Processing Java UDFs in a C++ Environment

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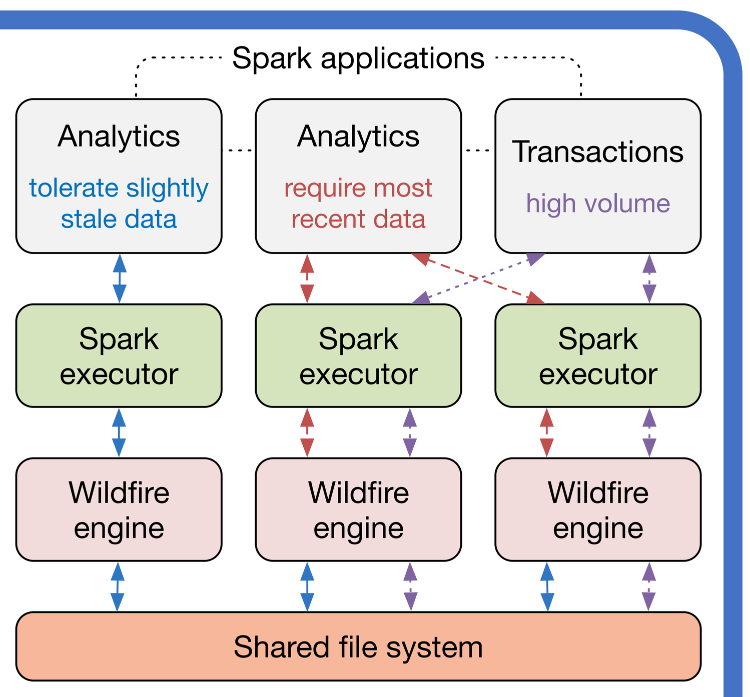
Wildfire

- Distributed HTAP system
- Columnar, pipelined query execution engine
- Written in C++
- Spark as user-facing front end
- Data analytics with SparkSQL



Execute Scala UDFs found in SparkSQL queries on the Wildfire C++ engine.

SparkSQL UDFs

- Represented as Java classes
- SparkSQL UDFs are closures
- Free variables captured in class instance

Usage

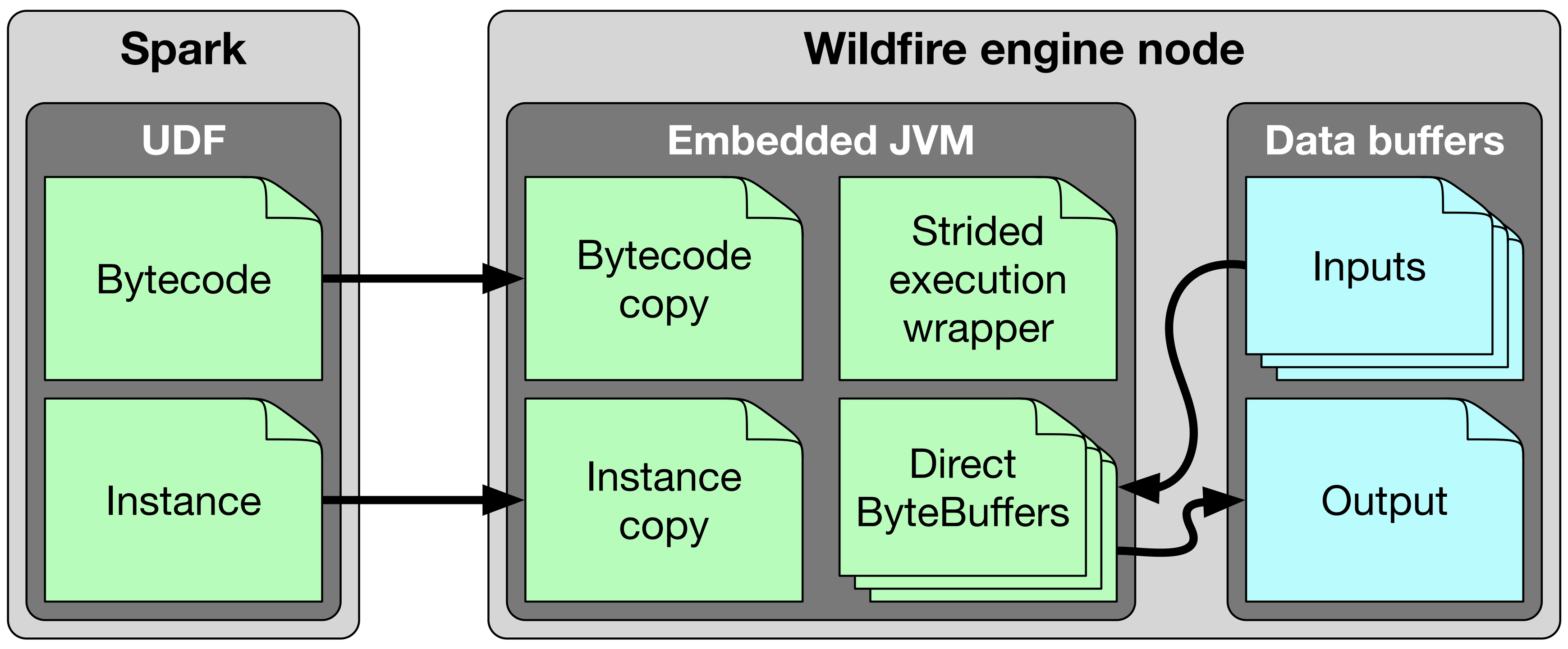
```
var offset = 10
sqlContext.udf.register("add_offset", (i: Int) => i + offset)
sqlContext.sql("SELECT add_offset(i) FROM table").show()
```

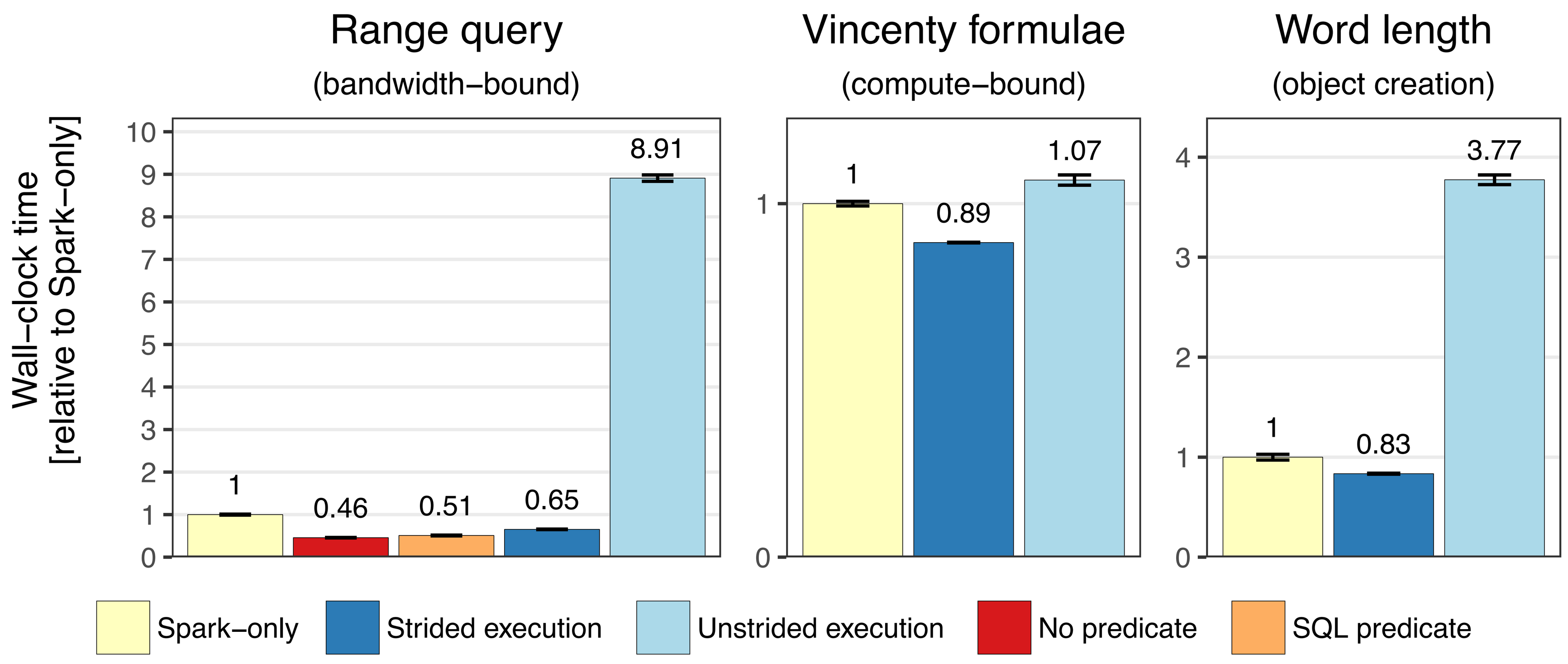
Class representation (simplified)

```
public final class SparkProgramm$$anonfun$run$1
    extends scala.runtime.AbstractFunction1$mcII$sp
    implements scala.Serializable {
  public SparkProgram$$anonfun$run$1(scala.runtime.IntRef);
  public final int apply(int);
  ...
}
```

Execution in Embedded JVM

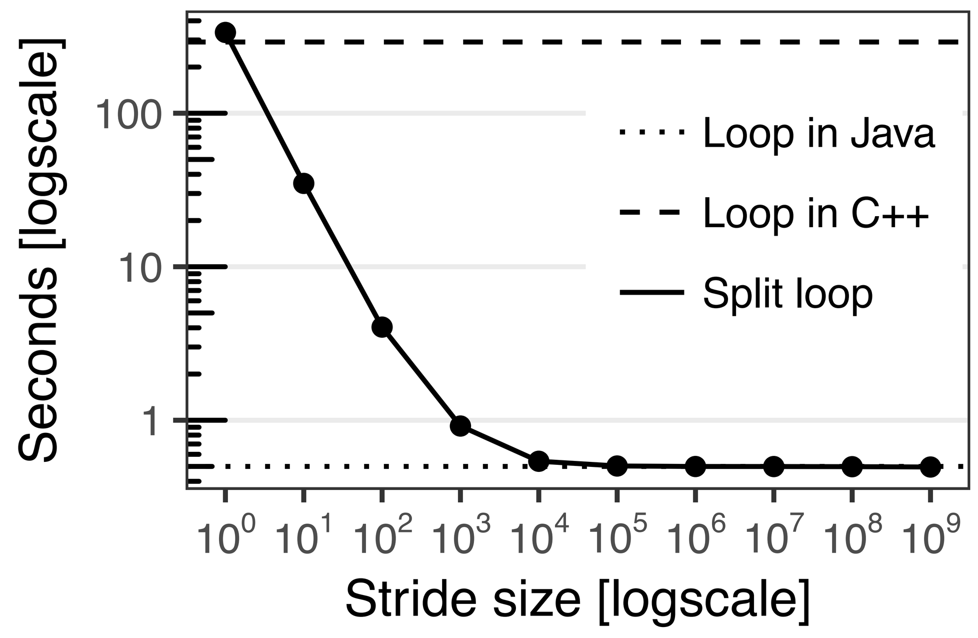
- Strided execution wrapper compiled transparently
- Engine buffers wrapped as Java direct ByteBuffers
- Comparable performance to execution in Spark and as SQL statement





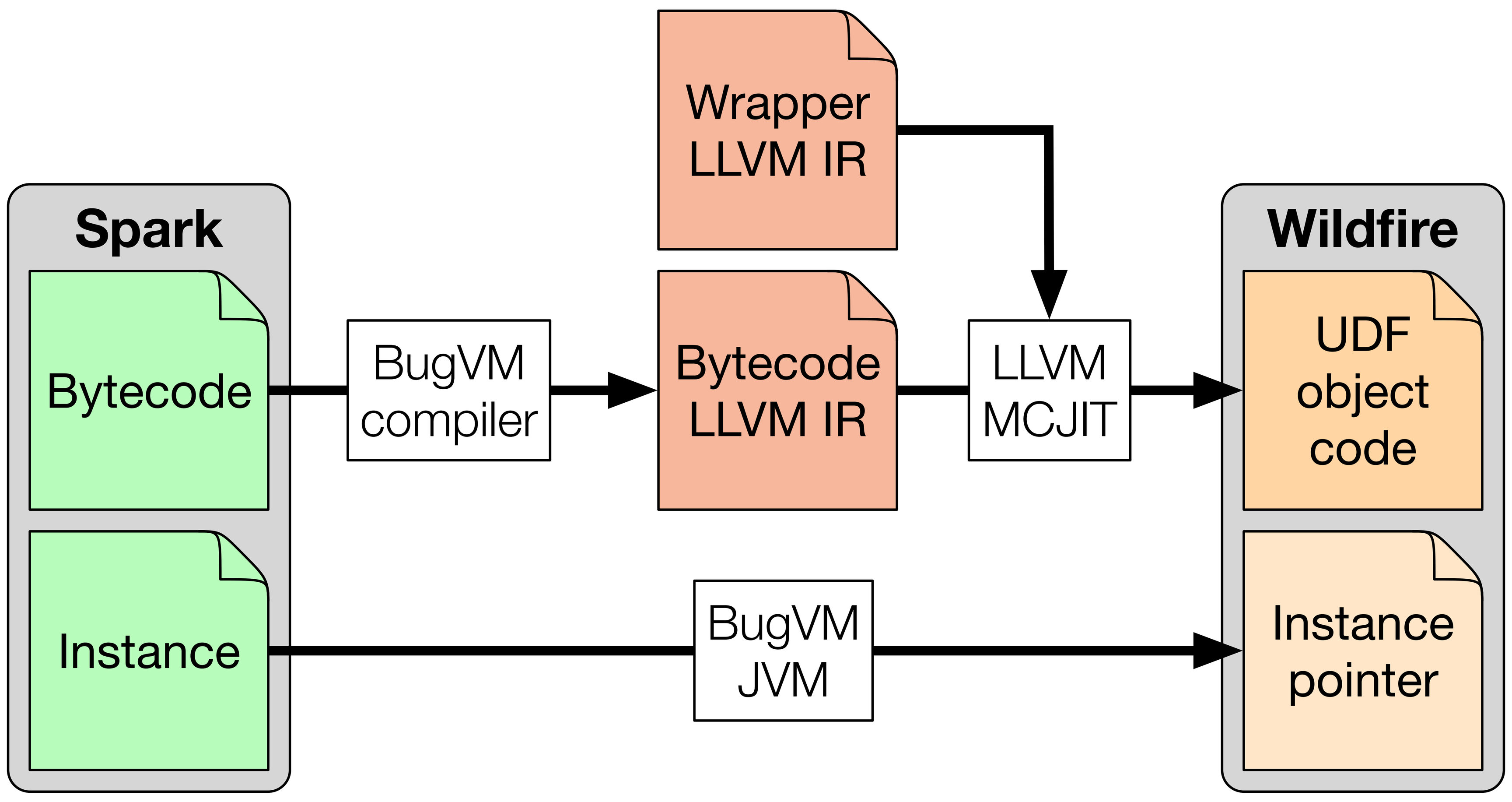
Java Native Interface

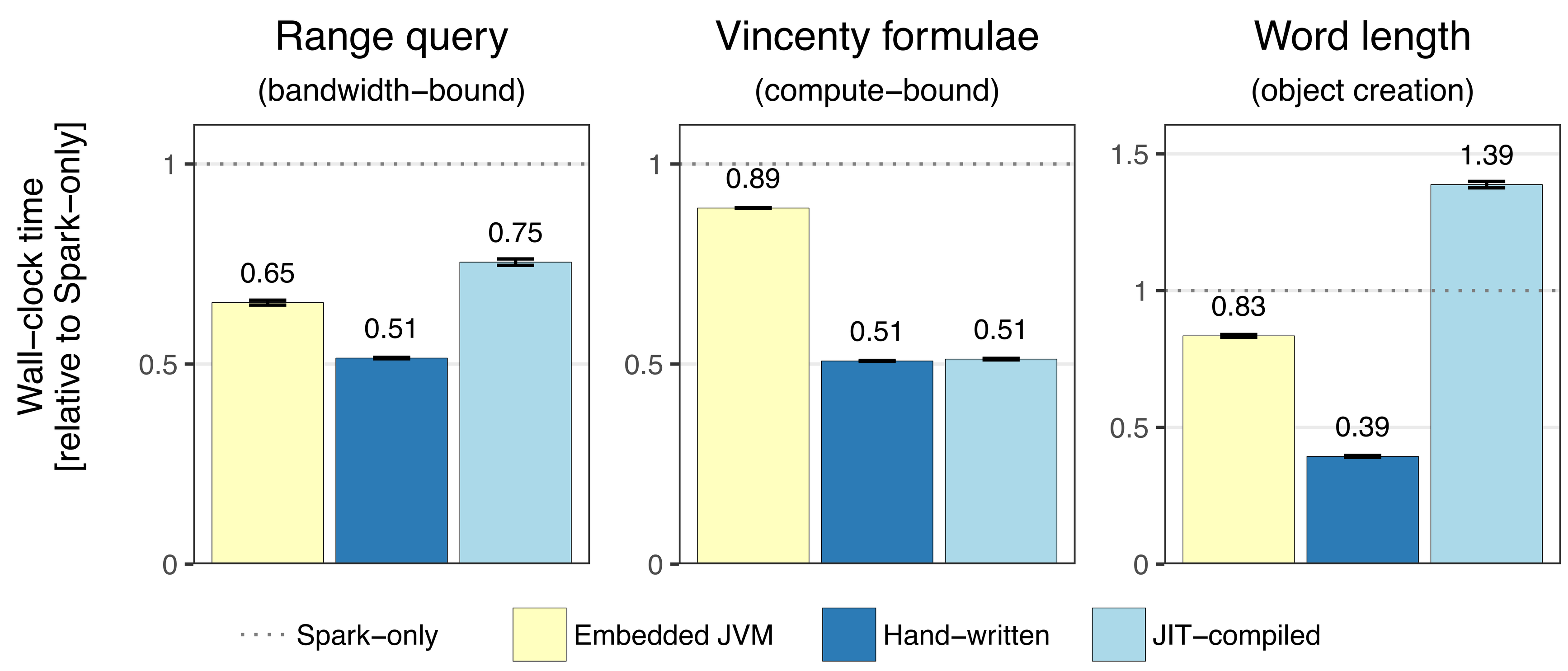
- Standard way to connect JVM with native code
- JNI calls have significant overhead
- Strided execution hides overheads



JIT compilation to machine code

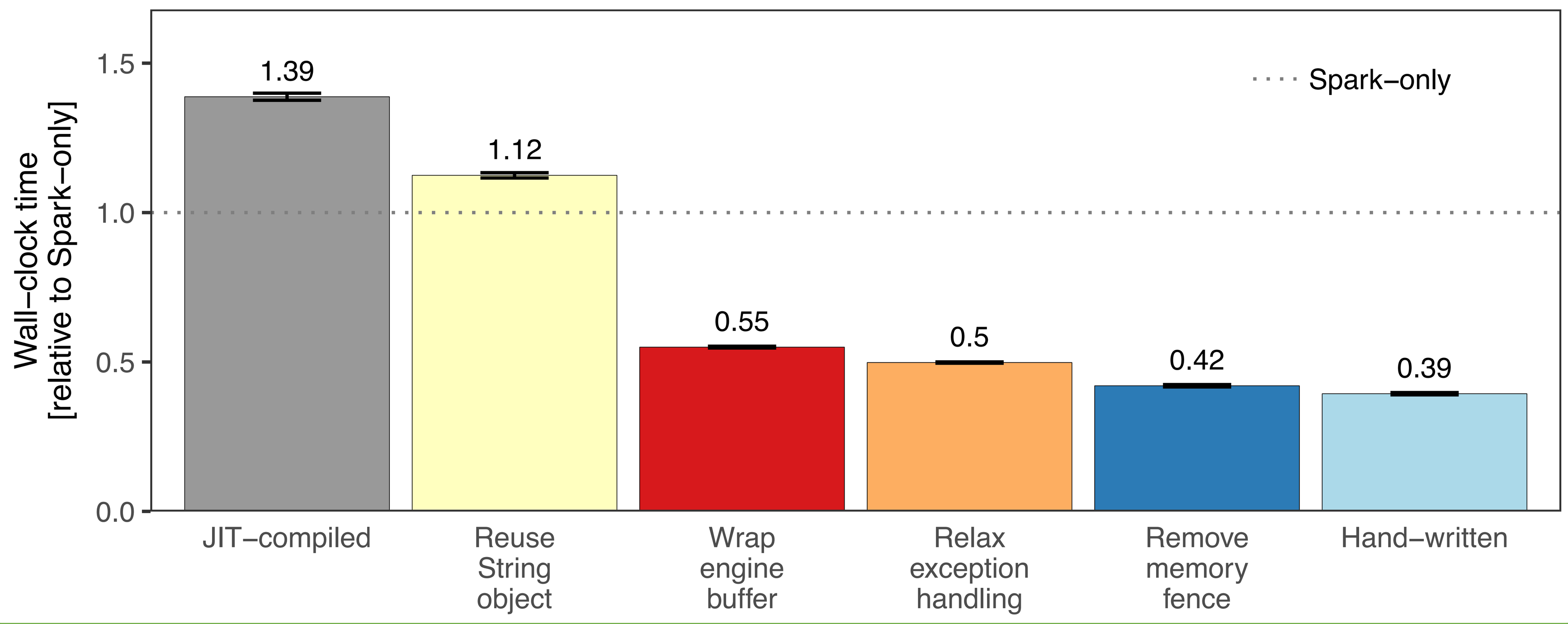
- UDF bytecode translated to LLVM IR with BugVM
- Object code dynamically loaded and executed
- Beneficial for computationally heavy UDFs that do not create objects
- Optimizations to speed up UDFs that create objects violate Java language guaranties





Word length UDF wrapper

for $i \leftarrow 1$ **to** *size of input* **do**
  $javaString \leftarrow$ CreateJavaString($input_i$)
  $output_i \leftarrow$ WordLengthUdf($javaString$)
  CheckForJavaException()
  ReleaseJavaObject($javaString$)
end



Contributions

- We transparently enable strided execution of tuple-based Java UDFs in a C++ query engine.
- The performance of our solution is comparable to execution in Spark and UDFs hand-written in C++.
- Our analysis shows that compiling UDFs to machine code has only marginal benefits.