Abstract

Electric Vehicles (EVs) are the future of sustainable global transportation. The world is currently going through a paradigm shift in phasing out traditional fuel-based Internal Combustion Engine (ICE) vehicles towards energy efficient EVs. While EVs are indeed eco-friendly, they have their own set of challenges, especially with respect to their charging overhead. In the present scenario, while the number of EVs is increasing day by day, the number of Charging Points (CPs) is not increasing in corresponding numbers to cater to the accelerated growth of EVs. Most of the CPs that are available are concentrated in urban regions with rural areas or countrysides having limited charging infrastructure, giving rise to the so called *range anxiety* among EV owners. Additionally, even with the latest charging technologies, it takes a significant time for an EV to get charged up to a reasonable State-of-Charge (SoC) (SoC represents the amount of charge remaining in the EV battery), thereby leading to sufficiently high queuing delays at individual CPs. Moreover, unplanned charging patterns may overload the backend electric grid as multiple EVs connect simultaneously to the CPs to draw power.

On account of the aforementioned issues, several solution paradigms have been proposed recently, among which blockchain-based solutions have gained significant attention. Through the use of Internet of Things (IoT), the EVs and the CPs form an overlay data communication network with each other, that exhibits a distributed topology over a wide geographic area. Being a distributed and decentralized database itself, blockchain is a suitable candidate to execute over the network of CPs and the mobile EVs. Among other things, blockchain based solutions have been proposed for effective EV charge scheduling and CP placement that provides optimum scheduling for EVs with different charging requirements. Towards the efficient realization for such a blockchain network over EV application scenarios, this thesis aims to enhance and improve the execution infrastructure of the blockchain over resource constrained IoT. Specifically, the works presented in this thesis consider a distributed edge network over constrained IoT nodes (corresponding to the CPs and the EVs) acting as the blockchain miners themselves. Hence, the run-time overheads with respect to the mining parameters have been considered to be effectively improved. First, this work proposes a cross domain communication among heterogeneous IoT nodes along with a least-hop wireless routing protocol for fast route discovery and seamless data exchange between edge IoT clusters.

This helps in faster block mining by maintaining appropriate routes and communication channels among the miners. Next, the thesis proposes a geographic segmentation of the distributed mining pool of the IoT nodes, which clusters the set of available IoT miners into segments each of which execute parallel block mining. The proposed segmentation can be dynamic in nature, where bigger segments are divided into smaller clusters and smaller clusters are merged to form large segments. Hence, the next work considers a branched blockchain architecture over each miner of the segmented domain, such that the view of the blockchain as a whole starting from the genesis block remains the same, but consistent with the dynamic resizing of segments. In order to efficiently execute resource heavy mining at the edge, the subsequent work proposes an adaptive solution whereby edge IoT nodes can be programmed on-the-fly and on-demand to change their real-time configurations. This enables them to act as minute Turning complete computational cores through reverse task offloading, leading to a speedup in edge block mining. As mining computations are predominantly being considered over constrained IoT nodes, it is imperative that the security, trust and the integrity of the nodes must be maintained at all times. Towards this, the next work proposes a truly novel scheme inspired from quantum entanglement where pairs of IoT nodes separated physically are put into a mutual back and forth 'communication', whereby they exhibit properties similar to entangled qubits. Through this, the nodes are made to ensure that the integrity of their computational, memory and storage mechanisms are strictly maintained for them to act as trustworthy mining nodes.

The works and ideas presented in this thesis are expected to provide a holistic framework for enabling edge blockchain mining over IoT. By proposing solutions that mitigate mining challenges over constrained nodes coupled to distributed roadside EV infrastructure, it is envisaged that with the growing adoption of EVs, issues such as charge scheduling, trip feasibility and rage anxiety can be effectively managed through decentralized blockchain algorithms.

Keywords: Blockchain, Electric Vehicles (EVs), Internet of Things (IoT), mining infrastructure, geographic segmentation, parallel mining, adaptive computing, reverse-task offloading, quantum-like entanglement, mining integrity