Khronos Group
Request for Proposals

LLVM SPIR-V Backend

November 2024

1. Background

The SPIR-V target within LLVM, also known as the LLVM SPIR-V backend, facilitates code generation for the OpenCL SPIR-V binary format, as outlined in the SPIR-V specification[1]. This backend was upstreamed into the LLVM repository in 2022 and is on track to become a stable, permanent target. Historically, the Khronos LLVM/SPIR-V Bi-Directional Translator has served as the official tool for generating SPIR-V from LLVM IR. However, due to ongoing developments and contributions from various SPIR-V vendors, the backend is anticipated to fully supplant the translator.

The goal of this project is to address and integrate specific functionalities that are currently available in the translator project but missing from the backend.

2. Methodology

Khronos has a fixed budget for this project, with payment due on project completion.

This RFP is being circulated to all Khronos members, and publicly, any interested party is welcome to respond.

Khronos will establish a Slack channel for communications regarding this project that any interested Khronos member may join. Short status and progress reports should be prepared for the weekly OpenCL and SPIR meetings, and the biweekly OpenCL Tooling meetings and circulated on the email lists for those groups.

All code development shall take in place in the public LLVM project repository (https://github.com/llvm/llvm-project) and Khronos LLVM/SPIR-V Bi-Directional Translator repository (https://github.com/KhronosGroup/SPIRV-LLVM-Translator) using GitHub pull requests and issues, reviewed by OpenCL and SPIR Working Group members members.

3. Scope

Main Areas of Work

The scope of this Request for Proposals (RFP) is concentrated on aligning the capabilities of the experimental LLVM SPIR-V Backend with those currently supported by the Khronos LLVM/SPIR-V Bi-Directional Translator. This involves several main areas of work, outlined below (in the order of importance):

1. **Porting existing tests:** Existing tests from the LLVM/SPIR-V Bi-Directional Translator are to be ported to the LLVM SPIR-V backend and current LITs in the backend contributed back. This will help identify future areas of work to ensure functional parity.

2. **Implementation or correction of LLVM intrinsics lowering methods:** This work includes implementing the missing intrinsics or correcting current implementation, supporting the implementation with appropriate test cases, using the LLVM's Integrated Testing (LIT) framework. Test cases should be sourced both from existing ones in the Khronos LLVM/SPIR-V Bi-Directional Translator repository and newly created tests, which shall be contributed back to the Khronos repository.

3. **Implementation of SPIR-V extensions:** Each implementation must be supported with test cases, using the LIT framework, and similar to the intrinsics, these must be both copied and newly created where necessary, with new tests also being pushed to the Khronos repository.

4. **Adding missing OpenCL builtin functions TableGen definitions**: Fixes should be applied to the current LLVM SPIR-V backend's implementation of the GlobalISel lowering flow, if these would impact the work mentioned above. However, no significant rework or refactor of the current CodeGen passes and lowering methods is expected.

Details of Specific Work

The focus will be on several LLVM intrinsics and SPIR-V extensions that are currently untested, incorrectly implemented, inefficient, or entirely missing in the LLVM SPIR-V backend:

- Intrinsics include *llvm.experimental.constrained.** (arithmetic, comparison, and conversion), *llvm.debugtrap, llvm.memmove, llvm.experimental.noalias.scope.decl, llvm.fptosi, llvm.is.fpclass , llvm.frexp, llvm.instrprof.*,* and *llvm.nearbyint*.

- Extensions:
  SPV_KHR_integer_dot_product, SPV_KHR_non_semantic_info, SPV_EXT_image_raw10_raw12, SPV_EXT_rel axed_printf_string_address_space, SPV_INTEL_arbitrary_precision_fixed_point, SPV_INTEL_arbitrary_precisi on_floating_point, SPV_INTEL_arithmetic_fence, SPV_INTEL_bindless_images, SPV_INTEL_blocking_pipes, and SPV_INTEL_complex_float_mul_div.

The lists are not comprehensive, depending on the estimated effort, the above extensions can be substituted with other already present in the Khronos LLVM/SPIR-V Bi-Directional repository. Minimum-implementation tests from the Khronos repository will be utilized to verify the accuracy and completeness.

4. Deliverables

Upon approval and acceptance of the work plan, the sequence in which the deliverables are completed may vary. Nevertheless, priority should be given to the work on LIT tests and LLVM intrinsics, ensuring the tasks are completed within the allocated budget and effort.

4.1 Full Project Work Estimate and Plan

An estimate of the amount of effort required to implement the above design and a full project plan for completion by the end of 2024.

Acceptance Criteria: signoff after discussions with the OpenCL Working Group that the project work estimate and plan is feasible and practical.

4.2 LIT Tests Ported from the Khronos LLVM/SPIR-V Bi-Directional Translator

Pull requests with the tests ported from the Khronos LLVM/SPIR-V Bi-Directional Translator repository with changes to the checks, additional verification and validation runs. Also, back contributions with additional checks to the tests in the Khronos LLVM/SPIR-V Bi-Directional Translator repositor where relevant.

Acceptance Criteria: discussion, code review, and acceptance by the OpenCL Working Group.

4.3 LLVM Intrinsics Implementation and Tests

Pull requests with the tests and implementation of the LLVM intrinsics pushed to the LLVM project repository on the ongoing basis.

Acceptance Criteria: discussion, code review, and acceptance by the OpenCL Working Group.

4.4 SPIR-V Extensions Implementation and Tests

Pull requests with the implementation of the SPIR-V extensions. Minimum-implementation tests from the Khronos repository will be utilized to verify the accuracy and completeness of the implementation.

Acceptance Criteria: discussion, code review, and acceptance by the OpenCL Working Group.

5. Schedule and Budget

Khronos has a budget of $40K USD for this project and expects work to be complete within three months of project initiation, or sooner, with payment due on completion and acceptance. Project acceptance will be agreed by the OpenCL Working Group.

6. Selection Process

Khronos shall designate a Khronos RFP Manager and will use an RFP email list (opencl-rfp@lists.khronos.org) that can be used to contact the RFP Manager and all other OpenCL Working Group members involved in the bid selection process. No Khronos member making a bid shall be on the RFP list. Any company considering making a bid in response to the RFP should notify the RFP list as soon as possible. Any potential bidder may request additional information and submit questions directly to the RFP manager or on the RFP email list. Any additional Khronos information and RFP clarifications will be distributed equally to all potential bidders.

All bidders should provide the following information in the format of their choice:
- Proposed schedule, assuming work starts in December 2024.
- Confirmation that if your bid is accepted, you are willing to work under the terms of the Khronos Contractor Agreement[2].
- Any issues or risk factors that they wish to highlight.
- Supporting materials, including background materials about their company, highlighting experience and expertise relevant to this project.

RFP responses are requested by **5PM PT on Friday December 6th, 2024** and should be sent to the RFP list. Bidders may update their bid as they wish before the submission deadline. In exceptional circumstances a requested submission deadline extension may be issued to all bidders at Khronos' discretion.

Khronos will evaluate all bids and select the winning bid based on timescales, and relevant experience and expertise.

Khronos expects to announce the selected bid one week after the submission deadline and will immediately notify all bidders and enter into contract negotiations with the selected bidder to finalize deliverables and payment schedule. Khronos will immediately notify all other bidders once contract negotiations are complete. In the case contractual agreement cannot be reached, Khronos may select an alternative bidder and re-enter negotiations.

Work can start immediately when the contract is negotiated and executed by both parties.

7. Contractors Agreement

The selected contractor will be required to execute the Khronos Contractors Agreement with Milestones and Costs entered into Exhibit B and Contractor Disclosures entered into Exhibit C..

No work shall begin, and Khronos shall be liable for no costs or expenses, until the selected contractor is in receipt of a mutually executed Contractor's Agreement.

It is important that contractors understand that, under the terms of the Contractors Agreement, Khronos will assess progress on a regular basis and reserves the right to terminate or renegotiate the contract in the event of insufficient progress or other issues.

8. References

[1] SPIR-V Specifications
https://www.khronos.org/registry/SPIR-V/

[2] Khronos Contractors Agreement template
https://members.khronos.org/wg/All_Khronos/document/previewpdf/23303