Programming The Fabric Blockchain on RaspberryPi4

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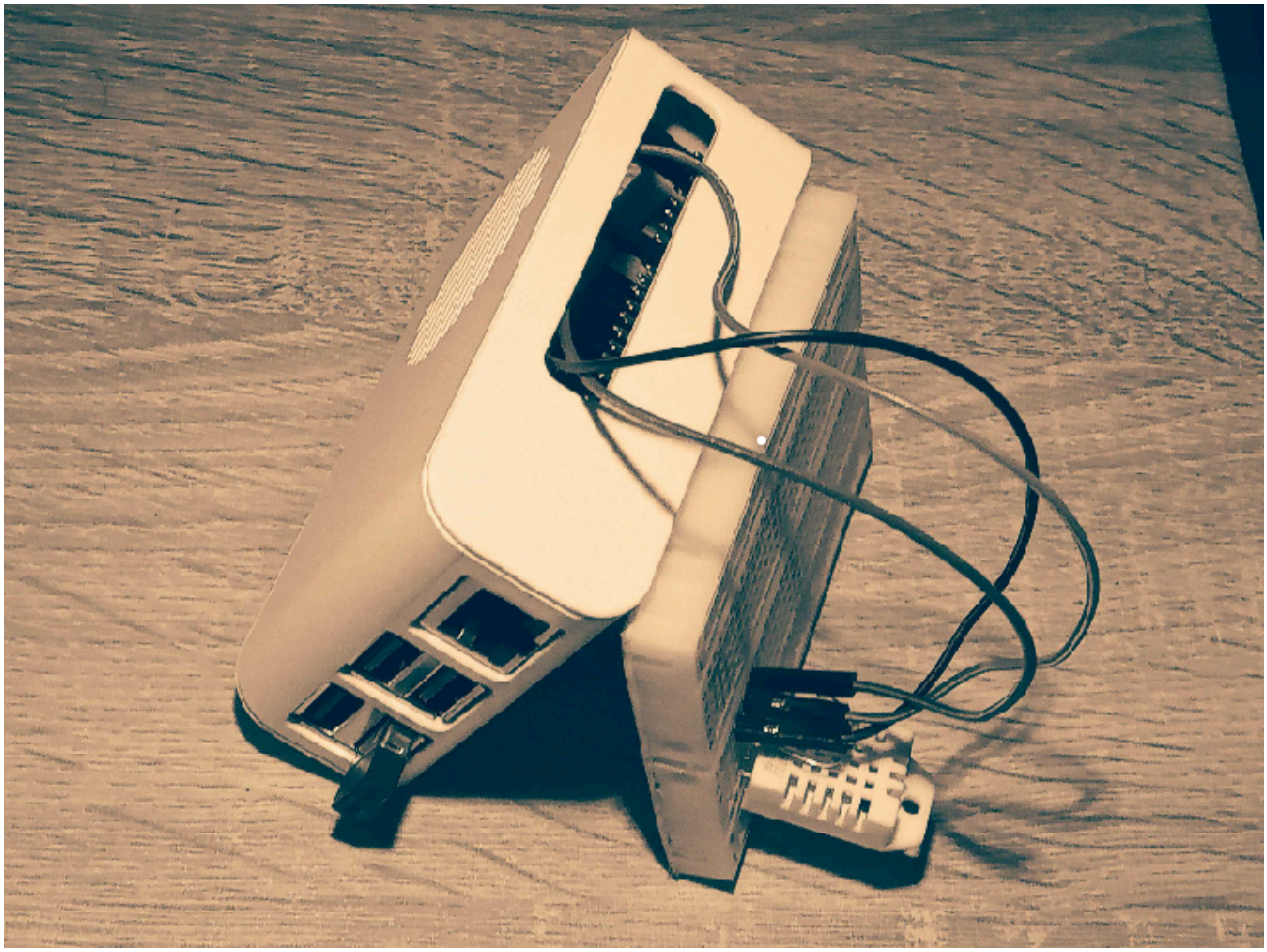

Introduction

This report summarizes the technical background, motivation, and testing experience of executing a Hyperledger Fabric Blockchain chaincode on the Raspberry-Pi4 computing device for sampling temperature and humidity readings from a wired DHT-22 sensor.

Motivation

The Blockchain, fundamentally a collection of append linked blocks of immutable data, is a simple graspable concept. Thus this technical exercise stems from the conviction that the Blockchain, despite its rich technical underpinnings, when presented with an amusing educational computing device such as the Raspberry Pi, it makes the concept intellectually accessible from children to professionals in various learning scenarios. Nevertheless, the Blockchain has received minimal attention compared to other disrupting computing technologies. Beyond the research and commercial potential of IoT and blockchain integration, education opportunities are trailing the technical progress in these two areas. Case in point, a search at the educational project ideas of the Raspberry device results in a plethora of learning and building experiments[1] ranging from simple entertaining projects to ingenious team scientific explorations of raspberry as an IoT device. However, the lack of any Blockchain learning experiments at the same site highlights a gap in the most popular educational IoT device to showcase the Blockchain.

Versatile IoT and Blockchain technologies

Blockchain and IoT technologies have separately emerged as disrupting technologies in various business industries, i.e., in Financial, Supply chain. Even more importantly, when combined as a unified technology offering, they enable trust-building among several parties, auditability of tracked information, automated decision-making, information, and value exchange among business parties [12].

The Raspberry Pi series of computing products is a popular credit-card-sized single-board computer board. [13] The immense popularity of the Raspberry Pi computing device has resulted in the development of a vibrant ecosystem offering add-on learning, industrial, and community engagement experiences. The Raspberry Pi Trading corporation released the latest Raspberry-Pi4 model-B+ utilized in this project on June 24 of 2019. The retail

price for the most capable Raspberry Pi4 with a 64bit ARMv8 1.5GHz quad-core processor, dual-4k HDMI ports, 4Gig Ram edition board lists for about $65 at amazon[2]. This is the model selected for this exercise for its performant profile and attractive price point.

Hyperledger Fabric by the Linux Foundation [3] is an open-source permissioned blockchain software platform, along with tools, and applications. It features 9,845 stars in its GitHub repository[4], high-performance (~1000tx/sec)[5], general applicability to various business use cases and long continuous software evolution that have placed it into a prominent industry Blockchain choice. For this exercise, Hyperledger Fabric was selected in its latest code base release of v1.4.4.*.

**Shortly before the completion of this project, Hyperledger released v2.0 and v.1.4.5 of its flagship Fabric platform.*

Technical Objectives

The Hyperledger Fabric codebase does not support the Arm processors as an explicit target[6]. Moreover, the Raspberry foundation advises against running Linux distributions as they are not PI-optimized. Version 4 of the Linux kernels suffered a 600 Mhz clock speed ceiling.[6]
Thus this exercise tested the hypothesis that the latest Fabric v1.4.x codebase ports to the RaspberryPi4 node and runs without any performance limitations. Previous efforts were scant(three published efforts), obsolete(v1.4.1 or lesser), and limited(600MHz CPU clock ceiling) ports of Hyperledger Fabric to the Raspberry Pi 3 device.

Specifically, these objectives were identified to meet the goal of a successful proof of concept (POC):

- Produce functional Hyperledger Fabric v1.4.4 Docker images capable of running in a Ubuntu release featuring the latest 5.3 Kernel targetting the ARM 64-bit processors.

- Successfully sample DHT-22 temperature and humidity readings and save them in the Fabric blockchain.
- Develop and deploy a Fabric chaincode to append the DHT-22 values successfully to the ledger.
- Showcase the data export of the appended values for later analysis.
- Produce documentation of the technical work and supply the Docker images in a docker hub.

Prior Work Not Up To Par

Three prominent documented efforts for porting Hyperledger Fabric to Raspberry Pi3 did not meet the standards for this work:

1. Joe Motacek [7]
2. StackOverflow user Artem Barger[8]
3. The most recent by Petter Tunstad [9].

Their documentation targetted outdated Fabric 1.0-1.4.1 versions. They addressed the Raspberry Pi3 device only and required to install Ubuntu 16x (release of the infamous Linux Kernel v4.9-v4.18[6] suffering from the CPU clock ceiling limit set at 600MHz). Ubuntu v16x is the only referenced ubuntu version at Fabric's prereqs page[10].

Contributions / End Result

This project produced a successful proof-of-concept. This effort validated that the Hyperledger Fabric codebase is compatible with the Raspberry Pi 4* model without suffering from a CPU penalty. Moreover, the Fabric performance profile on the Pi4 device showcased it as a great server choice for hosting the Fabric blockchain (CouchDB), peers, orderer, certificate authorities, multiple chaincode Docker containers, and sampling Heat and Humidity applications with less than 25% Cpu utilization.

** Though this project did not test the Raspberry-Pi3 device, no indications suggested the produced images or sampling application would not be successful on a Pi3 node.*

Relying on the interim Ubuntu 19.10 release with the modern Linux 64bit (Fabric requires a 64-bit os which excludes the Raspbian os) Arm Kernel 5.3.0-10xx-raspi2 series paid off as the results justified the decision.

This exercise relied on the Fabric single-organization Blockchain configuration sample **basic_network**, which offers a streamlined cryptographic material generation experience and blockchain management through the scripts of **generate.sh**, **start.sh**, **stop.sh**, **teardown.sh**. [11]

Open Source Contributions and Extensive Documentation

This work complied with the principle of open source contributions ultimately to produce the following deliverables:

- Dockerhub repository hub.docker.com/blewater with 11 generic Fabric 1.4.4+ Docker images to use in this or any raspberry Fabric blockchain project.
- GitHub repository github.com/blewater/pifabric
    - Raspberry 64-bit Fabric binaries,
    - A DHT-22 native interface library and a Go language reader.
    - A Go language Fabric chaincode for appending the following data to the CouchDB ledger:
        - UTC Timestamp,
        - Sensor temperature reading in Celsius,
        - Humidity percentage
- Linux Bash Scripts for managing the chaincode (sampleCC) lifecycle of **Install** / **Upgrade**, **Instantiate,** and **Invoke**.
- Two extensive setup guides:
    1. README.md: Instructions for setting up and running the Fabric blockchain and sampling application on a single Raspberry-Pi4.
    2. buildfabric.md: Optional instructions for editing and applying Makefile and configuration "fixes" for Fabric to build the binaries and Docker images. As noted, it is not required to produce those for running this application.

Future Work

This successful POC offers numerous opportunities for further exploration utilizing raspberry as an educational and research device. These are a few initial ideas to explore for both hobbyist, professional, and research audiences:

- Extend the same POC to operate under any or all orchestrating permutations: MicroK8s, K3s, Kubernetes (AKA K8S).
- Build a Linux cluster of 2…n Raspberry-Pi3 and Pi4 nodes for hosting a multiorganizational Fabric blockchain.
- Utilize the building Fabric guide to generate Fabric v2.0 images.
- Inquire Hyperledger of their interest in contributing the changes to target the ARM processor. Alternatively, offer a cloned Fabric repository targetting the Raspberry devices.
- Extend this exercise to two or more low-profile Raspberry-Pi models (including 32-bit Raspbian OS nodes) belonging to different organizations equipped with a sensor to communicate over wifi Internet to the Raspberry-Pi4 multiorganization hosting Blockchain. Alternatively, each sensor Pi node (requiring a 64bit Cpu) acts as an organization blockchain peer for a genuine decentralized solution.
- Inquire the Raspberry foundation of their interest for including the Raspbian solution as a learning experiment on their project site.
- Create educational courses at any online educational platform, i.e., edx.org, udemy.com, etc. for teaching these project ideas. The author of this exercise may, in actuality, engage in that.
- Research Blockchain in its fundamental Data Block representation as an improved first computing educational encounter to young audiences compared to competing technical educational topics i.e., the database.

Conclusion

This report presented the results of applying a recent Hyperledger Fabric codebase release to the latest RaspberryPi4 model without any compatibility issues and performance limitations. The produced deliverables prove that the RaspberryPi4 device is compatible with the current Hyperledger Fabric codebase, and its performance profile, combined with

its attractive price point, is suitable for a wide range of blockchain research and educational projects. Promoting a greater educational understanding of Blockchain appears still to be at its infancy if non-existent for young audiences and deserves attention.

References

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