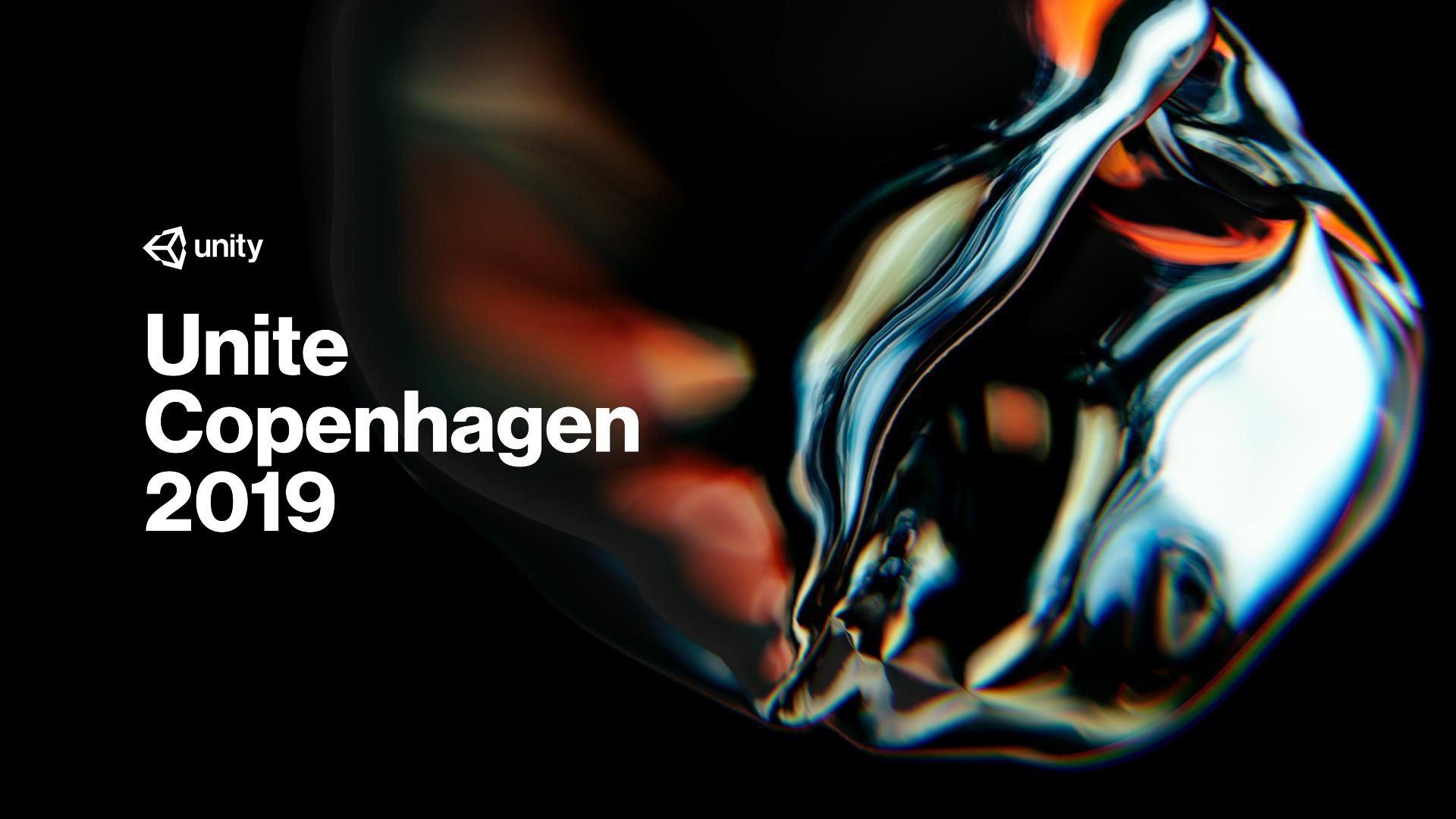
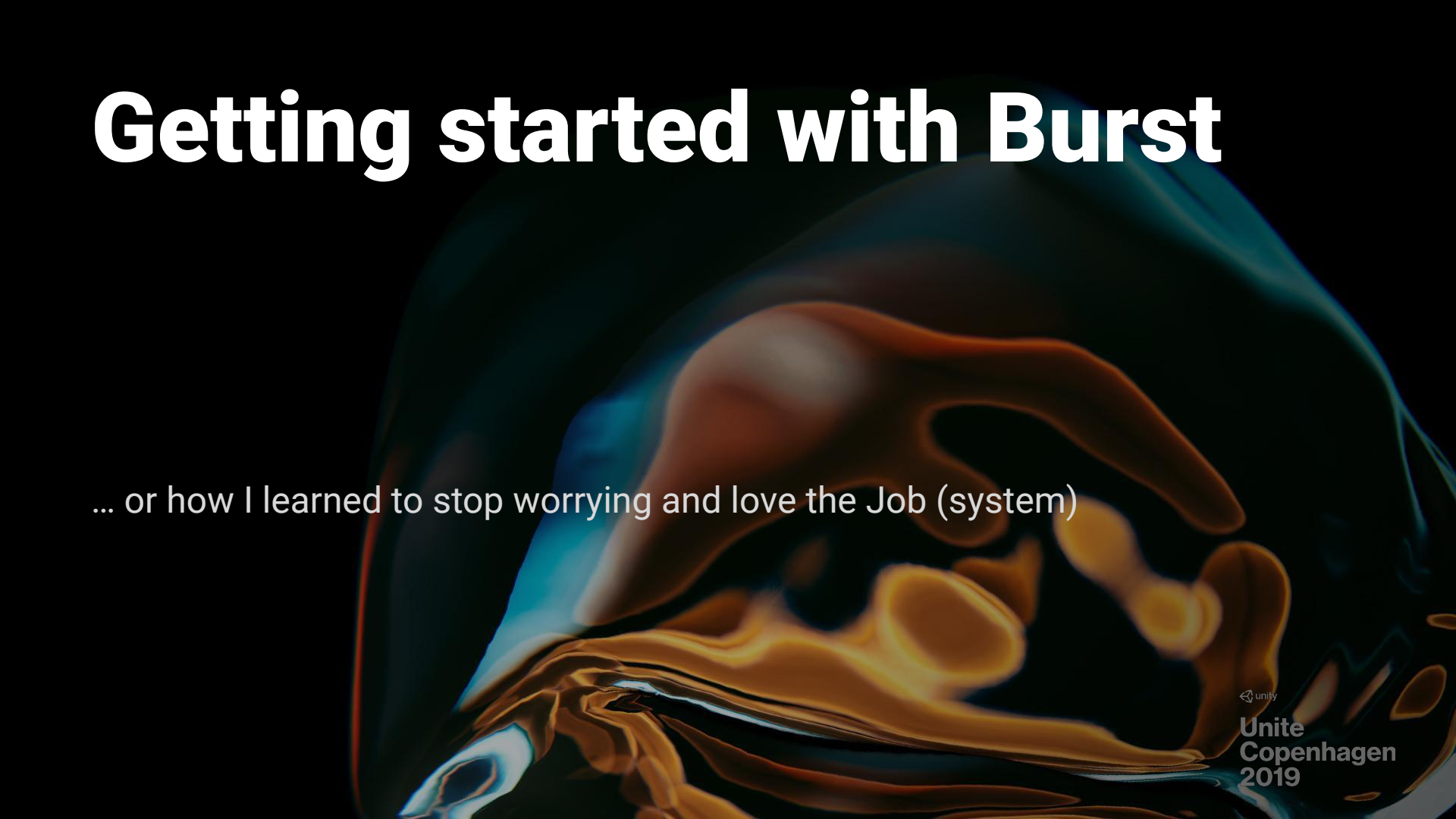

unity
Unite
Copenhagen
2019

Getting started with Burst



… or how I learned to stop worrying and love the Job (system)

unity
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Burst Team


the ultimate compilation
BASIC
FAIRLY OLD KIDS ON THE BLOCK
(except Marco)
PARENTAL
ADVISORY
EXPLICIT LAYOUT

Agenda

- What is Burst
- Adding Burst to an existing project
- Common pitfalls
  - What you can’t do with Burst
  - What you can do with Burst
- Where to get help
- Future

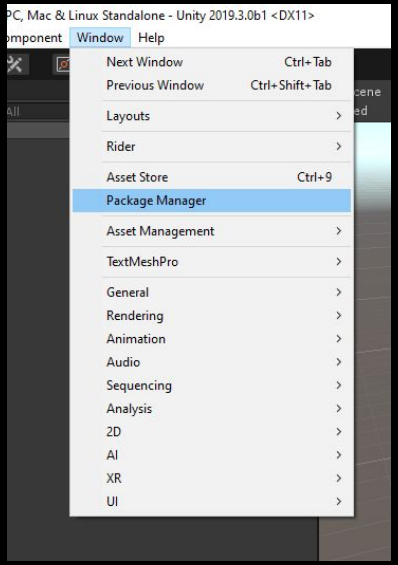
What is Burst

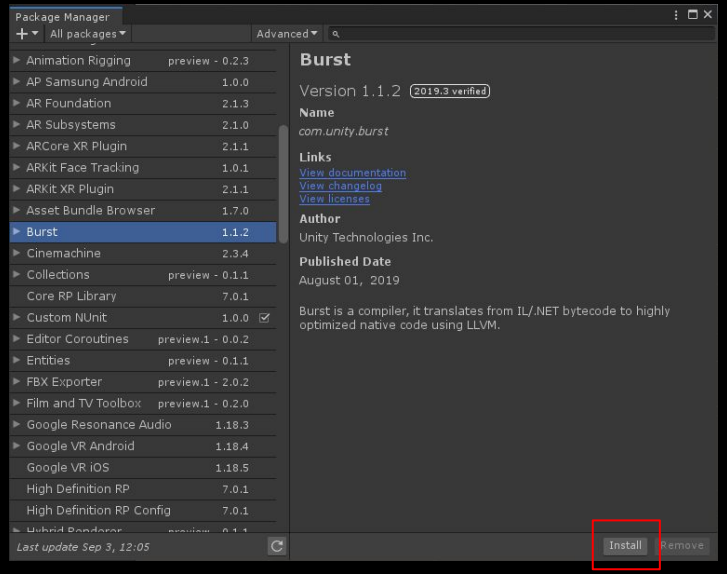
- Burst is a compiler for (some of) your code
- … that makes it run really fast
- It translates .NET bytecode into highly optimised native code
- It works with Unity’s job system
- It is part of the Data Oriented Technology Stack (DOTS)

Demo - Adding Burst to an existing project

Burst package

- Open Package Manager
- Install Burst package





Move code to the job system

- No Job System - No Burst
- We are running the Burst compiled code on the main thread
- The job system allows you to do more
  - Run across multiple threads
  - Schedule work and await completion
  - Setup dependencies between jobs

Move code to the job system

- Create a Job

```
struct MyJob : IJob
{
    // ... Copy data required here
    public void Execute()
    {
        // ... Copy code here
    }
}
```

- Initialise and run the job (inline on the main thread)

```
var t = new MyJob { /* initialise data references here */ };
t.Run();
```

Using Burst to compile code

- Add [BurstCompile] attribute to the job struct

```
[BurstCompile]
struct MyJob : IJob
{
    public Map.MapDataStore map;
    public NativeArray<float> stepField;
    public NativeArray<Vector2> flowField;
    public NativeList<Vector2Int> openSet;
    public NativeList<Vector2Int> nextSet;
    public PathType pathType;

    static readonly Vector2Int[] moveDirs = new Vector2Int[] {new Vector2Int(0,1),
                                        new Vector2Int(1,1),
                                        new Vector2Int(1,0),
                                        new Vector2Int(1,-1),
                                        new Vector2Int(0,-1),
                                        new Vector2Int(-1,-1),
                                        new Vector2Int(-1,0),
                                       new Vector2Int(-1,1)};
    public void Execute()
    {
```

How it works (from 10,000 feet)

When compilation happens

Editor (Just In Time - JIT)

- When a job is scheduled, Burst schedules background compilation for that job
- Original Mono version is used in Play mode until Burst-compiled version is ready
- Use `[BurstCompile(Synchronous=true)]` to force synchronous compilation (if you want to ensure Mono version is never used, such as for profiling)

Player (Ahead Of Time - AOT)

- When building player, Burst compiles your code immediately after normal C# compilation
- Your game ships with precompiled code
- This works the same whether using a Mono or an IL2CPP based player.

AOT additional notes

- Burst currently requires native toolchains (even on desktops)
  - https://docs.unity3d.com/Packages/com.unity.burst@1.1/manual/index.html#burst-aot-requirements
- Most platforms build a shared library
  - Windows, Mac, Linux, Android for example
- Some platforms are statically linked
  - iOS for example

[BurstCompile] attribute

- [BurstCompile]
  - FloatMode (Default, Strict, Deterministic, Fast)
    - Defaults to Strict
  - FloatPrecision (Standard, High, Medium, Low)
    - Defaults to Medium
    - Use unity.mathematics
  - CompileSynchronously
    - Only affects Editor, not standalone Player builds
    - Blocks game until compilation has finished

Common pitfalls

… or confession time!

What you can’t do with Burst

- **Can’t** use reference types (`class`, `string`)
- **Can’t** access classic GameObject/Component code
- **Can’t** write to static variables
- **Can’t** try/catch

What you can’t do with Burst

- https://github.com/Unity-Technologies/GettingStartedWithBurst-Unite2019
- Extra commits
  - Profile Markers
  - C# Arrays -> NativeArrays
  - Map data class -> struct
  - Lists -> NativeLists
  - Lookup table (moveDirs) tweaked

Dealing with arrays

- 2 Dimensional Arrays are converted to 1 Dimensional

```
int[,] occupants;

occupants = new int[width, height];

var value = occupants[x, y];
```

Becomes e.g.

```
int[] occupants;

occupants = new int [width * height];

var value = occupants[x + y * width];
```

Dealing with arrays

- Arrays are converted to NativeArrays

```
int[] occupants;

occupants = new int [width * height];
```

Becomes e.g.

```
NativeArray<int> occupants;

occupants = new NativeArray<int>(width * height, Allocator.Persistent);

// and a destroy method was added to properly dispose of the array

occupants.Dispose();
```

Dealing with Map class

- Map was used as a reference to avoid duplicating data

```
class Map
{
    public NativeArray<MapTile> tiles;
    public NativeArray<int> occupants;
    public int width; public int height;
}
```

Moved the data into a local struct

```
class Map
{
    struct MapDataStore
    {
        public NativeArray<MapTile> tiles;
        public NativeArray<int> occupants;
        public int width; public int height;
    }
    public MapDataStore mapDataStore;
}
```

Dealing with List

- Lists are converted to NativeLists

```
List<Vector2Int> openSet = new List<Vector2Int>();

while (openSet.Count > 0)
```

Becomes e.g.

```
NativeList<Vector2Int> openSet = new NativeList<Vector2Int>(Allocator.Persistent);

while (openSet.Length > 0)

// and because we are using a native container, disposes were added

openSet.Dispose();
```

Dealing with Static Data

- MoveDirs was declared as

```
Vector2Int[] moveDirs = new Vector2Int[] {new Vector2Int(0,1),
                                          new Vector2Int(1,1),
                                          //....
```

Became :

```
static readonly Vector2Int[] moveDirs = new Vector2Int[] {new Vector2Int(0,1),
                                        new Vector2Int(1,1),
                                        ///....
```

- Note this is the only supported use of C# arrays!
- readonly applies to moveDirs, not its contents.
- Possible to modify outside of burst!

Dealing with containers

- If you want a temporary Native container

```
occupants = new NativeArray<int>(width * height, Allocator.TempJob);

// do some work

occupants.Dispose();
```

- Note, Native containers do not have ref indexers

```
NativeArray<Vector2Int> openSet = new NativeArray<Vector2Int>(Allocator.Persistent);

openSet[0] = new Vector2Int(0,0);
```

❌

```
openSet[0].y = 4;           // compilation error, cannot modify struct member access
```

✔️

```
var t = openSet[0];
t.y = 4;
openSet[0] = t;             // fine, if a little verbose
```

What you can do with Burst

- **Can** use `struct` and other value types
- **Can** be used with ECS
- **Can** use generic types
- **Can** improve performance

Floating-point performance

- Use `FloatMode.Fast` to speed up floating-point calculations

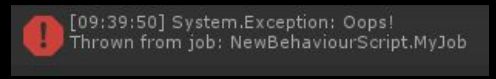
```
[BurstCompile(FloatMode = FloatMode.Fast)]
struct MyJob : IJob
{
```

- Sacrifices accuracy
- Burst Inspector defaults to showing the results as if FloatMode.Fast was used!

Throwing exceptions

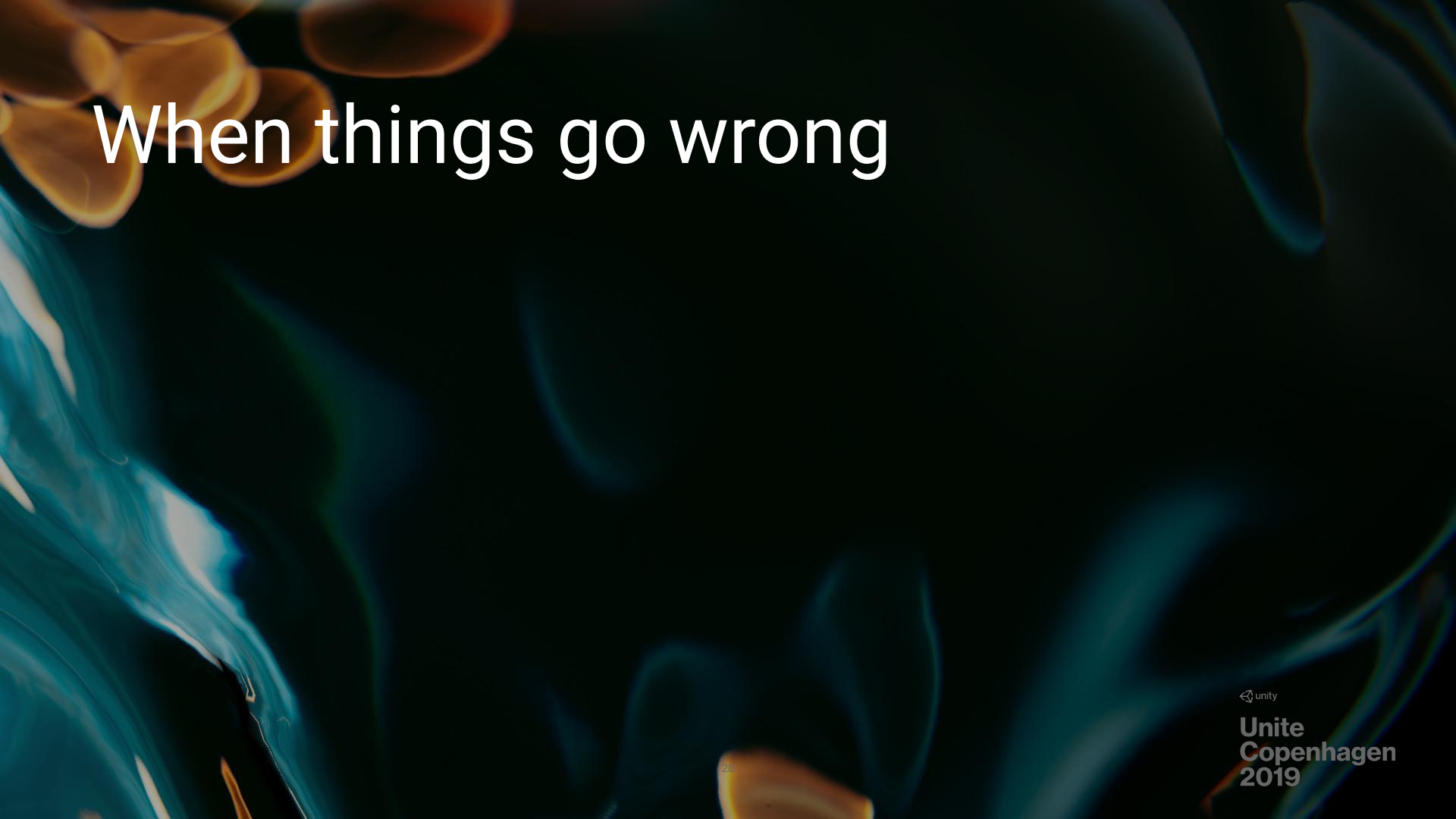
- You can throw exceptions
- … **but** only do this in the Editor… because throwing exceptions crashes standalone players
- Exception messages are output as errors to console
- … and then your code will continue running
- Can't use `try/catch`

```
throw new Exception("Oops!");
```



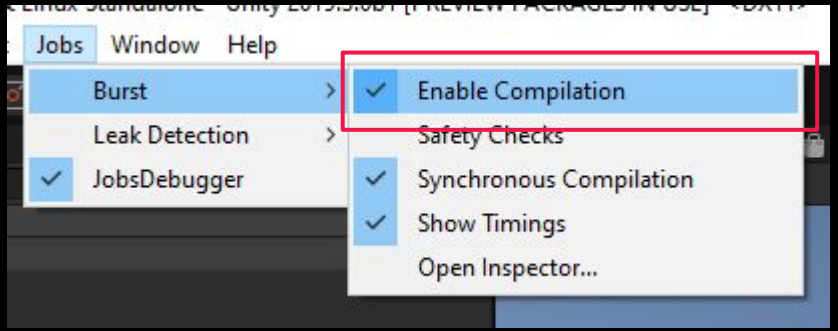
Demo - Copying To Avoid Converting Types

When things go wrong



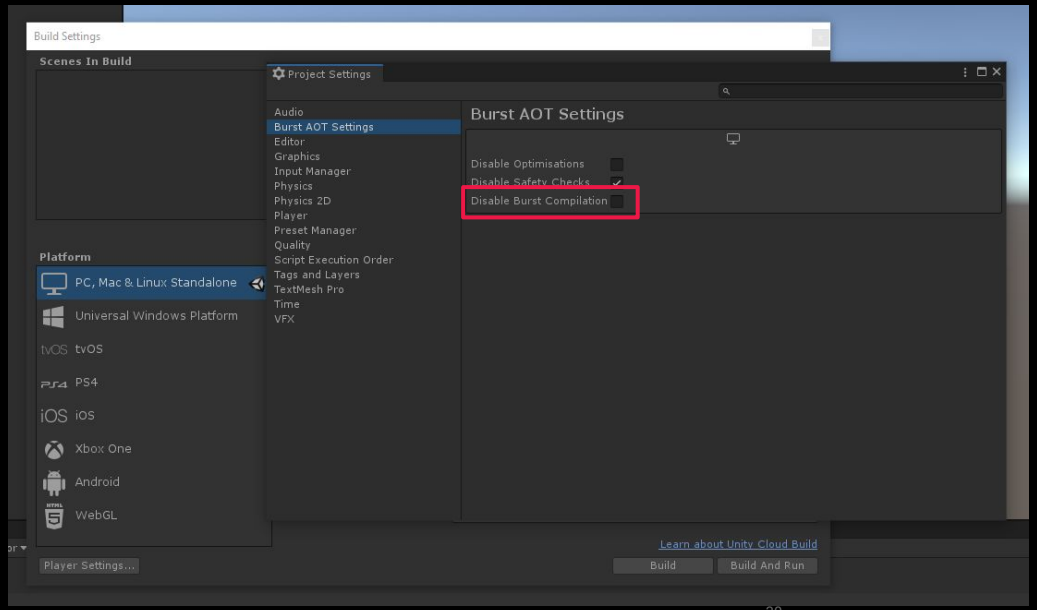
Enable Burst compilation in Editor

- Ensure you have ticked Enable Compilation in the Burst menu



Enable Burst compilation in Player

- Ensure you have **not** ticked Disable Burst Compilation in player build settings



Burst Inspector

- Lists all the jobs in your project
- Jobs that are not burst-compiled are greyed-out
- You can view the resulting assembler etc
- [Enhanced Disassembly] = intermixed asm & c#

Dealing with runtime crashes

- Look in the player.log and locate the stack trace :

```
========== OUTPUTTING STACK TRACE ==================

0x00007FFB930A131E (lib_burst_generated) fb9e181e1474d8fe95fc697646aad17d
0x00007FFB05F03DDB (UnityPlayer) UnityMain
0x00007FFB05F0445C (UnityPlayer) UnityMain
.....
```

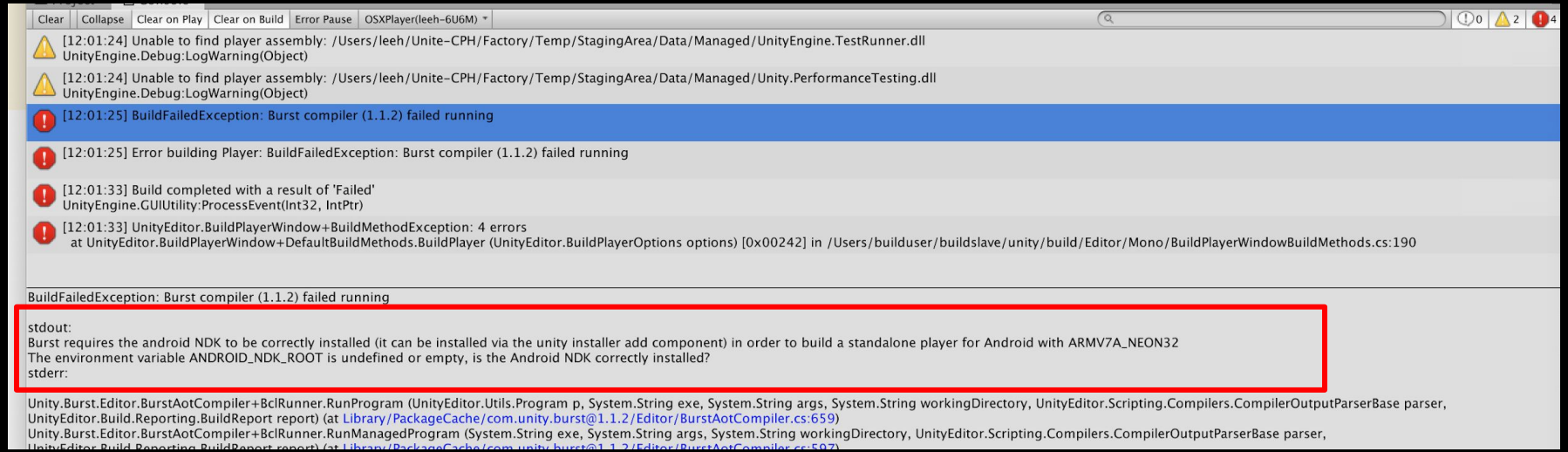
Dealing with runtime crashes

- Look in the lib_burst_generated.txt for the previously highlighted hash
- Scan along the line (backwards from the hash), looking for ::Execute
- The name of the job struct and the parent class can be seen

PublicKeyToken=**null::Execute(FlowField+MyJob**&, Assembly-CSharp, Version=0.0.0.0, Culture=neutral, PublicKeyToken=null|System.IntPtr, mscorlib, Version=4.0.0.0, Culture=neutral, PublicKeyToken=b77a5c561934e089|System.IntPtr, mscorlib, Version=4.0.0.0, Culture=neutral, PublicKeyToken=b77a5c561934e089|Unity.Jobs.LowLevel.Unsafe.JobRanges&, UnityEngine.CoreModule, Version=0.0.0.0, Culture=neutral, PublicKeyToken=null|System.Int32, mscorlib, Version=4.0.0.0, Culture=neutral, PublicKeyToken=b77a5c561934e089)--**fb9e181e1474d8fe95fc697646aad17d**

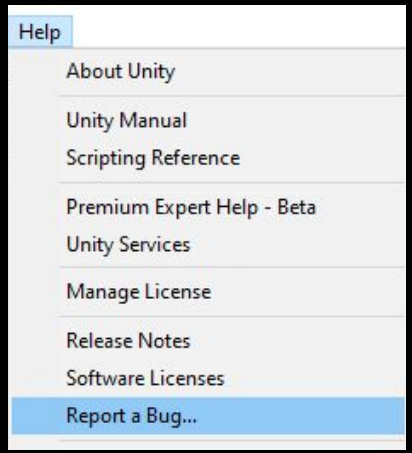
Finding more detail on errors

- Burst Failures when building standalone player
- Sometimes you have to click for more information



Where to get help

- Read the user guide:
  https://docs.unity3d.com/Packages/com.unity.burst@1.1/manual/index.html
- Ask a question in the DOTS forum:
  https://forum.unity.com/forums/data-oriented-technology-stack.147/
- Please report bugs! [via menu in Unity]



Future plans

Coming in 2019.3 / Burst 1.2.0

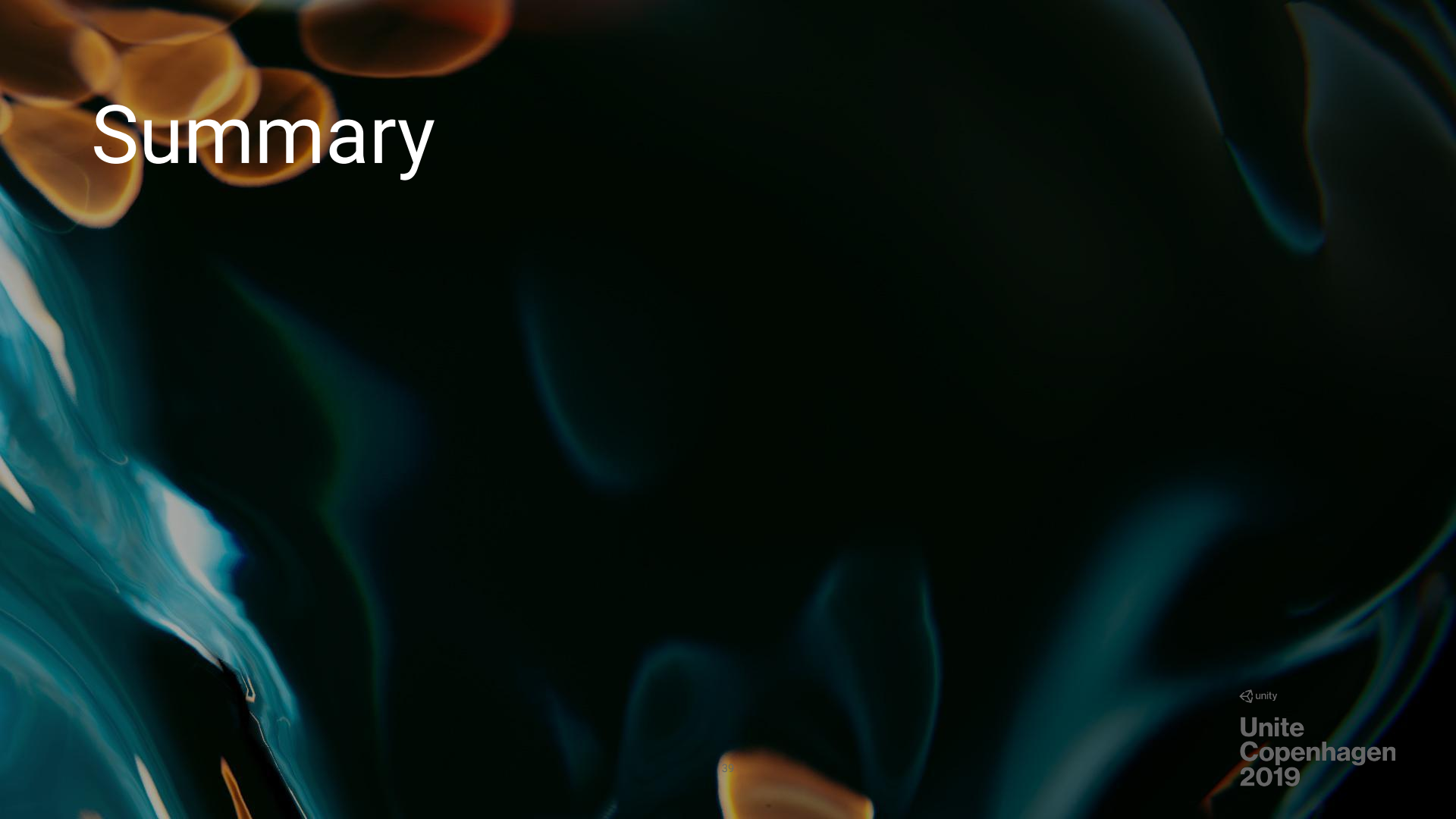
- LLVM version 8
- Various bugs squashed
- Entity Command Buffer (ECB)
- Improved compilation times

You can test out these features in 1.2.0-preview.5 Today

Roadmap

- Determinism
- Debugging
  - E.g. Logging messages from a burst compiled job
- Improved performance of generated code
- Compilation time
- Cross-compilation
- Additional Platforms

Summary



Summary

- Burst is Almost Free Performance
- Job System gets you 99% of the way
- Copy/Burst/Copy can be enough

Thankyou!

https://github.com/Unity-Technologies/GettingStartedWithBurst-Unite2019