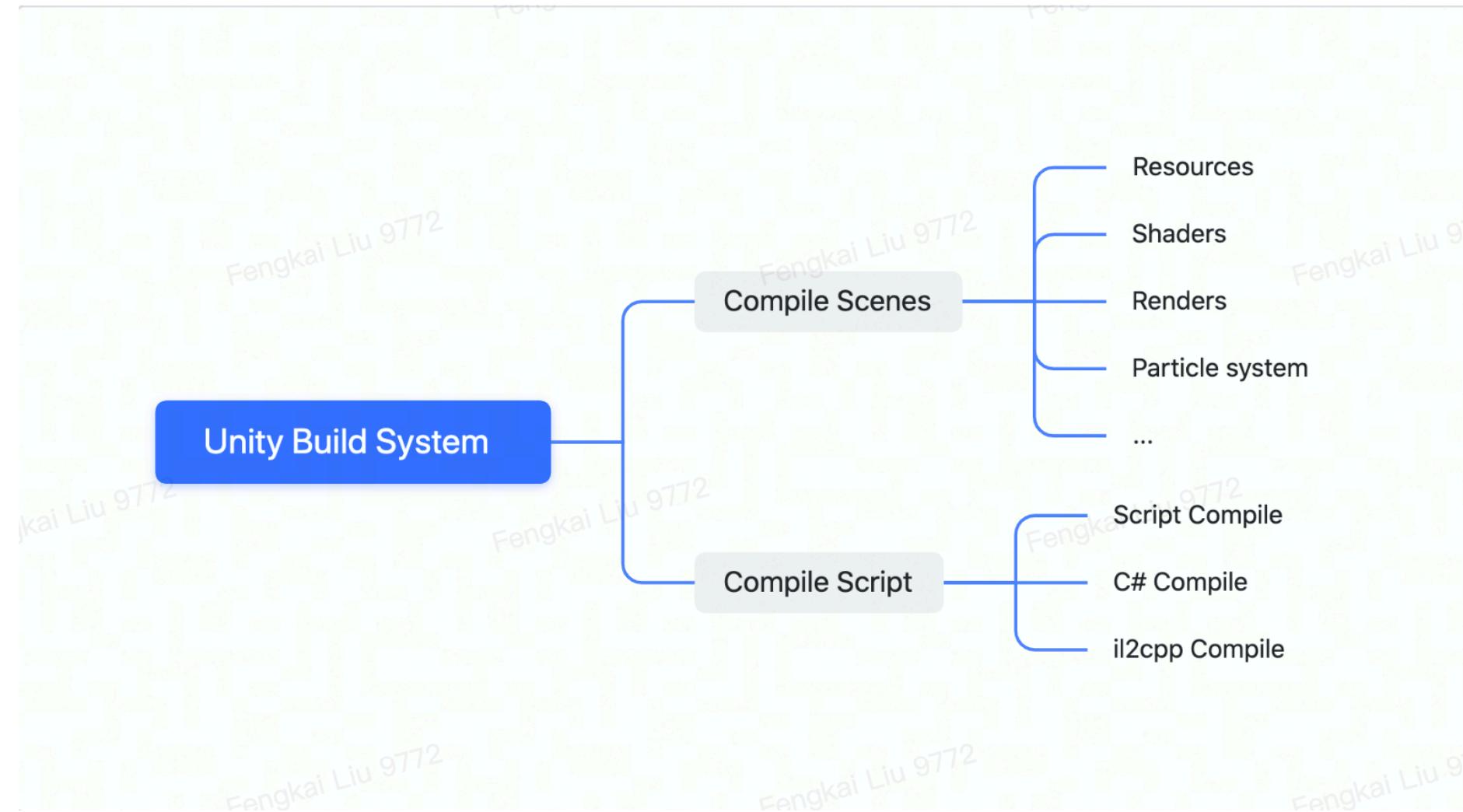


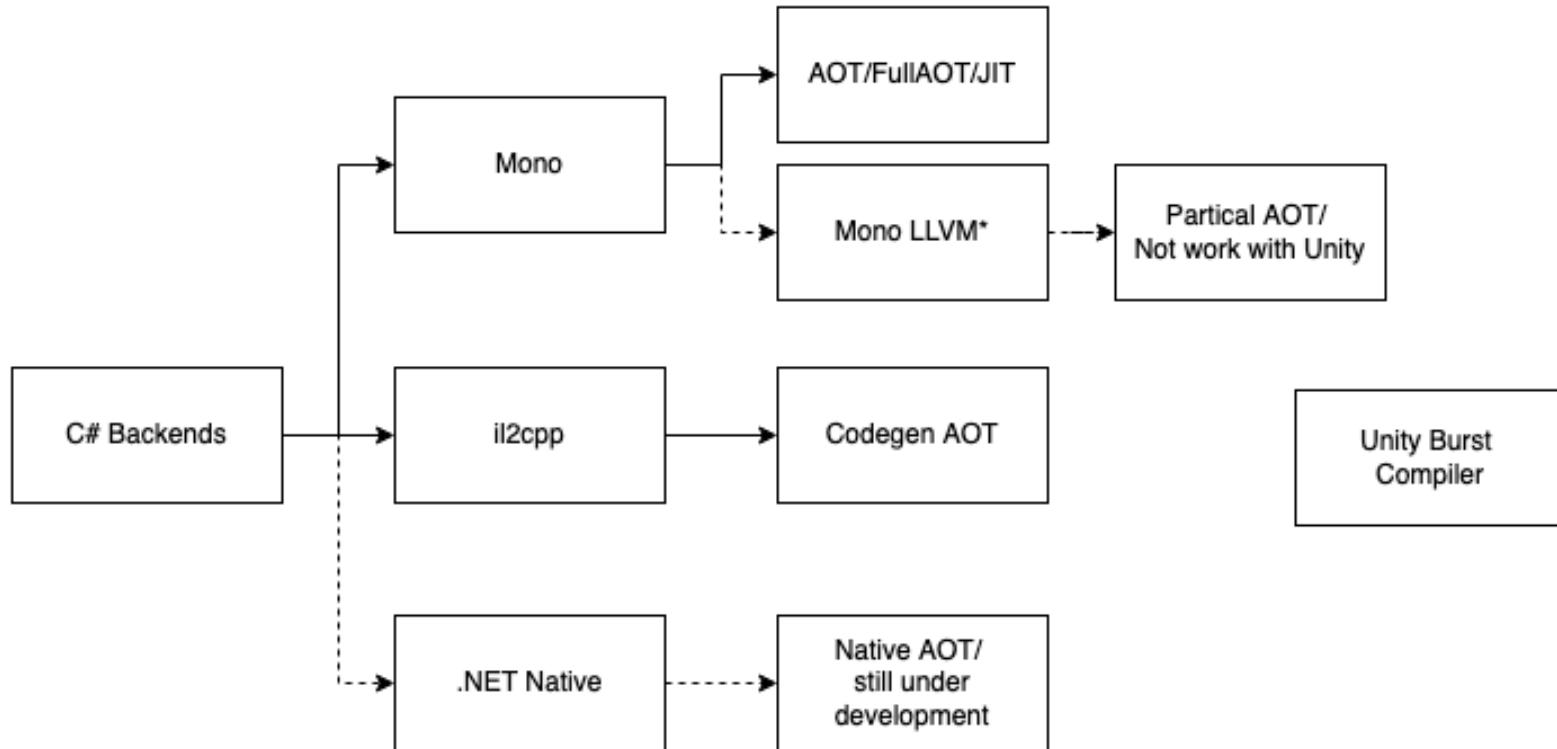
Unity il2cpp Compilation

Fengkai Liu

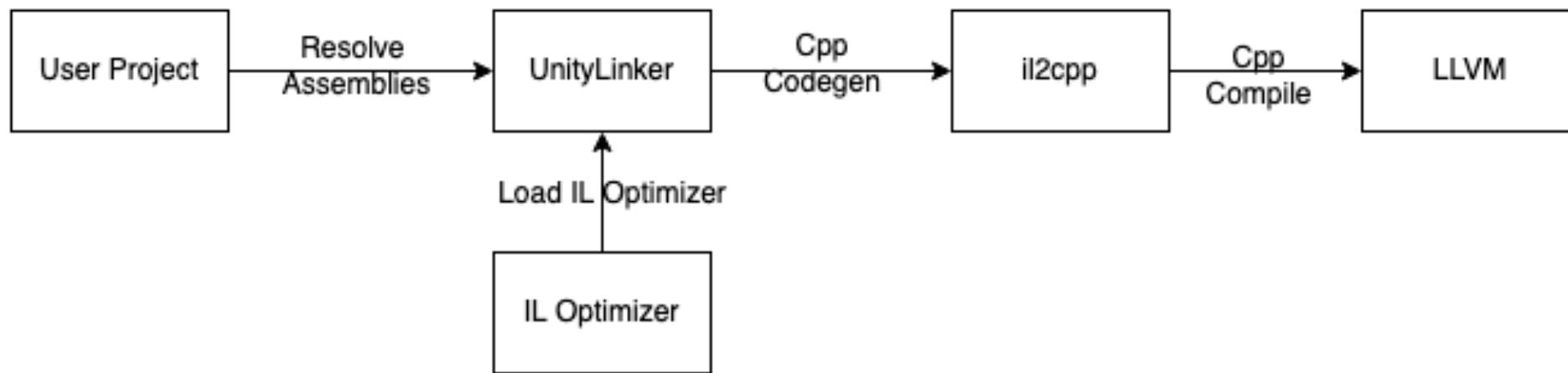
Unity Build System



C# Backends



il2cpp Compilation



Frontend: C# Build & Linker

C# Compiler :

- Roslyn Compiler (csc)
- Mono Compiler (mcs)

Linker:

- Mono Linker
- Unity Linker



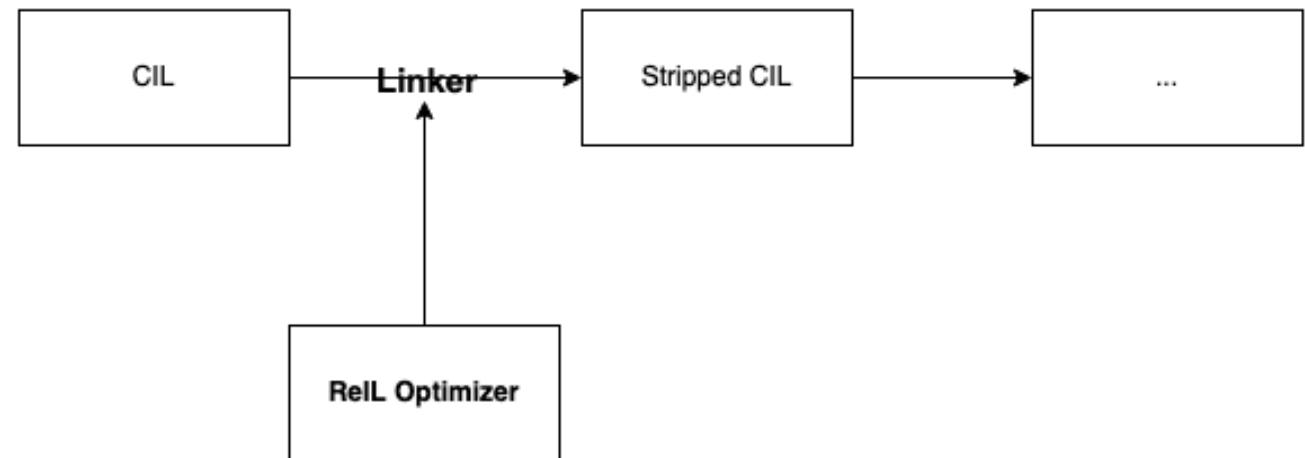
Linker : Link & Strip

- Type Mapping (Generic Class Hierarchy)
- Mark Step (Find Usage)
- Sweep / Clean Step (Strip Code)

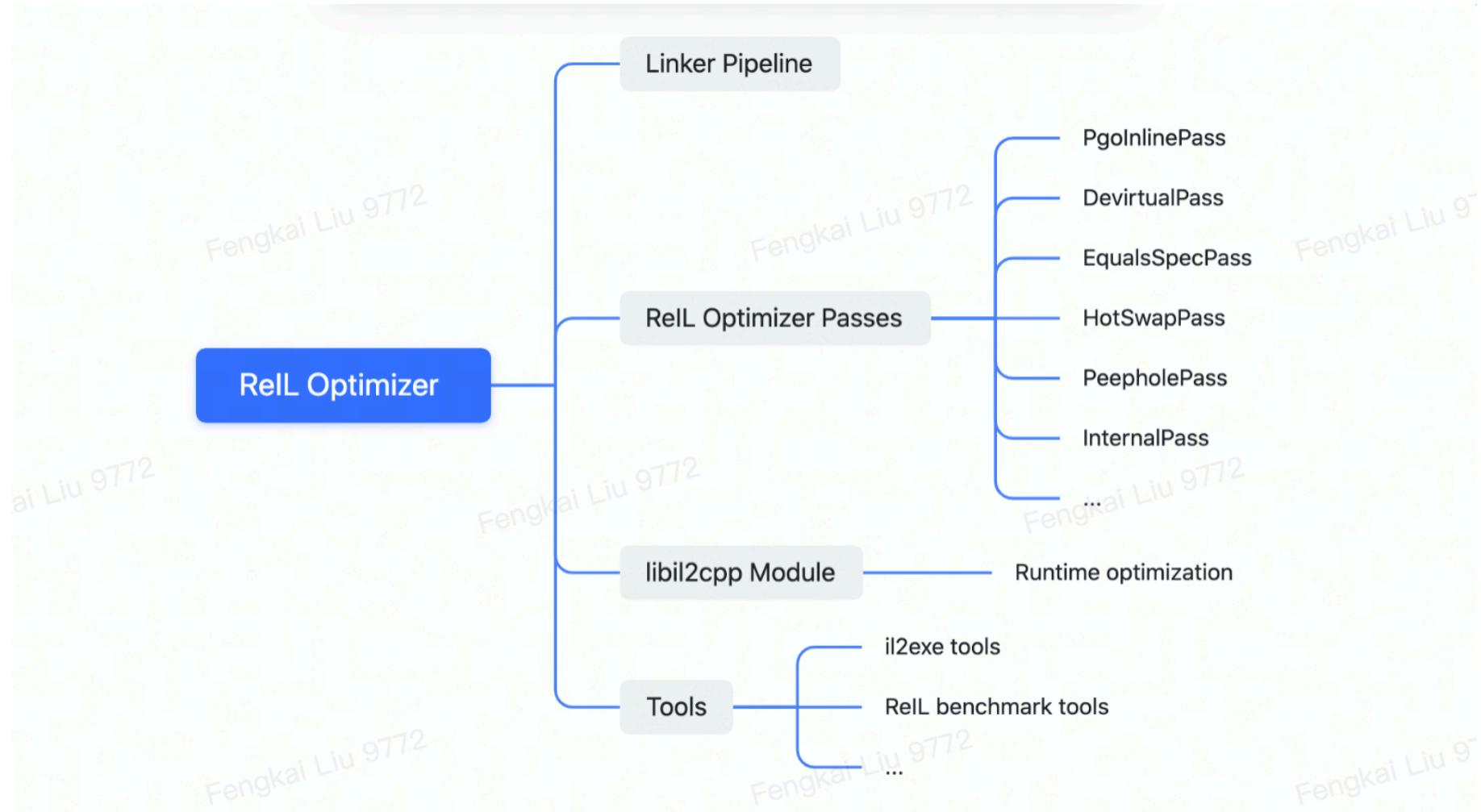
```
● ● ● Title  
1  static Pipeline GetStandardPipeline ()  
2  {  
3      Pipeline p = new Pipeline ();  
4      p.AppendStep (new LoadReferencesStep ());  
5      p.AppendStep (new BlacklistStep ());  
6      p.AppendStep (new PreserveDependencyLookupStep ());  
7      p.AppendStep (new TypeMapStep ());  
8      p.AppendStep (new MarkStep ());  
9      p.AppendStep (new SweepStep ());  
10     p.AppendStep (new CodeRewriterStep ());  
11     p.AppendStep (new CleanStep ());  
12     p.AppendStep (new RegenerateGuidStep ());  
13     p.AppendStep (new OutputStep ());  
14     return p;  
15 } // Code here
```

ReIL : Linker Optimizer

- Peephole Pass
- Devirtual Pass
- PgoInline Pass
- HotSwap Pass
- ...

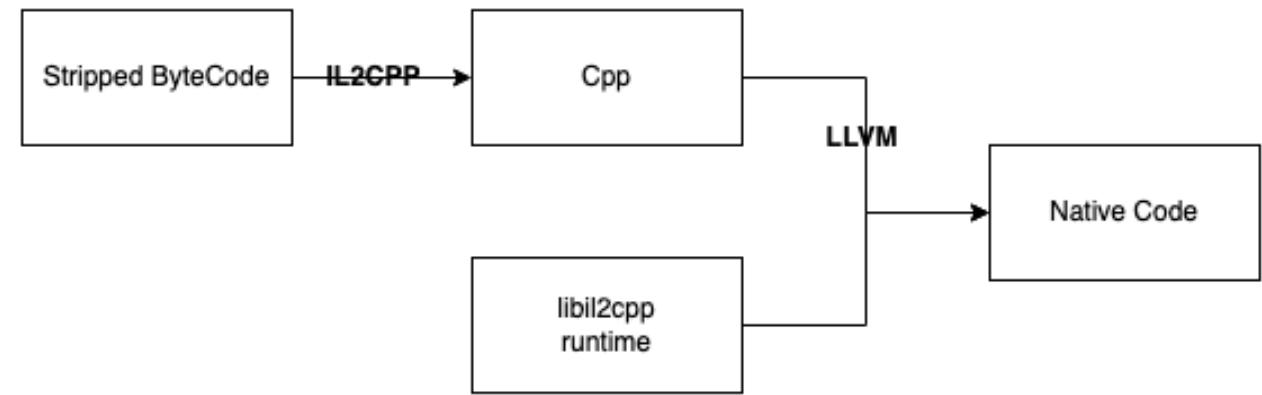


ReIL : Linker Optimizer



Backend : il2cpp codegen & LLVM compile

- Complex Args : il2cpp tools aren't developed for common developers.
- Transpiler: Convert IL => Cpp Code.
- libil2cpp Runtime
- Linker Cache: Incremental Compile



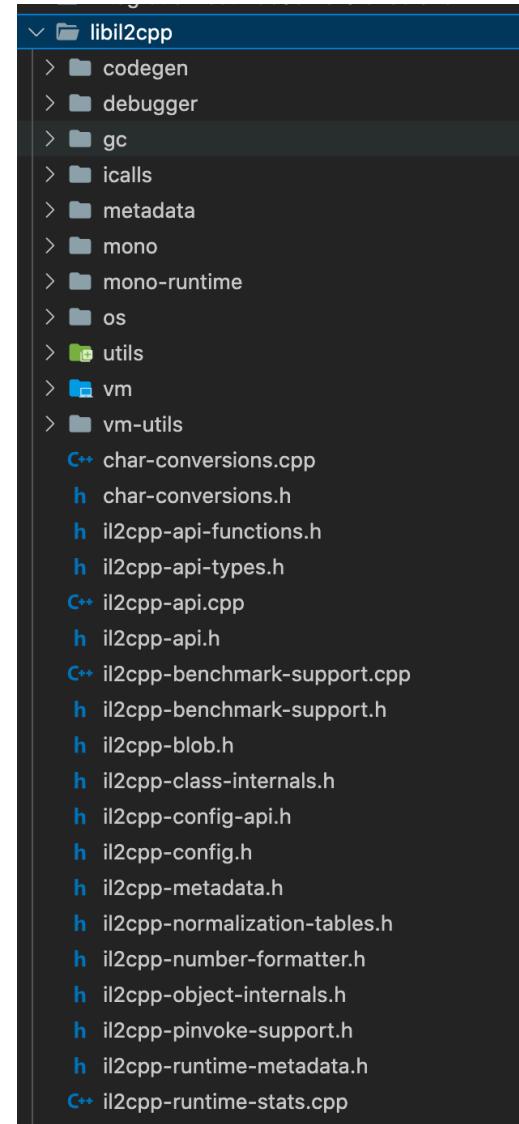
Backend : il2cpp Transpiler

ByteCode to Source Transpiler

- Metadata Writer
- ByteCode Converter
- Generic Type Collect & Converter
- Naming Component (Type, Method, Field, Class)
- VTable & MethodPointer Gen.

Backend: libil2cpp runtime

- GC
- icalls
- VM Runtime
- il2cpp internal callsite



Example: Devirtual Optimize

```
1 // ...
2 int[] index = { 1, 2, 3, 4, 5, 6, 7, 8, 9 };
3 int total = 0;
4 for (var i = 0; i < 10000; i++)
5 {
6     Base obj = new Derived(index[(i + 1) % index.Length]);
7     total += obj.GetValue();
8 }
9 // ...
```

Example: Devirtual Optimize

Assembly language ▾

```
1      IL_0021: ldc.i4.s 9
2      IL_0023: newarr System.Int32
3      IL_0028: dup
4      IL_0029: ldtoken <PrivateImplementationDetails>/__StaticArrayInitTypeS
5  ize=36 <PrivateImplementationDetails>::E3D25E7590EDD76206831801F67D1EE231D8B90
6 A2BB4BFE31A152BE21D2F536C
7      IL_002e: call void System.Runtime.CompilerServices.RuntimeHelpers::Ini
8 tializeArray(System.Array, System.RuntimeFieldHandle)
9      IL_0033: stloc.0
10     IL_0034: ldc.i4.0
11     IL_0035: stloc.1
12     IL_0036: br.s IL_0050
13     IL_0038: ldloc.0
14     IL_0039: ldloc.1
15     IL_003a: ldc.i4.1
16     IL_003b: add
17     IL_003c: ldloc.0
18     IL_003d: ldlen
19     IL_003e: conv.i4
20     IL_003f: rem
21     IL_0040: ldelem.i4
22     IL_0041: newobj void ReIL.Benchmark.Benchmarks.DevirtualCalls/Derive
23 d::.ctor(int32)
24     IL_0046: callvirt int32 ReIL.Benchmark.Benchmarks.DevirtualCalls/Bas
25 e::GetValue()
        IL_004b: pop
        IL_004c: ldloc.1
        IL_004d: ldc.i4.1
        IL_004e: add
        IL_004f: stloc.1
```

| Cancel wrap | Copy

Assembly language ▾

```
1      IL_0021: ldc.i4.s 9
2      IL_0023: newarr System.Int32
3      IL_0028: dup
4      IL_0029: ldtoken <PrivateImplementationDetails>/__StaticArrayInitTypeS
5  ize=36 <PrivateImplementationDetails>::E3D25E7590EDD76206831801F67D1EE231D8B90
6 A2BB4BFE31A152BE21D2F536C
7      IL_002e: call void System.Runtime.CompilerServices.RuntimeHelpers::Ini
8 tializeArray(System.Array, System.RuntimeFieldHandle)
9      IL_0033: stloc.0
10     IL_0034: ldc.i4.0
11     IL_0035: stloc.1
12     IL_0036: br.s IL_0050
13     IL_0038: ldloc.0
14     IL_0039: ldloc.1
15     IL_003a: ldc.i4.1
16     IL_003b: add
17     IL_003c: ldloc.0
18     IL_003d: ldlen
19     IL_003e: conv.i4
20     IL_003f: rem
21     IL_0040: ldelem.i4
22     IL_0041: newobj void ReIL.Benchmark.Benchmarks.DevirtualCalls/Derive
23 d::.ctor(int32)
24     IL_0046: call int32 ReIL.Benchmark.Benchmarks.DevirtualCalls/Derived::
25  GetValue()
        IL_004b: pop
        IL_004c: ldloc.1
        IL_004d: ldc.i4.1
        IL_004e: add
        IL_004f: stloc.1
```

| Cancel wrap | Copy

Example: Devirtual Optimize

```
C++ ▾ 1 Int32U5BU5D_t70F1BDC14B1786481B176D6139A5E3B87DC54C32* L_9 = V_0;
2 int32_t L_10 = V_1;
3 Int32U5BU5D_t70F1BDC14B1786481B176D6139A5E3B87DC54C32* L_11 = V_0;
4 NullCheck(L_11);
5 NullCheck(L_9);
6 int32_t L_12 = ((int32_t)((int32_t)((int32_t)il2cpp_codegen_add((int32_t)L_10, (int32_t)1))%(int32_t)((int32_t)((RuntimeArray*)L_11)->max_length))))));
7 int32_t L_13 = (L_9)->GetAt(static_cast<il2cpp_array_size_t>(L_12));
8 Derived_t2C236A4DCAB0DE3DA01428DD77A7E014A6BF2582 * L_14 = (Derived_t2
C236A4DCAB0DE3DA01428DD77A7E014A6BF2582 *)il2cpp_codegen_object_new(Derived_t2
C236A4DCAB0DE3DA01428DD77A7E014A6BF2582_il2cpp_TypeInfo_var);
9 Derived__ctor_m031C770C44E9EA120C345C78B3325D4B73E78C67(L_14, L_13, /*hidden argument*/NULL);
10 NullCheck(L_14);
11 int32_t L_15;
12 L_15 = VirtFuncInvoker0< int32_t >::Invoke(4 /* System.Int32 ReIL.Benchmark.Benchmarks.DevirtualCalls/Base::GetValue() */, L_14);
13 int32_t L_16 = V_1;
14 V_1 = ((int32_t)il2cpp_codegen_add((int32_t)L_16, (int32_t)1));
```

```
C++ ▾ 1 Int32U5BU5D_t70F1BDC14B1786481B176D6139A5E3B87DC54C32* L_9 = V_0;
2 int32_t L_10 = V_1;
3 Int32U5BU5D_t70F1BDC14B1786481B176D6139A5E3B87DC54C32* L_11 = V_0;
4 NullCheck(L_11);
5 NullCheck(L_9);
6 int32_t L_12 = ((int32_t)((int32_t)((int32_t)il2cpp_codegen_add((int32_t)L_10, (int32_t)1))%(int32_t)((int32_t)((int32_t)((RuntimeArray*)L_11)->max_length))))));
7 int32_t L_13 = (L_9)->GetAt(static_cast<il2cpp_array_size_t>(L_12));
8 Derived_t2C236A4DCAB0DE3DA01428DD77A7E014A6BF2582 * L_14 = (Derived_t2
C236A4DCAB0DE3DA01428DD77A7E014A6BF2582 *)il2cpp_codegen_object_new(Derived_t2
C236A4DCAB0DE3DA01428DD77A7E014A6BF2582_il2cpp_TypeInfo_var);
9 Derived__ctor_m031C770C44E9EA120C345C78B3325D4B73E78C67(L_14, L_13, /*hidden argument*/NULL);
10 NullCheck(L_14);
11 int32_t L_15;
12 L_15 = Derived_GetValue_mF09F969F2771A86068552E7FEB68001E799EB284_inline(L_14, /*hidden argument*/NULL);
13 int32_t L_16 = V_1;
14 V_1 = ((int32_t)il2cpp_codegen_add((int32_t)L_16, (int32_t)1));
```

VirtualFunc/Action Invoker

```
template <typename T1, typename T2, typename T3>
struct VirtActionInvoker3
{
    typedef void (*Action)(void*, T1, T2, T3, const RuntimeMethod*);

    static inline void Invoke (Il2CppMethodSlot slot, RuntimeObject* obj, T1 p1, T2 p2, T3 p3)
    {
        const VirtualInvokeData& invokeData = il2cpp_codegen_get_virtual_invoke_data(slot, obj);
        ((Action)invokeData.methodPtr)(obj, p1, p2, p3, invokeData.method);
    }
};
```

Q & A