MLLIF : Automating Cross-Language Interoperability With MLIR and LLVM

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Cross-language interoperability is a persistent challenge in modern software development, where applications often integrate languages like C++ and C# for game development or Python and CUDA for machine learning to harness their unique strengths. Existing tools, such as IKVM.net, which connects Java and .NET but is restricted to Java 8, and Jython, which runs Python on Java Virtual Machine but remains stuck at Python 2.7, are outdated and insufficient. Modern runtimes like .NET Core also face difficulties replacing legacy systems, such as the .NET Framework and Mono used in the Unity Engine. Furthermore, interprocess communication (IPC) frameworks like gRPC has overhead, making them unsuitable for low-latency applications. This paper introduces an innovative method to automate cross-language interoperability using MLIR and LLVM infrastructure. Unlike conventional techniques, this solution automatically generates code for seamless function calls and data exchange across languages, reducing manual effort significantly. It eliminates the need for hand-coded bridges, ensures memory safety, and maintains consistent garbage collection. In a case study combining C++ and C#, it streamlined data sharing, automated bridge creation, and minimized complexity and errors. This approach offers platform independence, high performance, and compatibility with native compilers and runtime environments, making it highly adaptable across diverse ecosystems. By providing a scalable, efficient way to integrate multiple languages, this method accelerates development cycles, enhances software robustness, and establishes a new benchmark for cross-language interoperability, addressing modern software development challenges effectively.

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