 10$

Withdraw 20$

Thread B

A simple example is a bank account.

BANK

90$

The bank account

Thread A

Balance

100$

Deposit 10$

Withdraw 20$

Thread B

An account has a balance.

BANK

90$

The bank account

Thread A   Balance   Thread B

                             100$

Deposit 10$ Withdraw 20$

BANK

                              90$
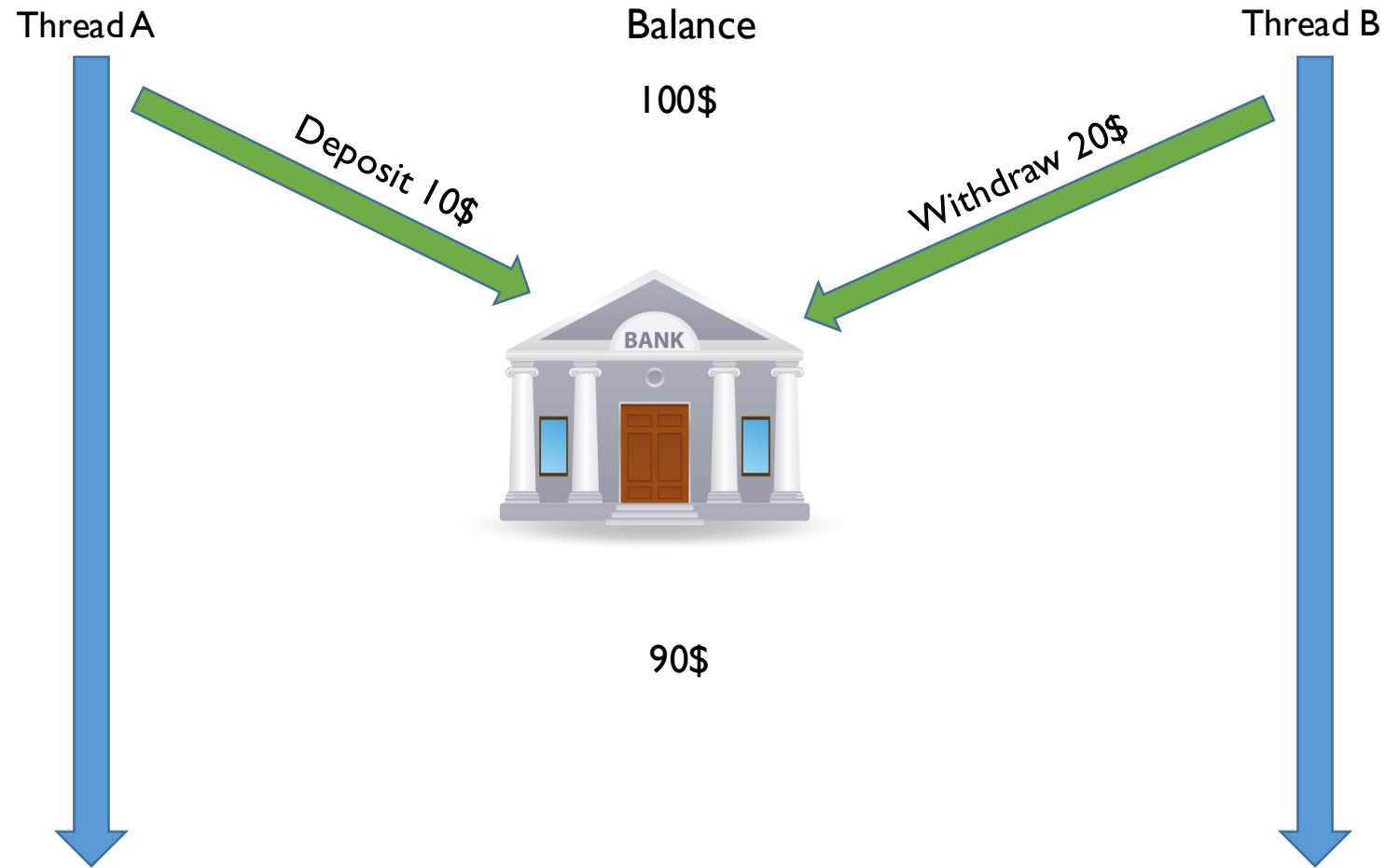
An account has a balance.

You can deposit and withdraw money.

The bank account

Thread A

Deposit 10$

Thread B

Withdraw 20$

```
class Account
{
    private int _balance = 100;

    public void Deposit(int amount)
    {
        _balance = _balance + amount;
    }

    public void Withdraw(int amount)
    {
        _balance = _balance - amount;
    }
}
```
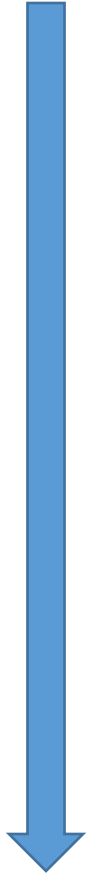
What the computer really does... (the bank account)

Thread A

Deposit 10$

Thread B

Withdraw 20$

```
class Account
{
    private int _balance = 100;

    public void Deposit(int amount)
    {
        int internalRegister = _balance;
        internalRegister = internalRegister + amount;
        _balance = internalRegister;
    }

    public void Withdraw(int amount)
    {
        int internalRegister = _balance;
        internalRegister = internalRegister - amount;
        _balance = internalRegister;
    }
}
```

What the computer really does... (the bank account)

Thread A

Deposit 10$

Thread B

Withdraw 20$
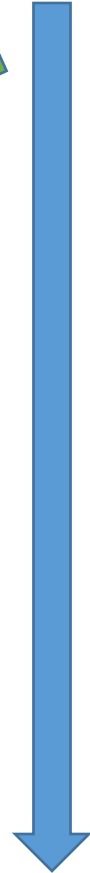
```
class Account
{
    private int _balance = 100;

    public void Deposit(int amount)
    {
        int internalRegister = _balance;
        internalRegister = internalRegister + amount;
        _balance = internalRegister;
    }

    public void Withdraw(int amount)
    {
        int internalRegister = _balance;
        internalRegister = internalRegister - amount;
        _balance = internalRegister;
    }
}
```

Without synchronization, the scheduler may switch threads at any time.

And also switch multiple times.

Exclusive locking using lock()

The C# `lock()`-statement is shorthand for using monitors

Best practice is to create a lock object.

You can lock on any object, including `this`, but then others can lock on the same object as well and prevent concurrency. So don't do that!

```csharp
class Counter
{
    private int c1 = 0;
    private object myLock = new object();

    public void Increment()
    {
        lock (myLock)
        {
            c1 = c1 + 1;
        }
    }


    public int Count
    {
        get
        {
            lock (myLock)
            {
                return c1;
            }
        }
    }
}
```
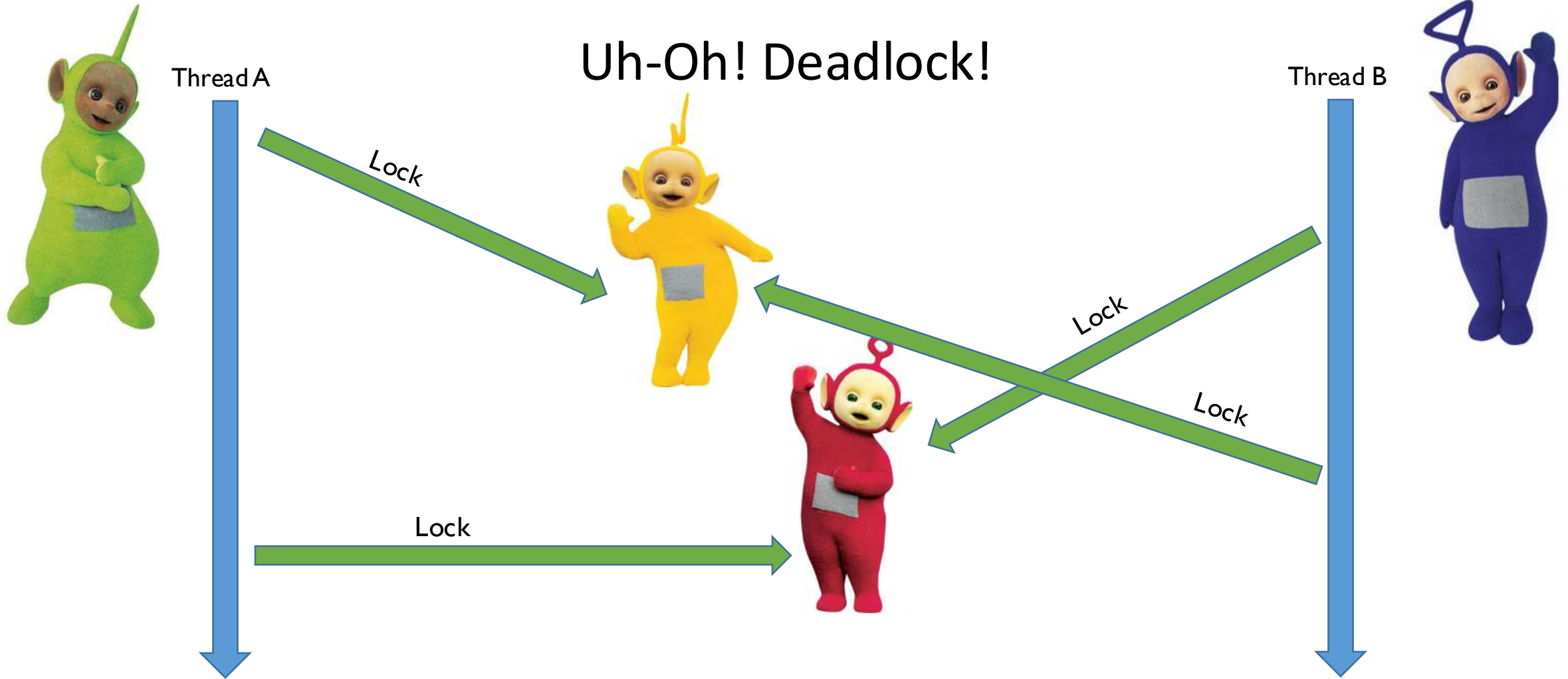
Deadlock

The crew

Tinky Winky

Dipsy

Laa-Laa

Po

The tubbies wants to play

Uh-Oh! Deadlock!

Always aquire resources in the same order

Tinky Winky must wait

Thread A

Thread B

Lock

Lock

Lock

Lock
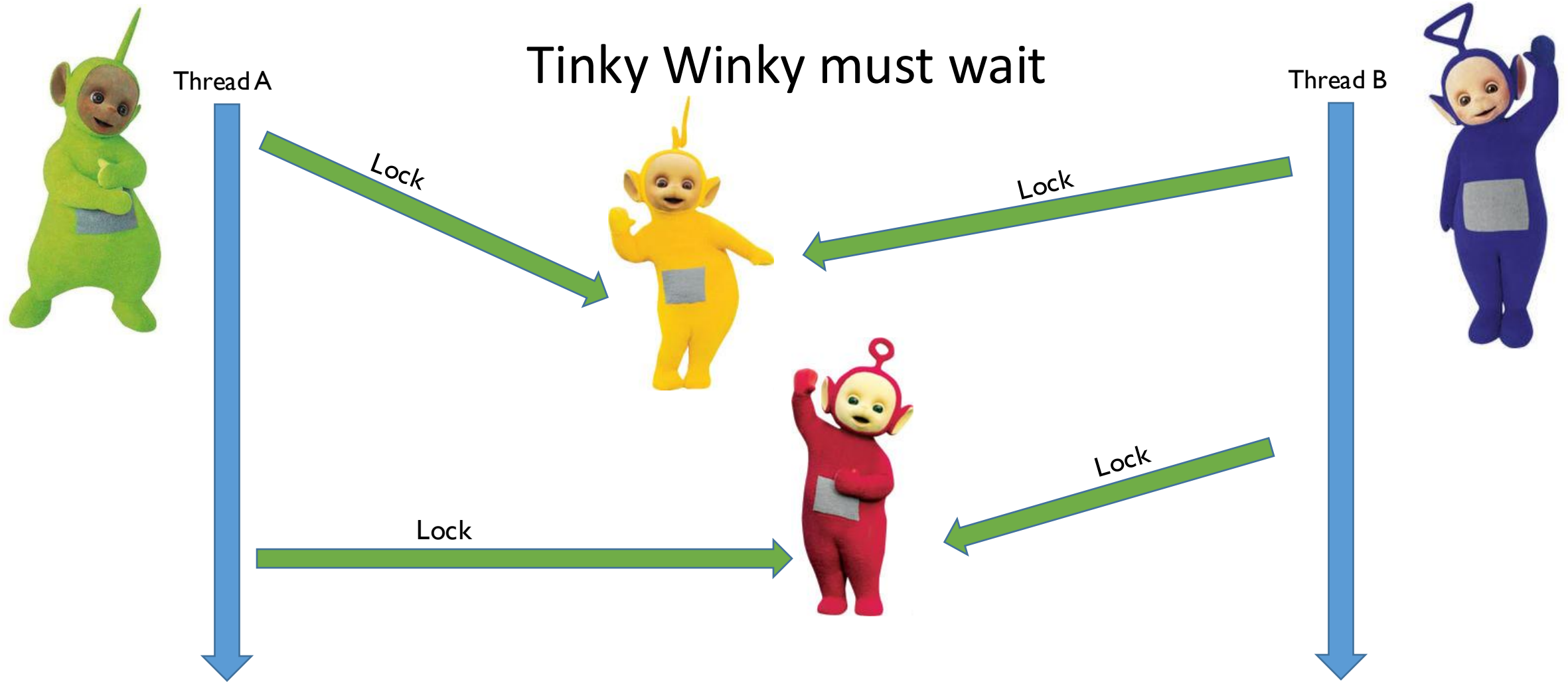
Your turn

Solve exercises 2 and 3

and when done, jump to the advanced exercises

Threads and MAUI GUI's

BadApp.exe

BadApp.exe is not responding

Windows can check online for a solution. If you close the program, you might lose information.

→ Close the program

→ Wait for the program to respond

Updating Windows GUI's

MAUI Controls (all the GUI elements) are **not** thread safe.

Only the GUI update thread (the Dispatcher thread) is allowed to modify GUI elements.

If we want something to be updated from another thread, we must tell the Dispatcher thread to do so.

Two ways

System.Threading.Thread
　　Create a thread from the main program.
　　The thread keeps running, until stopped by some of your code.
　　Update the UI with the "Invoke" methods.

System.ComponentModel.BackgroundWorker
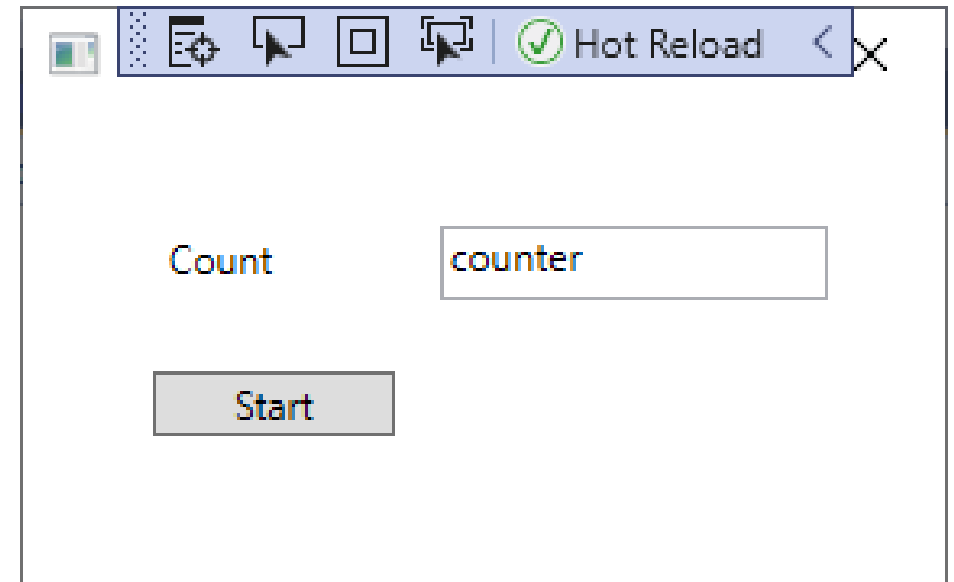　　Initiate a background thread from the UI.
　　Do some work and then the thread stops.

Basic example: Counting thread

```
public class Counter
{
  readonly MainPage _mainPage;

  public Counter(MainPage mainPage)
  {
    _mainPage = mainPage;
  }

  public void Run()
  {
    for (int i = 0; i < 1000; i++)
    {
      _mainPage.UpdateCounter(i);
      Thread.Sleep(100);
    }
  }
}
```

MainThread example: Counting thread

```
public partial class MainPage : ContentPage
{

  public void UpdateCounter(int count)
  {
    if (MainThread.IsMainThread)
    {
      LabelCounter.Text = "" + count;
    }
    else
    {
      MainThread.BeginInvokeOnMainThread(() =>
        {
            LabelCounter.Text = "" + count;
        }
    );
    }
  }
}
```

IsMainThread checks if the calling thread is allowed to modify the control.

MainThread example: Counting thread

```
public partial class MainPage : ContentPage
{

  public void UpdateCounter(int count)
  {
    if (MainThread.IsMainThread)
    {
      LabelCounter.Text = "" + count;
    }
    else
    {
      MainThread.BeginInvokeOnMainThread(() =>
          {
              LabelCounter.Text = "" + count;
          }
      );
    }
  }
}
```

IsMainThread checks if the calling thread is allowed to modify the control.

If it is not, BeginInvokeOnMainThraed places the created delegate in a queue, from which it is taken and processed at a later time, by the Dispatcher thread.

Dispatcher example: Counting thread

```csharp
public partial class MainPage : ContentPage
{

  public void UpdateCounter(int count)
  {
    var dispatcher = Application.Current.Dispatcher;
    if (!dispatcher.IsDispatchRequired)
    {
      LabelCounter.Text = "" + count;
    }
    else
    {

      dispatcher.DispatchAsync(() =>
          {
              LabelCounter.Text = "" + count;
          }
      );
    }
  }
}
```

IsDispatchRequired checks if the dispatching is required for an action.

If it is not, DispatchAsync places the created delegate in a queue, from which it is taken and processed at a later time, by the Dispatcher thread.

Basic example: Counting thread

```
public partial class MainPage : ContentPage
{
  private void ButtonStart_Click(object sender,
                                 EventArgs e)
  {
    Counter counter = new Counter(this);

    Thread theThread = new Thread(counter.Run);
    theThread.IsBackground = true;

    theThread.Start();
  }
}
```

Configure a button to start the thread.

Note, that you probably want the thread to be a background thread.

Otherwise, it will continue to run, when you close the program.

Invoke or BeginInvoke?

Dispatch() will schedule the asynchronous action on the Dispatcher thread.

>   When the asynchronous action is scheduled, your code continues.
>
>   Some time later (you don't know exactly when) your asynchronous action will be executed

DispatchAsync() will execute your asynchronous action (on the Dispatcher thread).

>   Let you **await** for the action to finish or get a result back
>
>   Without **await** it's the same as **Dispatch()**
>
>   We talk about this in SW4SWD next semester

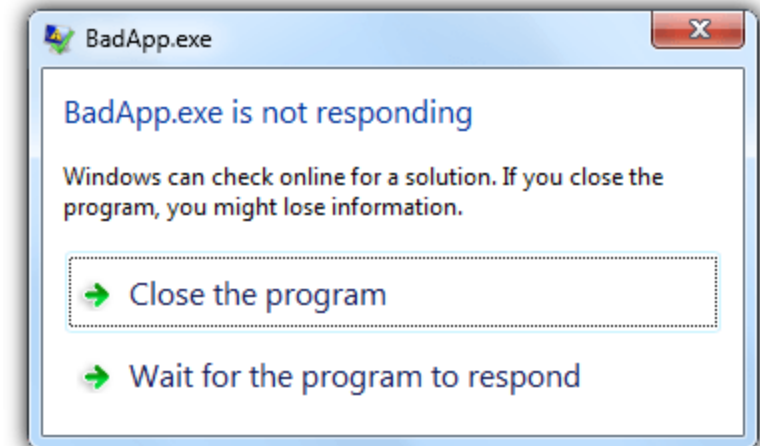# Extra stuff

Not solved here

Perform time consuming work and still have a responsive UI.

Inform the user about the state of the work in progress.

React when work is complete
- Inform the user.
- Do something based on the result.

Be able to cancel the work being performed.

Your turn

Solve exercises 4 and 5

and when done, jump to the
advanced exercises

More about locking

Exclusive locking using Monitor

The `Monitor` prevents collisions if used correctly, i.e. by all users of the shared resource

```
Monitor.Enter(o);
try{
   //critical section
   ...
}
finally{
   Monitor.Exit(o);
}
```

`Monitor.Enter()` only blocks other threads – the calling thread may re-enter the monitor

Monitors can only lock reference types – value types are *boxed* (this constitutes a synchronization error!)

Monitors can only lock within same application domain

Exclusive locking using Mutex

A `Mutex` can lock across application domains/processes

`Mutex` locks on itself (not an arbitrary `object`)

`Mutex.WaitOne()` acquires the mutex
    Blocks until mutex is available or optional timeout elapses

`Mutex.ReleaseMutex()` releases the mutex
    Only owning thread may release the mutex – otherwise an `ApplicationException` is thrown

Named mutexes can span processes

Exclusive locking using Mutex

```csharp
class SynchDemo
{
  private static int _c1 = 0;
  private static Mutex _mutex = new Mutex();

  public static void Main(string[] args)
  {
    var tasks = new Task[] { Task.Run((Action) IncC1), Task.Run((Action) IncC1) };
    Task.WaitAll(tasks);
  }

  private static void IncC1()
  {
    if (!_mutex.WaitOne(TimeSpan.FromSeconds(3)))
    {
        Console.WriteLine("Another task is holding C1 - bye!");
        return;
    }
    Console.WriteLine("Press a key to increment C1");
    Console.ReadKey(true);
    ++_c1;
    _mutex.ReleaseMutex();
  }
}
```

References and image sources

Images:

Printer: https://i5.walmartimages.com/asr/5bf8c70c-c0f4-46c8-8de2-d14417c3dcdb_2.a974142a063bb1f235f672f9a68eeb10.jpeg

Bank: https://images6.moneysavingexpert.com/images/reclaim-packaged-accounts-04.png

Lala: https://vignette.wikia.nocookie.net/telletubbies/images/b/b9/Laa_Laa.jpg/revision/latest?cb=20130707175328

Dipsy: https://vignette.wikia.nocookie.net/telletubbies/images/3/35/Url.jpg/revision/latest/scale-to-width-down/200?cb=20120211023613

Tinky Winky: https://vignette.wikia.nocookie.net/telletubbies/images/e/e5/Tinky_Winky.jpg/revision/latest/scale-to-width-down/180?cb=20111116163749

Po: https://vignette.wikia.nocookie.net/telletubbies/images/5/5d/Pic-meet-char-po.jpg/revision/latest?cb=20160303152950

Skulls skeleton: http://funjester.com/assets/images/decals/skulls%20skeleton/skulls%20skeletons004.jpg

Computer keyboard: http://stockmedia.cc/computing_technology/slides/DSD_8790.jpg

Bonus: http://wjreviews.com/reviews-cta/bonus.png

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