

An Utility based Peering Strategy for P2P IoT Network

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The rapid penetration of IoT has ignited umpteen possibilities to heterogeneous devices to blend within a network. To support the ever growing demand of IoT, Fog computing has uncovered a new paradigm of edge computing. In addition, peer-to-peer in IoT has also enabled a robust decentralized communication model where the IoT devices with same capability can cooperate with each other to lessen the workloads between peers to provide a balanced utility for the P2P IoT network. This paper addresses the peering strategy for establishing a P2P IoT communication network by using Irving's matching algorithm. We studied the performance of the proposed matching algorithm through simulation which indicates the benefit of using Irving's matching algorithm to solve the peering problem efficiently in IoT.

1. Introduction

The vision of IoT is to create a network of smart objects or things where billion of devices can operate autonomously without any human intervention. A study [2] by Gartner estimates that around 20 billion devices will be connected to the existing network by the year of 2020 which excludes the traditional smart phone, laptop and tablet pc. These devices will possess various kind of resources and capabilities where the demand for high-end IoT devices will increase exponentially in the coming decades. Moreover, these high-end IoT devices are well enough to work in a decentralized way so that the devices can share their network resources among themselves in order to efficiently utilize the network resources for better utility of the IoT network. Thus the concept of P2P in IoT will be crucial in near future where the IoT network will be distributed and decentralized to lessen the burden of workloads of peer IoT devices [3]. In addition, there are different sort range of communication medium like NFC, WiFi-Direct and Bluetooth which makes it possible to establish P2P communication model between IoT devices. In [5] the authors has used NFC communication medium for the IoT devices which ensures better throughput with low power consumption for secure P2P IoT transactions by proposing a new security protocol. Apart from that, an useful technological trend for distributed IoT is pervasive computing techniques like cyber foraging. This technique is vastly used to lessen the burden of the currently resource constrained IoT network by off-loading the heavy work to the nearby stronger

surrogate machine [4]. The main contribution of this paper is to propose an efficient strategy for establishing an utility based P2P IoT network to achieve a better network resource utility for IoT devices. There are some existing proposals [5]-[7] for matching game but these mainly focus on two sided matching strategy whereas this paper addresses the issue of one sided matching for creating stable one sided network utility based matching game to create P2P IoT network.

2. System Model

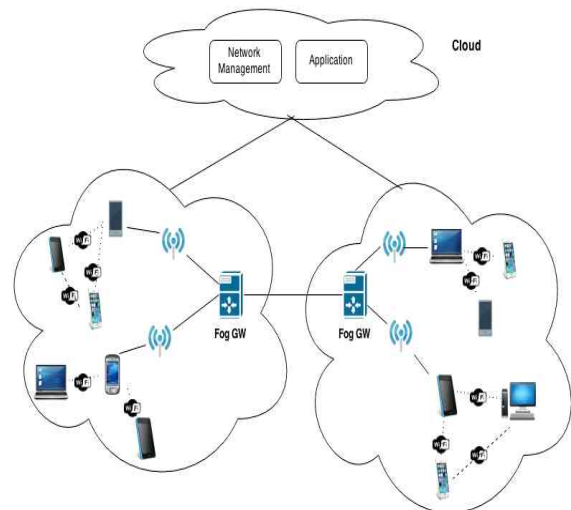


Fig. 1 System model for Fog based P2P IoT network

Fig. 1, represents the system model where there are n number of MIMO enabled IoT devices within a device set $S = d_1, d_2, d_3, \dots, d_n$. These devices are willing to

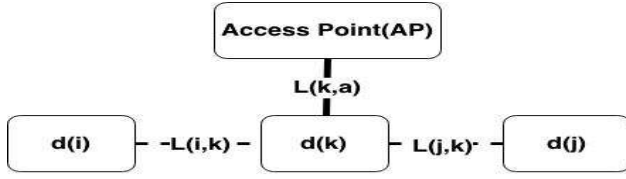


Fig. 2 Peer link between entities

establish peer-to-peer connection among themselves in Fog using WiFi-Direct in the Fog environment[8] as their communication medium. Each of the devices have individual utility based preference list P where the other devices in the set are ranked based on the utility for data flow. The size of the preference list should be $n-1$. There is also quota q for all the IoT devices which indicates the number of devices that any individual device can support simultaneously. Lets consider two devices in the device set d_i and d_j with one quota each. There is also another device d_k with quota two and together they want to pair with each other in order to establish a peer-to-peer connection.

In Fig. 2, let's assume in each time slot t , d_k is sharing its network resource using two links for d_i and d_j which are $L_{i,k}$ and $L_{j,k}$ with capacity $c_{i,k}$ and $c_{j,k}$ respectively. The device d_k has one link $L_{k,a}$ with capacity c_k connected to wireless access point(AP) a and used by both the links $L_{i,k}$ and $L_{j,k}$ for their data flows. The data rate of links $L_{i,k}, L_{j,k}$ and $L_{k,a}$ are $x_{i,k}$, $x_{j,k}$ and $x_{k,a}$ correspondingly.

$$R_{i,k}(t) = \frac{\log(x_{i,k})}{t} \quad (1)$$

$$R_{j,k}(t) = \frac{\log(x_{j,k})}{t} \quad (2)$$

$$R_{k,a}(t) = \frac{\log(x_{k,a})}{t} \quad (3)$$

In (1),(2) and (3) respectively represents the rate of the data flow in links $L_{i,k}$, $L_{j,k}$ and $L_{k,a}$ over time slot t .

$$C_{i,k}(l,t) = p_i * [R_{i,k}(t) + \frac{C_i}{P_i} + B_i(l,t)] + s_i * l \quad (4)$$

$$C_{j,k}(l,t) = p_j * [R_{j,k}(t) + \frac{C_j}{P_j} + B_j(l,t)] + s_j * l \quad (5)$$

$$C_{k,a}(l,t) = p_k * [R_{k,a}(t) + \frac{C_k}{P_k} + B_k(l,t)] \quad (6)$$

In (4) and (5) is the cost for data flow to d_k where p_i

and p_j are the flat rate prices that d_i and d_j have to pay in form of virtual currency to d_k . for using its link for their l bit of data through the data flow. $\frac{C_i}{P_i}$, $\frac{C_j}{P_j}$

and $\frac{C_k}{P_k}$ are the processor utilization for data flow where C_i, C_j, C_k are the processing time and P_i, P_j, P_k are the processing period. s_i, s_j are the service prices that d_i and d_j have to pay. In (6) is the cost that d_k has to pay because of the data flows of d_i and d_j to access point.

$$U_{i,k} = \gamma_{i,k} * l - C_{i,k}(l,t) \quad (7)$$

$$U_{j,k} = \gamma_{j,k} * l - C_{j,k}(l,t) \quad (8)$$

$$U_{k,a} = s_i * s_j * \gamma_{k,a} * l - C_{k,a}(l,t) \quad (9)$$

In (7),(8) and (9) are the utility for d_i , d_j and d_k where $\gamma_{i,k}, \gamma_{j,k}, \gamma_{k,a}$ are the flat rate pricing factor that can be set based on the number of packets that are transmitted in the data flow.

3.Irving's Matching Algorithm for Peering problem in P2P IoT

Based on the system model in Section 2, by using Irving's matching algorithm [1] we have provided a solution to solve the peering problem between IoT devices where the devices can create one-to-one and one-to-many utility based stable peering in IoT. As such, each IoT device creates a ranked utility based preference list where each of the device will map other devices in the set. If the devices form peering between themselves, the particular peer can be identified as "stable peer" if both the entities in the peer prefer each other the most in their list. The algorithm starts with individuals making sequence of proposals from the first devices in its list to peer in the first stage. The proposed devices will either accept if it has not received any proposal before or will reject if it has already holds better proposal than current proposal. The first stage will continue until each of the device will hold a proposal for peering or one device will be rejected by all the other devices. The algorithm will continue to second stage by creating a reduced list by rejecting the devices which are less preferred than the current preferred device. In the second stage if any device hold more than one device in its list, The algorithm will again continue to third stage and will imply the reduction policy to form a one-to-one stable peering. In case of quota base peering policy for the devices, the algorithm will continue to fourth stage if

still there are devices which have quota left to peer. In such situation, the rejected devices will again propose to the devices which have more than one quota left to peer with. At this point, if the devices fulfill their quota requirement or there are no quota left for further peering, the algorithm will stop.

4.Simulation and Result analysis

Table I Simulation parameters

5 Conclusion

In this paper, we have proposed a utility based P2P pairing algorithm with quota to establish a P2P IoT network. The simulation results show the efficiency of the proposed peering algorithm which eventually solves the Peering problem in P2P IoT. In future we will consider the contextual externalities in P2P IoT for optimized peering.

Number of Nodes	10
Number of node pair	5
Range	50 x 50
Uplink data rate (AP)	~ 0.75 Mbps
Downlink data rate (AP)	~ 4.2 Mbps
Uplink data rate (WiFi-Direct)	~ 20 Mbps
Downlink data rate (WiFi-Direct)	~ 30 Mbps
Packet size, <i>l</i>	2048 bit

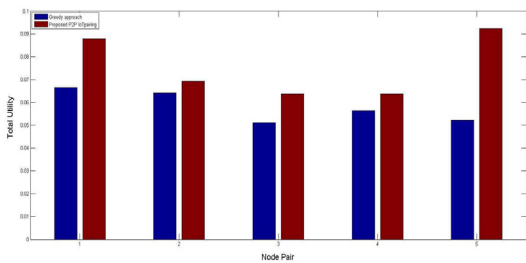


Fig 3 Comparison result between proposed P2P IoT device matching and P2P pairing using greedy algorithm in case of total utility of links

Fig. 3 is the performance of the proposed P2P pairing algorithm. The simulation parameters are in Table I. The comparison result shows the efficiency of using the proposed utility based P2P IoT device matching algorithm for 5 pairs of nodes with quota. The proposed algorithm is compared with the greedy algorithm which considers neighboring nodes for pairing. The proposed P2P matching is efficient because of the proposed algorithm is the combination of quota based approach and utility based selection of nodes for peering. The proposed peering strategy for IoT devices increase the total utility of the links.

Acknowledgement

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