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***Research paper***

# Access mechanism using inter planetary file system

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**Abstract**

Withthe advent of Internet of Things, trust is one of the important factor for provisioning secure, reliable, seamless communications and services. Connected devices are the order of the day, where IoT plays a vital role in the functioning. However, these IoT devices use various protocols for communication mostly a centralized architecture for data transfer. Some of these protocols are Message Queue Telemetry Transport (MQTT), which is a Pub-Sub (publisher and subscriber) protocol used for a device-to-device communication on TCP through a broker. This centralized server can be a third party service provider, which again raises the issue of trust. To address this, we propose a decentralized and distributed network architecture called Inter Planetary File System (IPFS) is used instead of third-party service provider. IPFS enables publish – subscribe model similar to MQTT, but by removing the broker and making a peer-to-peer communication. Peer-to- peer architecture has its own challenges like security. The issue of security is also addressed by encrypting the files or data that has to be sent over the IPFS network using PGP (Pretty Good Privacy).

***Keywords***: *Interplanetary File System; Message Queue Telemetry Transport; Internet of Things; Peer-to-Peer Communication.*

## 1. Introduction

The Connected devices also called as Internet of Things (IoT) is a global industry movement which brings together people, process, data and things are more relevant and valuable than ever before.The innovative developments in the area of digital technology along with the evolution of internet have paved way for the use of IoT in various applications from the past decade [1]. This technology can be usedto solve diversified problems in various sectors like automobile, medical and other allied areas. Though IoT has a good potential in the digital world, it come across several issues during its deployment, with respect to build quality of devices, identity, management and mainly secure communication between devices [2].

Security also plays a major role in communicationbetween devices. There are many protocols that IoTdevices use in which most of them are centralizedwhich have intermediate node (broker) for communication.In the recent days many cloud computing services emerged,which have quickly became popular for Big Data generatedby numerous IoT devices for processing [3]. Among the CloudService Providers, most of them offer the Data Owners withflexible approaches to store the datasets remotely in the cloud and facilitates the owners to change/update these datasets. Most of the IoT applications,which choose to store and process data on the cloud. Providing security will be the main concern, as Cloud Storage Service(CSS) is not secure by nature. "Cloud users will not haveno control over the cloud storage servers being used, whichmeans there are risks of Data Confidentiality, DataIntegrity, and Data Availability" [4]. MQTT is an openpub/sub protocol [5] designed for constrained devices usedin telemetry applications [6]. MQTT is designed in such away that its client's side implementation is made verysimple. All of the system complexities reside on thebroker's side. According to [6] the routing or networkingtechniques are not specified by MQTT, but instead theassumption made by MQTT is that the underlying networkprovides a "point-to-point, session-oriented, auto-segmenting data transport service with in-order delivery (such as TCP/IP)"[6]. As mentioned earlier, thisintermediate node can be a cloud service provider or anythird-party database service provider. As the data is beingstored in these third party service providers, there arerisks that the client should take like lack of trust and loss ofcontrol.

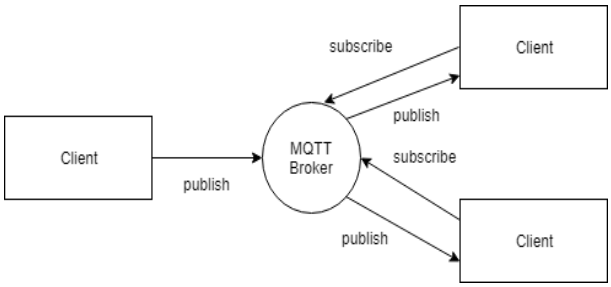



**Fig. 1:** MQTT Publish Subscribe Using Broker Asintermediate Node.

Considering the above discussed problems, a decentralizedand distributed architectural based protocol like IPFS canbe used to address the issue of broker. IPFS is a protocol designed to create a peer-to-peer scheme of storingand sharing data repositories of various kinds in a distributed file system. Itprovides high performance and clustered persistence. Whiledelivering large amount of data to users, a peer-to-peerapproach could save millions of bandwidths. High latencynetworks are a real barrier of entry to developing world.IPFS provides resilient access to data, independent of lowlatency or connectivity to the backbone. It has a publish-subscribe model which focuses on reliability, deliveryguarantee and data persistency data persistency.

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## 2. Literature survey

Many researches and authors have long been using MQTT for IoT and most of them stressed on privacy and security. In [7], ensuring privacy for IoT was given higher priority by applying ABE, grounded on nonspecific Pub-Sub architecture. In this technique a payload is used to encrypt by using Advance Encryption Standard (AES) algorithm which comes under Symmetric key cryptography is used to encrypt the payload and to make sure that the payload size and cipher text size as same, AES key is encrypted with the help of ABE. In [8] the authors argue that, both these encryption techniques i.e. AES and ABE are used to accomplish encryption on limited bits of data which are generated by the IoT will be a computational overhead for IOT devices. Hence in [8] the authors aimed at the optimization of ABE's complex arithmetic operations using suitable cryptography parameters (MQTT-S) instead of performing double encryptions. In [9] the authors proposed a middleware based on Pub-Sub architecture in which CP-ABE and Predicate based encryption is enabled to protect the privacy of subscriber's interest and the published content's confidentiality.
In [10] the authors present the strategy and executionof IoT based Home Automation, a steadfast WSNtechnology will be interconnected through MQTT(Telemetry Transport) protocol to establish thecommunication among diverse devices via Ngrok which is athird-party cloud access provider where the authorcompletely trusts their services, which might lead to apoint of failure and does not unravel the speed of lightproblem.

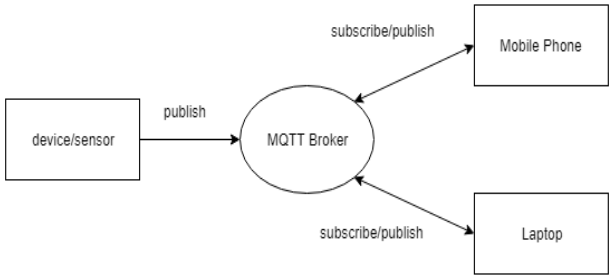



**Fig. 2:** MQTT Publish Subscribe Model.

The challenging aspect in IoT is to introduce privacy forusers' data. So, it is necessary to develop a decentralizedIoT, which should be designed to have a built in privacy [11]. With the decentralized IoT data management userswill have a choice to share and sell the sensor data to thethird party entities without any need of intermediaries.
According to the authors [11] the objective therefore, is toensure that the userdata is not delivered to the centralizedentities by providing a decentralized data access model forIoT. To realize this goal the Blockchain techniques and peer-to-peer communication will play a vital role [12], [11]. The InterPlanetary File System, "IPFS", [13] is a cutting-edgepeer-to-peer distributed file system that seeks to connectall computing devices with the similar system of files i.e.,By trading objects with each other. Unlike all otherTelemetry Transport protocol IPFS also has a publish-subscribe feature which does not require a broker for datatransmission. Which makes it more resilient to severalnetwork based criticization. IPFS has no single point offailure, and nodes do not need to trust each other which it aperfect alternative for MQTT protocol in our research work.

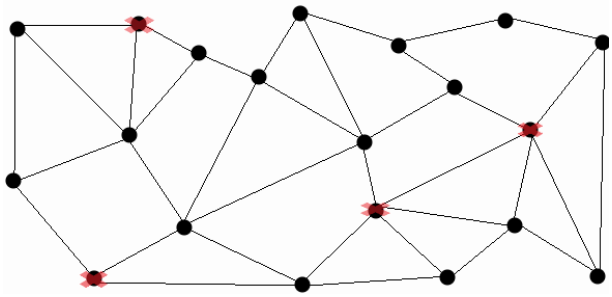


**Fig. 3:** Distributed Network.

As previously discussed centralized IoT devices will have scalability issues in regard to data management and access control which force the users to give their entire data to the third party brokers or intermediaries for managing their data and thus loosing the data privacy [14]. This problem has lead to the research on working with the blockchain technology with the help of peer-to-peer data storage mechanisms [11]. Bitcoin's success is the main motivation behind the research on using the blockchain and peer-to-peer technology. In [15] the authors have stressed on the capability of blockchains in maintaining the data exchanges through an immutable log as well as performing the access control. Access policies around the public key infrastructure of blockchain networks have been created from where the access control element comes from [16].
IBM Adept [17] [11] is a combined effort from IBM and Samsung whose aim is to connect the blockchain and to develop a decentralized platform for IoT. For peer-to-peer communication Adept uses TeleHash, and for peer-to-peer file sharing, an Ethereum blockchain development platform on top of BitTorrent is used. According to [11] "the issues IBM Adept faces in implementing a blockchain based solution for decentralizing IoT are the poor scalability of blockchains and the inherent latency in blockchain consensus". The authors in [15] suggest dividing the IoT blockchain network into smaller sub-networks, since a single blockchain cannot take the load [18]. The Author has explored about various aspects of the file system i.e., which implies security, transparency and data privacy of instigating along with The Internet of Things for a better data and healthy algorithm opacity which lacks the internal protocol security i.e., Encryption. This problem can be solved by open source tool OpenGPG. Thus, captivating all these characteristics into contemplation, A typical order of stages for out problem statement is Initialize the IPFS Daemon–ipfsinit(), Setting the Topic for publish–subscribe, Add Listeners, Encrypt Channel data by Asymmetric Key Encryption, Run scenarios using various cases (Relatedtoaccessibility). Impact of Spoofing on IoT devices are one of the major problem and can be secured by cryptographic algorithms [20].

## 3. Background

### 3.1. IPFS

The Inter Planetary File System (IPFS) is a distributedfile storage protocol that allows computers all over theworld to store and serve files as part of a giant, peer-to-peer network. It is also called as Distributed Web. Everysingle computer that is running IPFS acts as both aclient and a server. In other words, each computerrunning the IPFS software can serve content to any othercomputer in the network, as well as request content fromanyone int the network. Every file added to IPFS is given aunique address derived form a hash of the file's content.IPFS addresses are multi- hashes, which combineinformation about the hashing algorithm used as well ashash output into a single string.

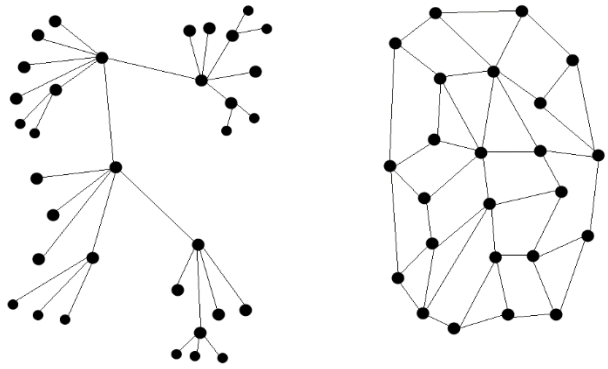


**Fig. 5:** Decentralized and Distributed Networks.

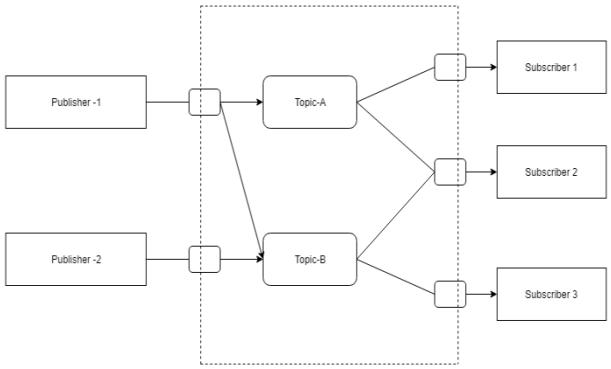



**Fig. 8:** Publish Subscribe Via Topic MoC.

IPFS uses Merkle data format for hashing. Every Merkle tree is a directed acyclicgraph (DAG) where each node is accessed by its name. In Merkle each branch represents the hash of its local contents and naming the children by their hash instead of their full contents. This restricts to edit a node once it is created by preventing cycles, there is no provision to link the first created node to the last node as the reference.

IPFS relies on a distributed hash table (DHT), i.e., amapping from hash to some people who may have thecontent addressed by that hash. The hash table isdistributed because no single node in the network holds thewhole thing. Instead, each node stores a subset of the hashtable, as well as information about which nodes are storingother relevant sections.

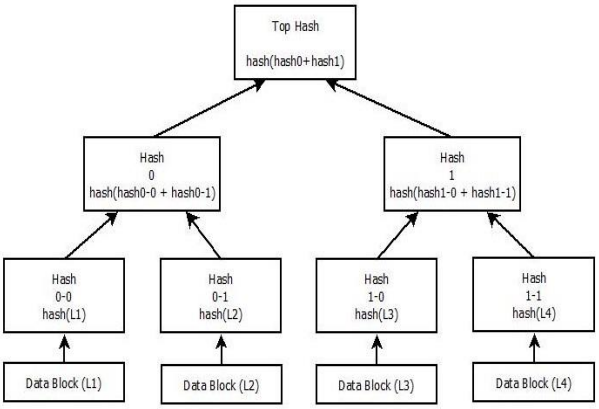



**Fig. 6:** Merkle DAG Hashing Method.

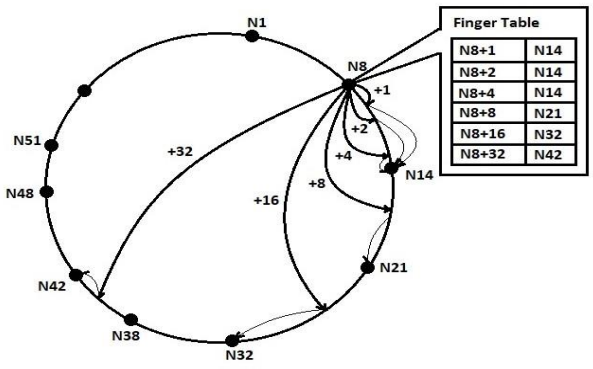



**Fig. 7:** Distributed Hash Table.

### 3.2. PUB-SUB model

Publish-Subscribe, called 'pubsub' for short, is a patternoften used to handle events in large-scale networks.'Publishers' send messages classified by topic orcontent and 'Subscribers' receive only the messages fromthe 'Topics they are interested in, all without directconnections between publisher and subscribers. Thisapproach offers much greater network scalability andflexibility.

### 3.3. Pretty good privacy

Pretty Good Privacy (PGP) provides a combination ofcryptographic methodologies such as digital signatures,hashing and public-key cryptography to keep dataprotected. Each public key is bound to a username or anelectronic mail address. This procedure can be used toencrypt text files, emails, data files, directories and diskpartitions. OpenPGP is a standard of PGP that is open-source for public use. The GPG software is an independentimplementation of the OpenPGP standards, so one can useit to exchange encrypted messages with people usingother OpenPGP implementations.

PGP can be used to send messages confidentially bycombining symmetric- key encryption and public-keyencryption. The message is encrypted using asymmetric encryption algorithm, which requires asymmetric key. Each symmetric key is used only once andis also called a session key. The message and its session keyare sent to the receiver. The session key must be sent to thereceiver so they know how to decrypt the message, but toprotect it during transmission it is encrypted with thereceiver's public key. Only the private key belonging to thereceiver can decrypt the session key.

It also supports message authentication and integritychecking. Because the content is encrypted, anychanges in the message will result in failure of thedecryption with the appropriate key. The sender uses PGPto create a digital signature for the message with either theRSA or DSA algorithms. To do so, PGP computes a hashfrom the plaintext and then creates the digital signaturefrom that hash using the sender's private key.

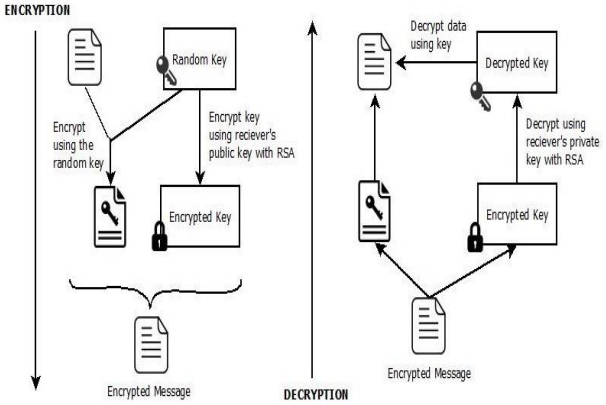



**Fig. 9:** PGP Encryption and Decryption.

## 4. Proposed architecture

### 4.1. Stage 1: (publish - subscribe)

Enabling Publish Subscribe between the end user (PC) and IoT device (Raspberry Pi2).When a message ispublished from the PC, it will be received by both the PCand the Pi as PC is self-subscribed to the topic and Pi is alsosubscribed to that topic.

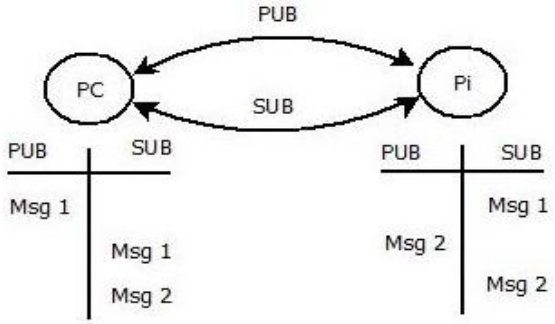



**Fig. 10:** Pub-Sub between PC and Pi.

### 4.2. Stage 2: (transfer files over IPFS)

Adding files to IPFS network and getting the hash for theuploaded file and publishing it to the IPFS network throughpub-sub model.

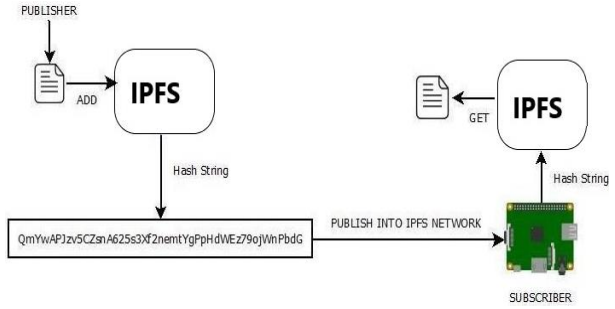



**Fig. 11:** File Transfer through IPFS Network.

### 4.3. Stage 3: (encryption using PGP)

While sending Hash through the IPFS network encryption isbeing done for allowing only the authorized users to decryptthe file and access the contents of it. PGP (Pretty GoodPrivacy) is used to encrypt the file using symmetric-keyencryption and public-key encryption.

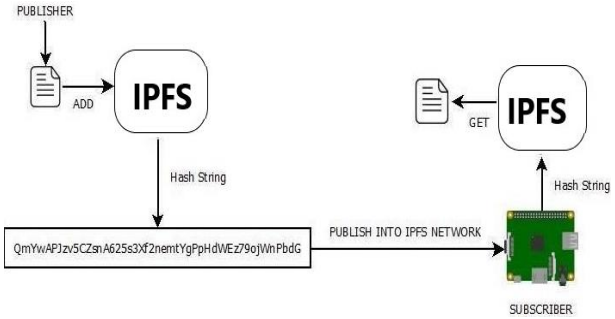



**Fig. 12:** File Encryption Using PGP.

### 4.4. Stage 4

Changing the state of servo based on the data fromthe decrypted file at the subscriber.

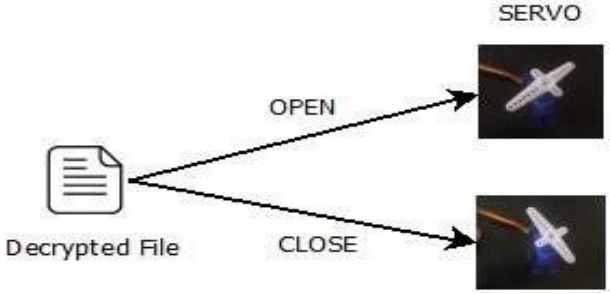



**Fig. 13:** Setting Servo State from File.

## 5. Results

### 5.1. Daemon running through console

Starting the IPFS network by running the followingcommand "ipfs daemon –enable-pubsub-experiment "

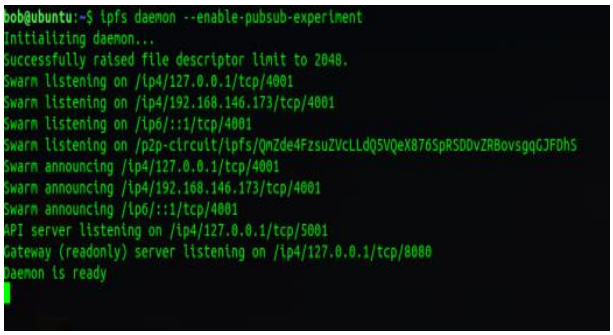



**Fig. 14:** Daemon Running in Console.

### 5.2. Daemon running through the java applet

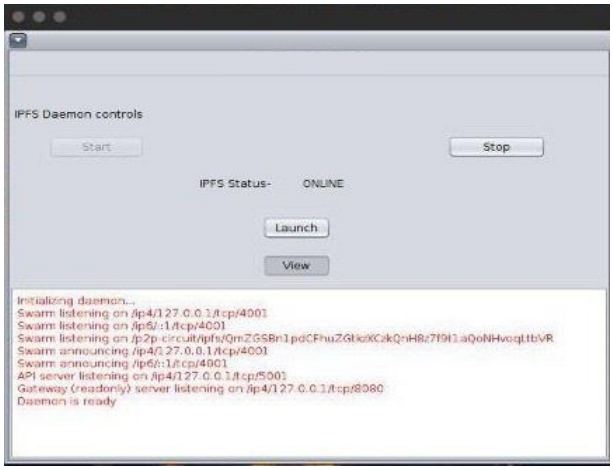



**Fig. 15:** Daemon Running Through Java Applet.

### 5.3. Controlling the servo using java applet

Servo can be controlled by clicking on "OPEN" and "CLOSE" buttons

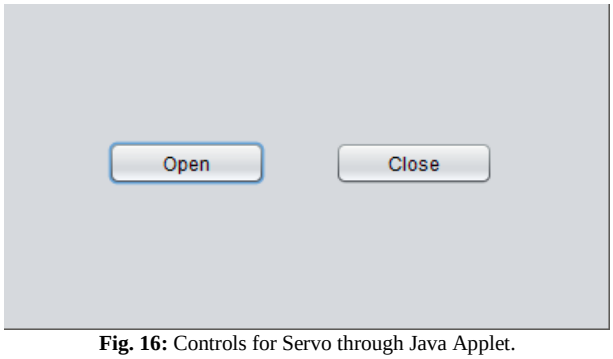



**Fig. 16:** Controls for Servo through Java Applet.

### 5.4. Servo results in terminal

Checking the published value in terminal by running thefollowing command "ipfspubsub sub servo" 0 – CloseAND 1 – Open

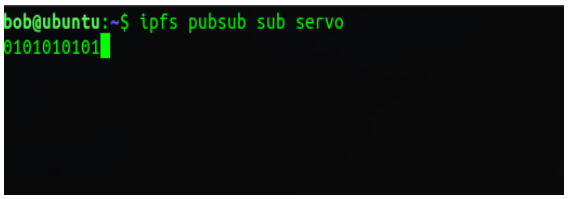



**Fig. 17:** Servo Results in Terminal.

### 5.5. Servo results in debugger console

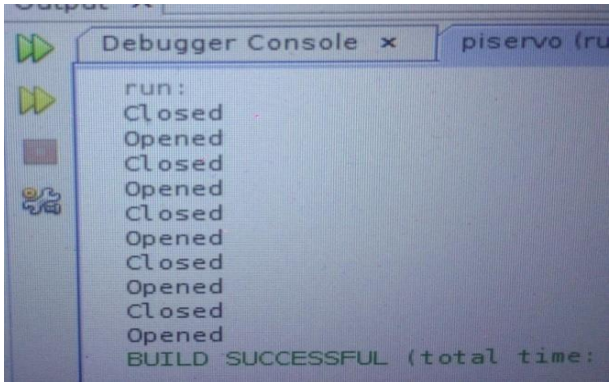



**Fig. 18:** Servo Results in Debugger Console.

### 5.6. Servo states

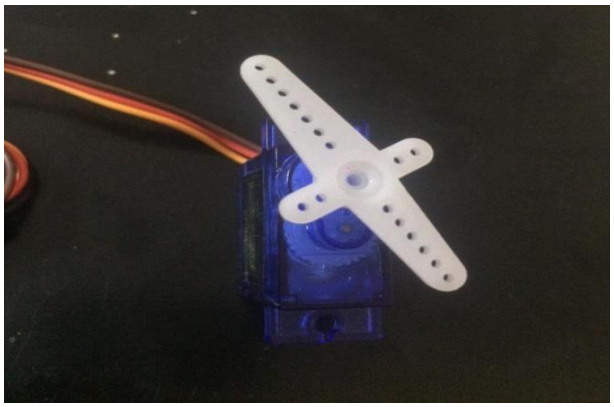


**Fig. 19:** Servo in Open State.

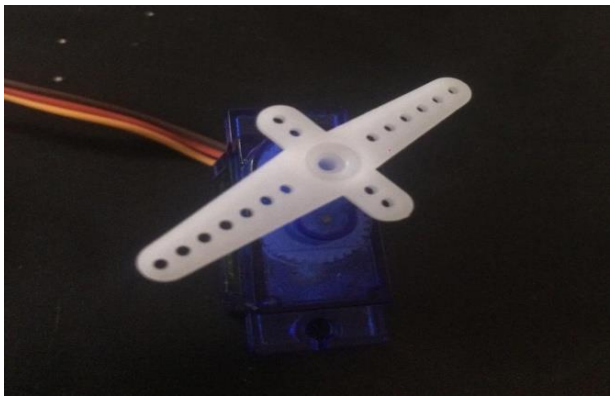


**Fig. 20:** Servo in Closed State.

## 6. Conclusion

Inter Planetary File System indeed plays a major role in the field of D2D communication. It is not only keeps the data secure but also guarantees a total control of the device which can be accessible from any part of the world due to its distributed architecture. The paper presents the use of IPFS in the field of Internet of things as a communication protocol which solves the problem of data accessibility and availability by scaling out centralized servers and cloud platforms. Which makes it reliable and inexpensive for users unlike MQTT.

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