Wireless Communication for Parallel Computing on Jetson Nano: Performance Evaluation and Comparison with Ethernet Connection via Switch

Mentor: Dr Kwai Wong, Patrick Lau

Member: Ryan Lei (The University of Tennessee, Knoxville) ; CHAN Chiu Hei, Siyi XIANG(City University of Hong Kong)

香港城市大學 City University of Hong Kong

THE UNIVERSITY OF TENNESSEE KNOXVILLE

Abstract

This research explores a comparative study of communication in a JETSON Nano Cluster using wireless connectivity technologies such as Narrowband Internet of Things (NB-IoT) and WiFi through switches, as well as wired connections like Ethernet (WiFi needed). The study begins with establishing various communication setups to form the cluster. Subsequently, the Message Passing Interface (MPI) is employed to achieve parallel processing across multiple NANO devices in the cluster. Building upon this foundation, CUDA is introduced to enable parallel processing on the cluster's GPUs. Finally, the Magma library is employed to fully leverage the GPU's structural characteristics, accelerating large-scale matrix-matrix multiplication operations.

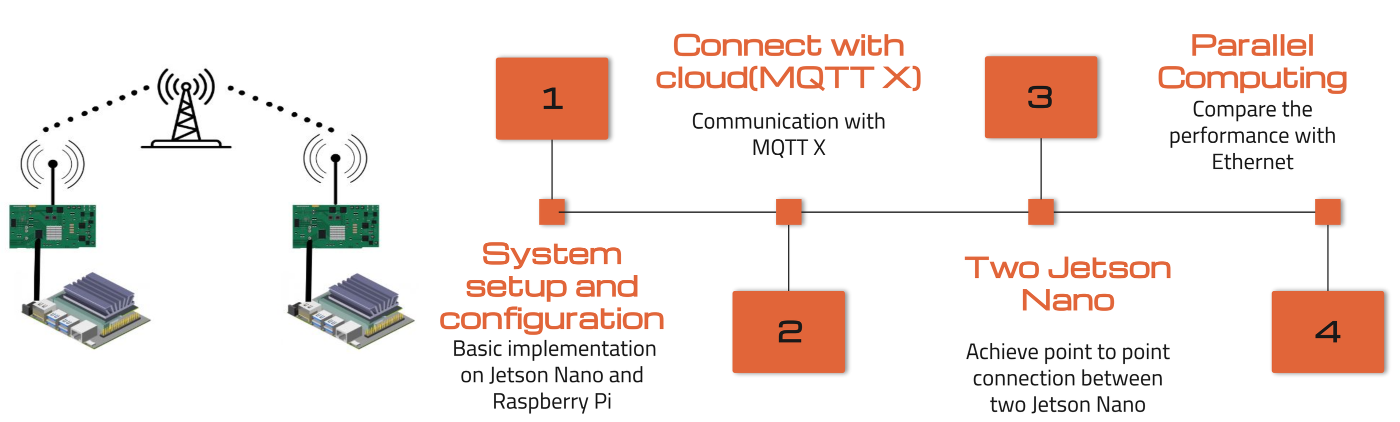
Objective

Our goal is to evaluate the feasibility and performance of wireless WiFi and NB-IoT communication in achieving parallel computing without relying on cloud services. The purpose is to compare the result with wired Ethernet-connected Jeston nano using the switch to respective performance in parallel computing tasks. At the same time, explore the parallel computing using GPU, and magma output performance of the jetson Nano cluster.

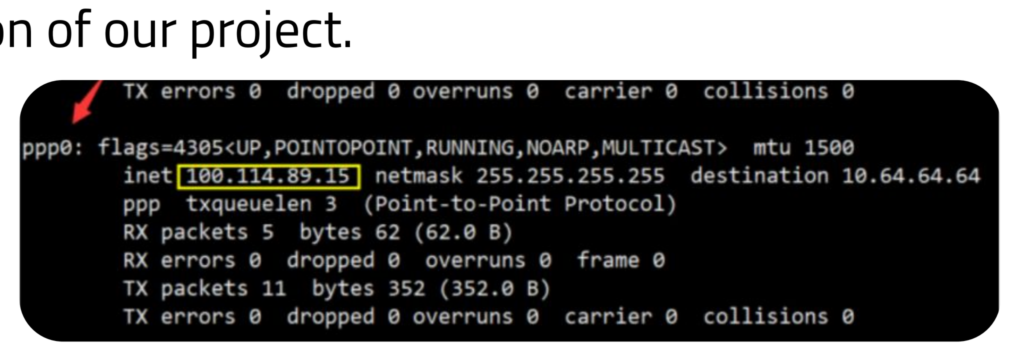
NB-IoT Connection

We use the NB-IoT module (SIM7070G) to connect with the Jetson Nano for the NB-IoT connection. Basically, they can communicate with each other via the base station.

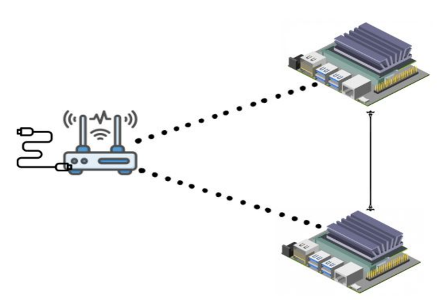
Here is a simple flowchart for wireless part:



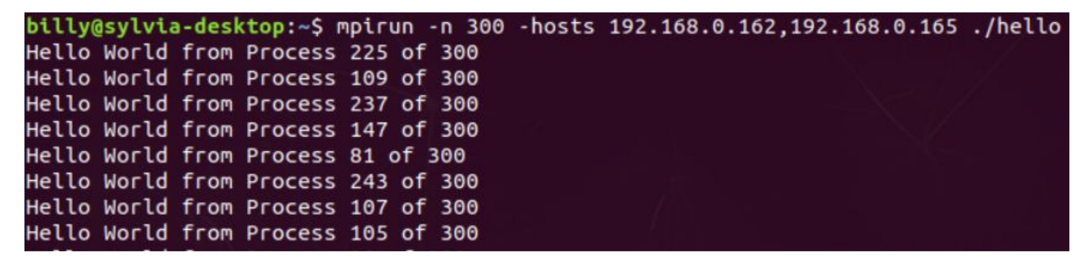
In the process, the connection of two Jetson Nano was completed, but the ppp0 port could not be found. In addition, due to the proximity of multiple Jetson Nano, with NB-IoT technology having a relatively high latency, it may not the best solution of our project.



WiFi Connection

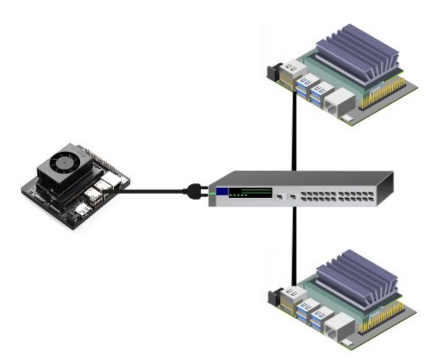


Using the router to connect with two Jetson Nano is do the parallel computing job. Implement Mvapich2 on Jetson Nano to run the MPI program and some performance tests.



These tests are able to run successfully on the CPU, Above is one of the results of latency tests (OSU benchmarks) on CPU.

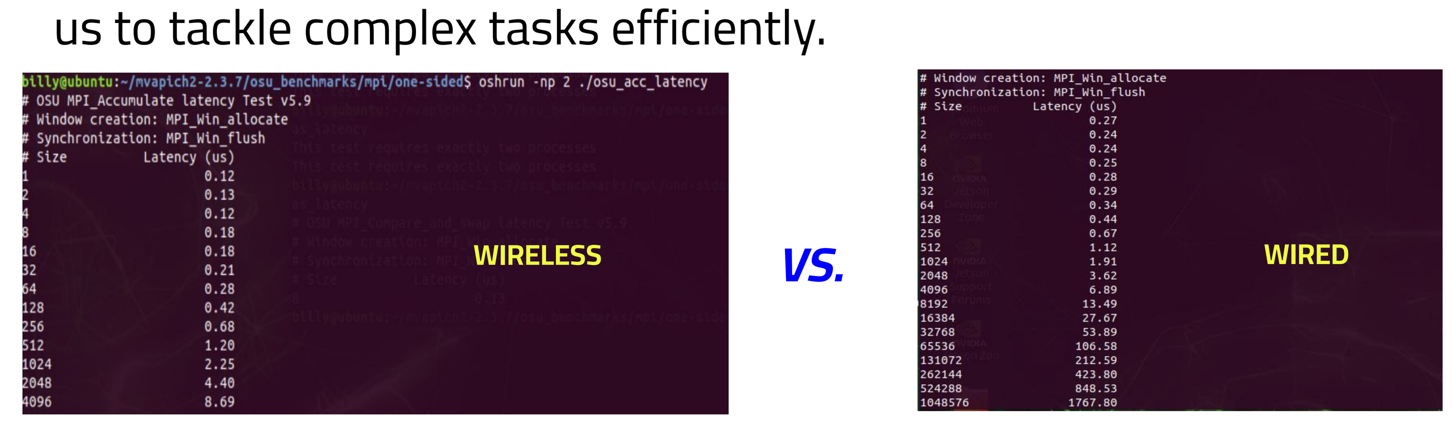
Wired Connection



Wire Connection used Ethernet cable through switch, and two Jetson Nano cluster is successfully done as well. The switch be able to manage the sub-network. For better performance, we have also examine the master node with more powerful Jetson Orin, and it did provide a better result.

Parallel Computing

We utilize the MVAPICH2 as our MPI software, to achieve parallel processing in the JETSON Nano Cluster. This software provides us with a robust framework for parallel computing in the cluster environment, effectively decomposing substantial tasks into smaller units and executing them in parallel across multiple devices. It improves the overall computational efficiency of the cluster, enabling us to tackle complex tasks efficiently.



Cuda Aware MPI

CUDA library from Nvidia is a parallel computing platform and application programming interface that enables developers to utilize the power of Nvidia GPUs for computing tasks. Its advantage lies in accelerating computationally intensive operations by leveraging the parallel processing capabilities of GPUs, significant speed-ups and improved performance for various applications ranging from scientific simulations to deep learning algorithms. We discover the Cuda react with Mvapich to approch parallel computing on GPU.

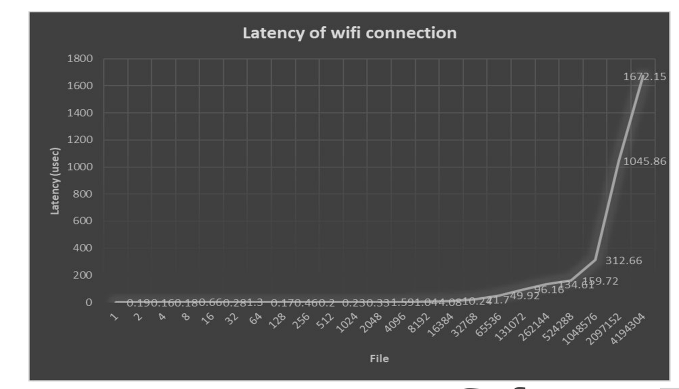
Magma

Matrix Algebra on GPU and Multi-core Architectures (MAGMA) is a set of advanced linear algebra libraries designed for heterogeneous computing environments. In this research, we have integrated MAGMA into the Jetson cluster to explore and utilize the unique capabilities of GPUs, investigate the performance and outcomes.

Conclusion

Communication Method Finalize

- NB-IoT: With comparing with WiFi technique, NB-IoT is cheap and low battery consumption. However, the latency is higher as well. In out project, the distance between two Jetson Nano is short. It may not the best way to construct parallel computing.
- WiFi: Using WiFi dongle and router to complete the connection. There is a result of the latency which using WiFi connection:

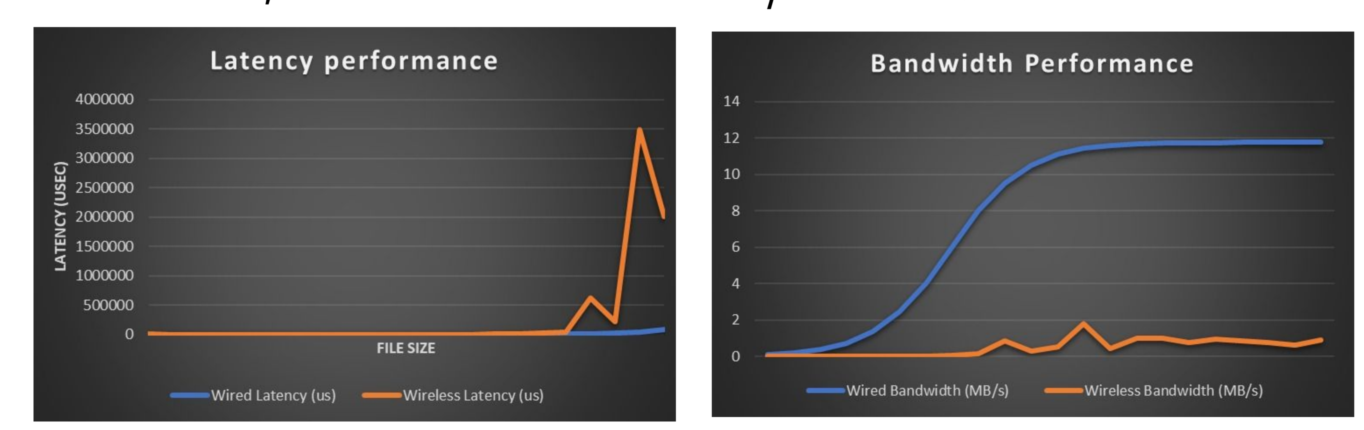


For the optimization, it revealed that the latency is lower or around 1 usec when the number of files are lower than 8192.

Software Finalize

MVAPICH

Based on the result of the performance of two techniques on CPU, we will be able to observe the latency of wired connection is lower than wireless connection. Meanwhile, the bandwidth of wired connection is higher than wireless connection. However, if user want to transfer the file with small size, wireless connection may be a better choice.

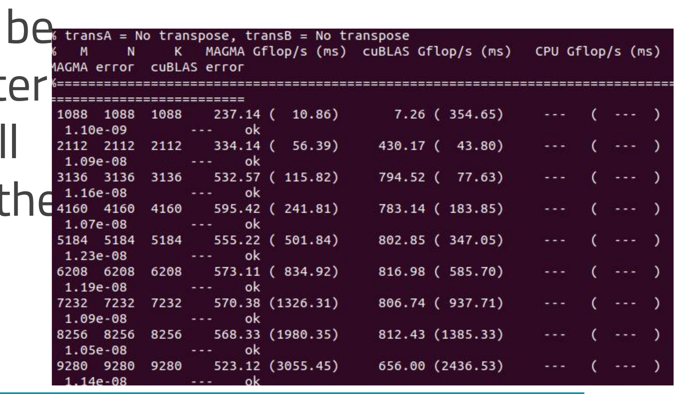


Cuda

Cuda are able to interact with magma and mvapich, we are able to running cuda-aware-mpi code to accomplish parallel computing task on GPU. And on larger number of processes and tasks, the GPU will have better time efficiency compare to the CPU.

Magma

After the research and testing with magma on the jetson nano cluster, due to the limited memorize and library size of magma, it seems like that the Jetson Nano won't be able to function it correctly. However, after our examination on the Jetson Orin, it will able to provide a great functionality. If Other developer want to investiga magma on cluster, we will recommend to use Orin.



Future Task

1. Research the performance testing of the parallel computing on GPUs, Parallel version of Magma Tensor on Jetson Cluster implementation
2. Jetson Cluster version of Jetbot, multiple Module processing at the same time, autonomous Jetbot

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