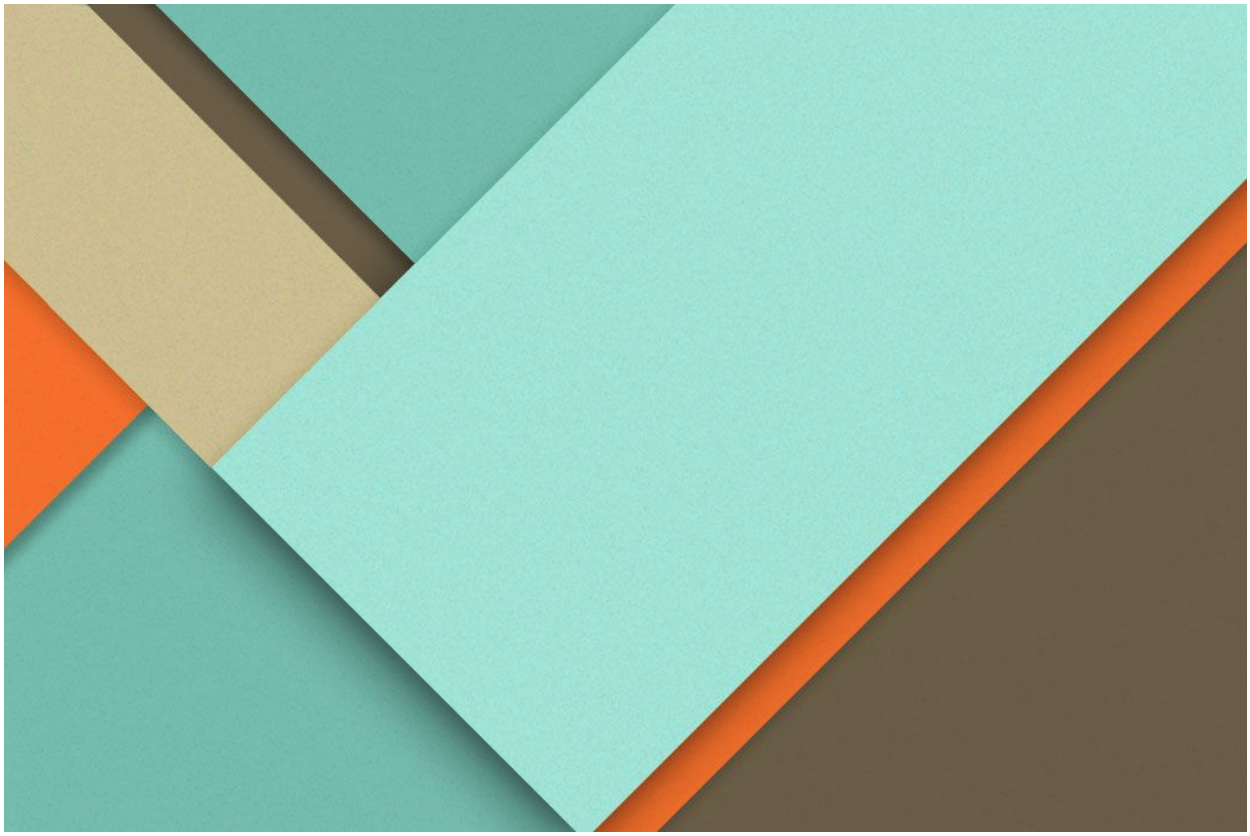


Dynamic CPU support for s390x in OpenBLAS

Naveen Naidu
naveennaidu479@gmail.com
Junior Year - Computer Science Undergraduate
PES University - Electronic City Campus
Banglore
India

Why would you like to execute on this particular project and why would you be the best individual to do so ?

The implementation of this project would be a nice addition to the OpenBLAS community as well as the users of s390x architecture. This would reduce the compile time and execution time and would help save the time of lot's of users when working on large arithmetic programs because, this would enable them to use the optimized codes made for z architecture.

This would also help increase the community/users of the s390x. This project would have a great impact for the community. And to add to that, the very idea of me helping the mainframe community in any small way possible, excites me.

As well as , I'm sure it will be an exciting challenge to get to grips with the s390x kernel architecture for mainframe. Learning more about how this architecture provides the flexibility of running Linux with the advantages of fault-tolerant mainframe hardware capable of over 90,000 I/O operations per second and with a mean time between failure (MTBF) measured in decades, is an opportunity I would not want to miss. This project would help me quench the thirst of my recently upsurging interest in mainframes and build systems.

Why me?

I am inquisitive by nature and have a burning desire to explore various fields to help people benefit from technology. I am an open source aficionado and have been a regular contributor to various open source projects . For this particular project, I have already read through the build logic of the OpenBLAS project and I can confidently say that I have a fair understanding of how the architectures are selected during the compile time (I have explained my understanding about the project in the proposal below, please have a look there)

This project requires me to have a good understanding of Build Systems (Especially Makefile and cmake) and also with C programming language. I have taken the `Programming with C course` where I scored among the top 5 percentile among the class of 100. I have also built few projects where I did use Makefile for the compilation. Though the makefile I had written weren't complex but I am familiar with the concepts of Build

Systems. In order to improve my understanding of Makefiles, I have also recently started to read through online Documentation, blogs and videos to fill up the gap that is required for the project.

Hence I can say that I have a fair working experience with Build Systems and if need be I would gladly put in more hours to improve my understanding.

As a Google Code In mentor for the coala organisation, I was constantly bombarded with questions from the participants, which pushed me to dive deeper and learn additional concepts about various repositories associated with coala and become capable of explaining the intricacies of those repositories in a simple way to the students so that they can achieve the goals of their task . This experience strengthened my ability to understand huge code bases faster.

I also do not have any other commitments and I would be available throughout the summer. I am willing to work for 40 hours a week and would gladly put in more hours if need be for the successful completion of the project.

Please share details of your academic, industry and/or open source development experience, as well as other details as you see fit.

Academic Details

During my freshman year at University, my teammates and I were among the top 5 teams among 100 teams selected for a National Level Hackathon (Ingenius 2017). We developed an application named CRYSIS - This application exploited the bluetooth connectivity of smartphones to create a **mesh network.** The aim of this software was to help people connect with each other in the times of natural calamities, when the cellular networks get wiped out entirely. Our application only requires the user to switch on bluetooth and it creates a bluetooth mesh network. This application supported the hopping of message via another devices to reach its destination.

I have been part of my university Computer Science Research team(SciBase). I led the development of an web scraper which helped the Researchers of my College gather metrics about journals from the various scientific journal websites. The scraper was designed in a way such that it can overcome the blockings from the research websites. This was used by the researchers to gather data to overcome the problem of fake citations.

I also have past experience working in the field of Computer Science as a Intern at a Fintech Company named **Fullerton India Credit Company Limited.** During the summer of my sophomore year, my team and I had developed a game to help people understand about 'Financial Literacy'. The product developed by us was also selected as a finalist in their annual Startup Hunt – Finnovatica. This internship gave me experience in working closely with end users in developing solutions.

During my 5th semester at University, I along with my teammates, had developed an application,which we named - DTS (Data Transmission through sound) . It was a hacky tool developed by us, using the zxing library provided by google. This application, took the text from the user - encrypted it - and transmitted it in a high frequency tone. This application was selected as the finalist for another National Level hackathon.

I have also taken various workshops for the students of my University and introduced them to Open Source development and the various benefits of being associated to it.

I was a part of the Technical Core Team for the annual hackathon hosted by my University. My responsibilities included handling the technical support of the event. During this time, I had set up various websites, built django applications and provided the team with various scripts to automate mailing.

Open Source Development

I have always been mesmerized by the impact an open source project can have. I have always had this intense desire to help people and open source had given me the platform to do so. And that's my main motive behind my contributions to open source organizations. It gives me the adrenaline rush to just think about how my little change in a huge code base can make someone's life easy.

It's almost been a year since I have started contributing to Open source projects.I go by the handle @Naveenaidu. I must say, I was hooked onto it from the very first day. I started out by contributing to an open source project named coala, which is a static analysis tool built for most programming languages. I now am, on the *main developer team of coala*. I have submitted various PR's, opened and reviewed many issues and have helped many newcomer's set up their environment and get started with open source development.

I also have been the **Google Code In Mentor - 2018** for coala. I was mainly in charge of the coAST, mobans and documentation tasks.

I also contribute to moremoban organisation. Particularly to the moban repository and pypi - moban. Moban is high performance template engine (JINJA2) for web into static text

generation. I have been recently added as one of the collaborators of the pypi-moban repositories.

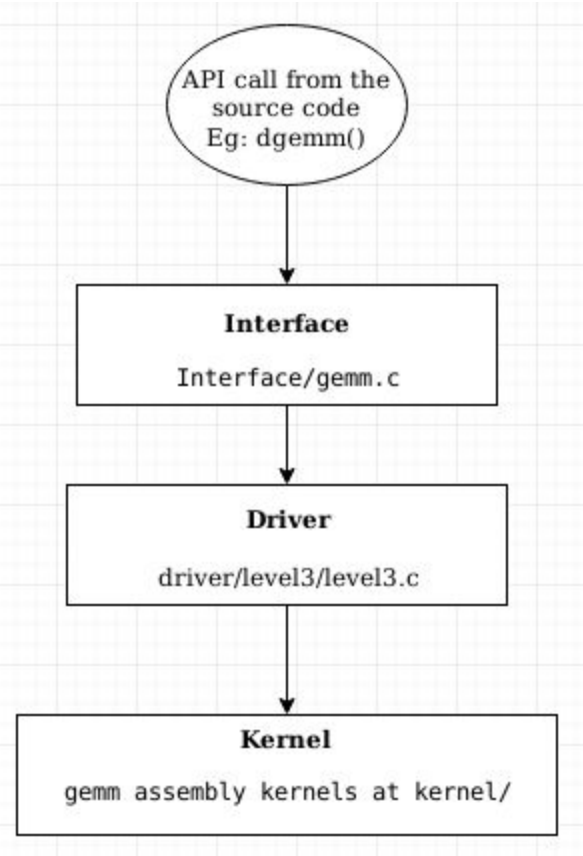
Whenever I am free, I also make few small hacks for fun.

Overview

BLAS - stands for Basic Linear Algebra subprogram. These subprograms are a specification that prescribes a set of low level routines for performing common linear algebra operations such as vector addition, scalar multiplication, dot product, linear combination and matrix multiplication.

OpenBLAS is a open source implementation of BLAS library, where it provides many API's to access the function of BLAS. It is important to note that the BLAS and many numerical libraries such as LAPACK were written in Fortran, a rather ancient language. OpenBLAS provides the C interface to access the functions provided by BLAS and LAPACK, thus providing more flexibility for programmers.

Before we go into the details of the project it's important for us to understand how the OpenBLAS library actually works.



The API call is first sent to the **interface** , which contains the implementation of BLAS and CBLAS. This API call is then transferred to the library(BLAS or CBLAS) which the user mentioned in their source code. The API call then interacts with the **driver** which is responsible to initiate the correct Library subroutine. This subroutine is then run according to the instruction of the **kernel**.

Description of the terms:

1. **Interface**: This contains the implementations of BLAS and CBLAS which calls the driver or kernel
2. **Driver**: This contains the linear algebra subroutines code implemented in c
3. **Kernel**: This is the core of the openblas library. They contain the Optimized assembly implementation for various architecture.

In short, The entire architecture of OpenBLAS is similar to that of a Linux Kernel, where Kernel is the core of architecture and drivers are attached to it. And in order to interact to the driver, we would need an interface.

Goals

To provide necessary CPU support code for the s390x architecture, so that OpenBLAS can dynamically detect the architecture of s390x during runtime.

Presently, Only Intel/AMD and AArch64 support the dynamic (runtime) selection of the best implementation now. That means when the openBLAS is run, it automatically detects which architecture it is working on and selects the best optimized codes/kernel for that architecture. This project would extend the capability to Z arch.

How is the dynamic detection done?

DYNAMIC_ARCH is a option provided by openBLAS that needs to be used along with *make* option while building in order to allow the detection of architecture during run time.

If DYNAMIC_ARCH is **not** used, then the cpu core detection logic and the defines in the ***cpuid_*.c*** files in the root directory *is used at compile time to detect cores* and compile in specific features. This is not optimal because openblas only builds for a generic architecture level which would ignore all the special capabilities of a architecture and thus increases the execution time.

If DYNAMIC_ARCH is used, then core detection is not done at compile time. Instead it compiles for all cores defined in the **DYNAMIC_CORES** variable in the ***Makefile.system***. Then at runtime, it uses the logic in *driver/others/dynamic*.c* to detect the core at run time. In short, when DYNAMIC_ARCH is set, openblas builds many micro-architectures. Then when openblas works on an application, it selects the appropriate library.

OpenBLAS also provides an environment variable (OPENBLAS_CORETYPE), which is used in *driver/other/dynamic.c* to select the appropriate core type at run time.

Implementation steps of the project

1. Read through the documentation of Make to get a better understanding and spend time in understanding the build process of OpenBLAS in depth.

2. Implement the dynamic detection logic for z architecture in the file **dynamic_zarch.c** in the **driver/others/** directory.(Use inbuilt function such as getauxval() to detect the processor information)

3. Check for the **z_arch** in the *Makefile.system.* If detected, then add update the value of **DYNAMIC_CORE**

4. Add the check for z_arch in the *drivers/others/Makefile* and also update the object list to build the appropriate kernel files.

5. Make changes to the suffix for the objects present in the kernels of z at /kernel/zarch

6. Implement the check for the architecture in cmake

Timeline

I don't have any other commitments and I would be available throughout the summer except for a week, when I would be having my university finals. I prefer to follow the US schedule. According to the schedule, there would be about 45 days excluding the last week and weekends. I am willing to work for 40 hours a week. For the time, that I might lose during the one week of my finals, I would put in more time before and after my exams to compensate for the loss.

Also, my development methodology includes writing daily reports, where I would write about the work I do daily. This helps me keep track of my work and makes me more productive.

Risk Management

If I get stuck on my project and my mentor is not around?

I would never let the unavailability of my mentor hinder my progress. There are many alternative ways that I can use to get help from. Such as:

1. Taking help from the community members through:
    a. Mailing List
    b. Slack Channel
    c. Community Forum
2. Taking help from the boost.context maintainers
3. Reading relevant articles, resources and figuring out on my own
4. Taking help from those who might have already worked on similar project

Keeping the community informed of my progress

Open Mainframe is a large-scale organization. It also supports many ways of communication where ideas/information can be shared/discussed and these platforms have large outreach. Thus, I would be taking advantage of these platforms to inform the community of my progress and also discuss any problems or questions I might have over the course of the project.

The different ways of communications are:
1. Interacting with mentors
2. Interacting with community members through:
    a. Mailing list
    b. Community Forum
    c. Creating issues on Github
    d. Slack Channel