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MANAGING AUTOMATED SWARM SYSTEMS USING BLOCKCHAIN

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Abstract

A cohesive system of automated robots working in unison like a colony of ants, working towards a goal is the basis of swarm systems. Such a system will revolutionize innumerable industrial applications. Such a system requires a complex, reliable and secure infrastructure for inter node communication so that it can function without a governing entity and hence be absolutely autonomous. Blockchain, a decentralized peer to peer network can be incorporated with swarm systems eliminating most of the challenges hindering the evolution of this technology and would add a whole other dimension to the growth of this technology. One of the major issues hindering the development of swarm systems is distributed decision making for example, which path to traverse, relative positioning of the obstacles the system should avoid. Hence, trade-off's such that all participants in the de-centralized network share an identical view of the world and it opens a path to achieve a more progressive collaborative models between the members of the swarm using multi signature technique. Another aspect of using blockchain is the incorporating robust security system for the system as even one compromised node can affect the whole system, resulting in total failure. Blockchain using its consensus algorithm can achieve the required agreement on a single state of the network among all the nodes of the system resulting in a self-diagnosing system. This study will explain how both these technologies can be designed and incorporated in a real-world scenario offering a solution to the limitations of swarm technology. as speed vs accuracy are. encountered. Blockchain offers an effective solution to this problem.

Keywords: Blockchain, Swarm System, Distributed decision making, Multi signature technology.

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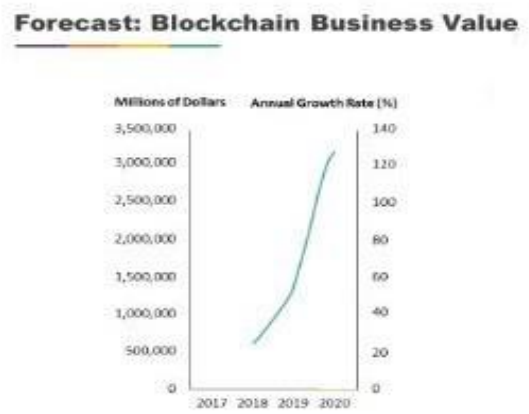
1.BLOCKCHAIN: FINALLY, A STABLE PLATFORM

Blockchain is a growing list of records. These records are treated a s blocks and are interlinked using cryptography. Every block in a blockchain contains the hash of the previous block and a timestamp. These records are stored in a verifiable and permanent way. It is managed by a peer to peer network that validated new blocks and allows inter-node .



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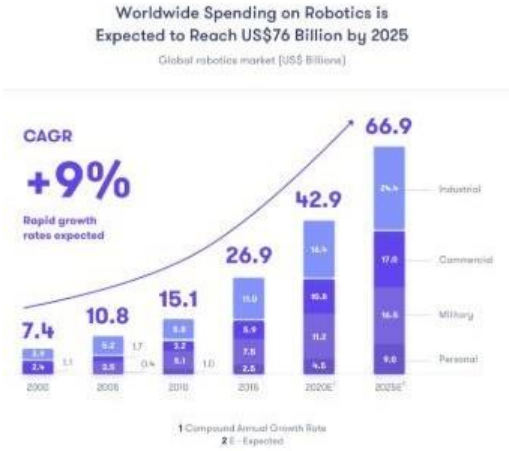
When the data is updated in a block, the block cannot be modified without changing every block that follows it. This requires a consensus by majority by the network, this allows blockchain to be extremely secure. From 2008 when blockchain was first introduced to 2019 , blockchain has travelled a long way in terms of development and usability , now with over 6 million users and over 150,000 transactions per day ,it has become a stable and reliable platform for businesses and entrepreneurs to build their services with the use of blockchain based systems. With an annual market growth of 61.5% and a market size of 210.2 Million in 2016 and a predicted size of 2312.5 million by 2021. Small and medium Enterprises and large enterprises are deploying blockchain solutions and the demand for such solutions is increasing rapidly due to the time and cost effectiveness. Countries like China, India and Singapore are particularly showing rapid growth in blockchain start-ups, this region is expected to show the highest growth rate in the blockchain market. Especially the security benefits of blockchain is enough to propel the growth of this technology,

2. SWARM SYSTEMS

A complete system consisting of several independent systems working in harmony is the backbone of swarm systems. The main advantages being scalability as adding a new system to the infrastructure will allow other systems to instantly incorporate the addition into the workload and without the hassle of reprograming a similar non independent



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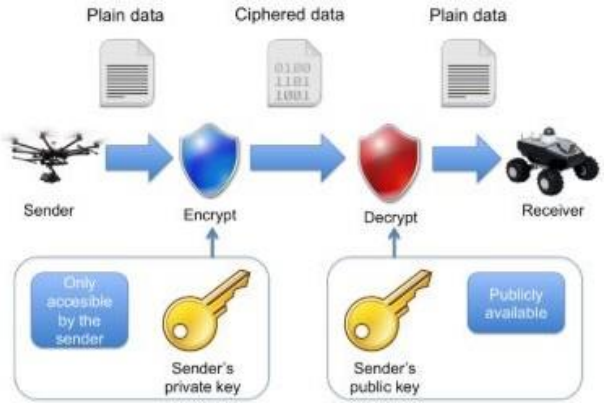
As the cost of robotics continue to decease, the application for such a system is increasing at an exponential rate. Instead of bulky system handling all the workload, it can be divided into several small systems allowing for fail-safe and increase productivity. The potential application of such a system includes task like construction, industrial maintenance and even in armed forces. Inspired by biological systems , such systems adopts the collective behavior of an organized group.

2.1 SECURING SWARM SYSTEMS

Such systems can be secured using public key cryptography, which uses a pair of a public and private key to validate several tasks. The public keys are widely distributed among the members of the swarm systems while the private key is unique to each member. A public key in conjunction with a private key is used to encrypt a message which can be sent through the blockchain channel to the member it is intended for and only the member with the required private key can access that message through the channel.



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Using a private key, a digital signature is created such that any member with the corresponding public key can verify the origin of the message as the person need a private to sign the message and that key is unique to that member, so each message can be tracked.The combination of public key encryption and digital cryptography allows the secure transaction with the ability to prove the identity of a member in the infrastructure.This allows the system to be secure to tempering as if an unverified member tries to communicate through the blockchain, the system will know that the member is unidentifiable and can pose a threat. This allows the system to isolate faults in the infrastructure which is one of the major issue when we are taking about the implementation of such systems in military based application.

2.2.DISTRIBUTED DECISION MAKING IN SWARM SYSTEMS

One of the key factors in the build out of swarm systems. A noteworthy instance is the use of robot swarms associated through ad-hoc networks — MANET — to accomplish distributed sensing applications. These systems have the ability to sense data from various perspectives and, subsequently, enhance the quality of data obtained. Be that as it may, the robots in the swarm need to achieve a global agreement with respect to the object of intrigue — e.g., ways to navigate, shape to frame, or deterrents to stay away from. Subsequently, there is a need to create distributed decision making procedure that guarantee ensured union towards a typical result. Decentralised algorithms have been encompassed in many robotic fields, including real time task

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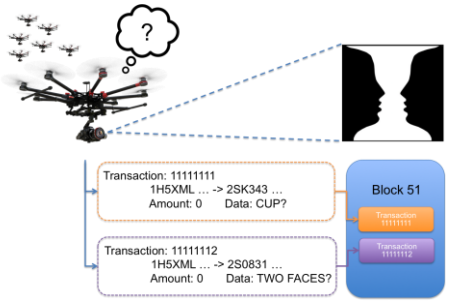
allocation etc. Several well-known trade-offs, such as speed versus accuracy during collective decision-making processes, have been identified Blockchain is a sensational solution to this problem as it offers an identical view of the world. Blockchain allows distributed polling system for distributed systems to reach a consensus using Blockchain Consensus Mechanisms.

Figure 1 outlines a simple instance of the advantage blockchain (hyper ledger) technology impart in the decision making process of robotic swarms. At any instance if a swarm member is in a situation requiring an agreement, it can issue a special transaction, and creates an address linked to all nodes to the form the system has to take depicted in Fig. 1(a). After being included in a block, the information is publicly available and other nodes can vote circumstantially, for example, transferring one token to the address corresponding to their chosen option, depicted in Fig. 1(b). Agreements e.g., by the majority rule — can be obtained rapidly and in a secure and audit-able way since all nodes can monitor the balance of addresses involved in the polling process which is depicted in Fig. 1(c).



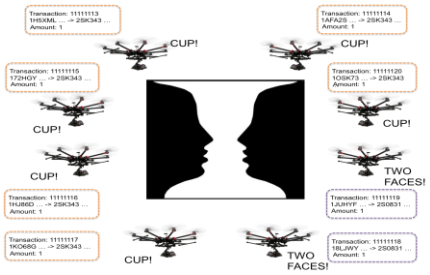
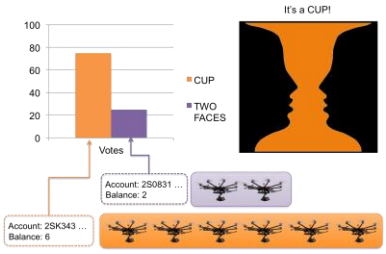


Fig 1©

Fig 1(b)



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Moreover, the incorporation of blockchain technology in robotic swarms opens new horizons to achieve more advanced collaborative models between swarm members using multi-signature (multisig) techniques. Multisig techniques depend on addresses and transactions that are associated with more than one private key. The most basic of multisig address is termed as an m- of-n address where m < n. Complex collaborative missions especially designed for heterogeneous groups of robots are easy to formalize, publish, and carry out in this way. Hence, the validation of blockchain technology in the distributed decision processes of robotic swarms provides added benefits to the robotic swarms' maintainers and operators. Notwithstanding the fact that all understandings and linked transactions are stored in the blockchain, there is no need to induct time in learning and training phases for new robots joining the swarm. Instead, these new nodes will be able to automatically synchronise with the rest of the system by downloading the ledger containing the history of all understandings and knowledge previously discovered and stored in the blockchain.

2.3 BEHAVIOUR DIFFERENTIATION IN SWARM SYSTEMS

The fusion of blockchain (hyper-ledger) technology and swarm handling mechanisms can be useful in overcoming issues that are not bound to security and distributed decision making. According to recent surveys, even though state-of-the-art algorithms have enabled specialized teams of robots to handle individual specific behaviors aggregation, flocking, foraging, etc. —, robot swarms deployed in the real world will likely need to handle a number of different behaviors, for example, by switching from one control algorithm to another to accomplish a given objective. The combination of different behaviors in a swarm has not been diligently

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studied in the literature. However, blockchain a hyper ledger technology establishes the opportunity of linking several blockchain , referred to as pegged side chains, which would enable the system nodes to act in various ways depending on the blockchain being used, where different factors like mining diversity etc., can be tailored to for the requirements.

As Depicted in Figure 2 which represents a typical blockchain (hyper-ledger) configuration in which the mining diversity i.e. the possibility of becoming a miner is allocated amongst system nodes using a round-robin planner. In such circumstances, the control behind the decision in relation to which transactions are a part of the blockchain is distributed and decentralized

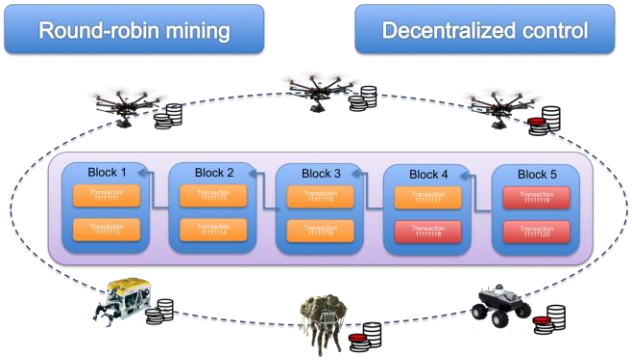

Fig. 2

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LIMITATIONS AND PROBLEMS TO OVERCOME

A. Latency

Bitcoin block takes roughly 10 minutes to be handled. This implies an exchange takes around 10 minutes to be affirmed. Despite that this standard can be adjusted in private blockchains by means of the expansion of various mining arrangements, for example, proof-of-stake, clients in the Bitcoin organize typically hold up until a few blocks are affixed to the blockchain to affirm their transactions. This abatements double spending assault hazard. In this way, dormancy shows up as the time distinction between the minute an exchange is sent and the minute it is affirmed.

The dormancy issue winds up critical are utilized data control or agreeable undertakings. In these circumstances, quick and dependable data is required to arrange the developments of the swarm.

Creative research is expected to address the dormancy issue and to examine which applications are most appropriate for the two closures of the security versus speed exchange off. One conceivable answer for relieve this issue may be to make connection based frameworks in which robots having a place with a similar association or organization are not required to hold up significant lots of time to acknowledge or process transactions among themselves. A notoriety framework could be built from arrangements of past acknowledged transactions inside the gathering to cut these holding up times.

B. Size, throughput and bandwidth

If huge number of robots of the swarm is released at the same time there would be a time where blockchain (hyper-ledger) technology will not be able to keep a track of the transactions. A similar problem is faced by Bitcoin referred to as “bloat” and is of particular importance in swarm systems management where simple robots with limited hardware capabilities are used.

Private blockchain, such as the ones presented in this report, are intended to have a relatively small size. However, the reality is that if a blockchain were scaled to function in mainstream applications, it would need to be big enough to allocate several types of information.

Future researchers in the blockchain field have to trial different accessibility methods to find which is the most suitable for obtaining information from a blockchain. New interfaces such as Chain12 may be able to facilitate automated calls to a blockchain by providing address balances and balance change, as well as notifying agents when new transactions or blocks are created on the network.