Smart Agent Based Data Aggregation for Smart City

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Abstract

Smart City is the vision of future modern intelligent technology toward the sustainable development of green technology and social development. Smart services e.g. smart transportation, smart health, smart home, smart grid, smart retail, smart security and many more service request IoT based applications are the key enablers of Smart city, which ensures the quality life and well-beings. To enable those services i.e. smart traffic system or smart security system the application requires to gather data from numerous IoT nodes. In such case, it becomes more challenging for huge network traffic and centralized network AP in Smart city. Therefore, in this research we have focused on solving this problem by introducing Smart agent in data aggregation from distributed dense network of Smart city to fulfill service requests from service providers and smart citizens. To be specific, here, we have modeled a peer to peer fully distributed system by using distributed hash table Chord protocol and algorithm for IoT network and also designed Smart agent based path searching algorithm for crowdsourcing. Finally, we have simulated the result of the proposed Smart agent based data aggregation model and we have found higher performance gain of the proposed approach in respect to service fulfillment time and convergence.

1. Introduction

Smart city shall be able to integrate understandably and seamlessly an enormous number of different and heterogeneous sensors and actuators with micro controller based devices like, surveillance cameras, smart grid monitor, smart traffic monitor (speed meter and geo monitors), temperature monitors . An amount architectures, protocols, and enabling technologies for Smart city research is ongoing based on IoT networks [1][3][7]. The data center is linked to a set of services, such as electrical energy, water, and central and gas supply provided in smart cities. Agents are goal oriented, autonomous, adaptive, and cooperative [2]. Smart agent is more intelligent and adaptive to achieve the target.

Smart city like environment has a more than a billion of IoT nodes. In Figure 1 shows a typical Smart city area with APs (red dot) and IoT nodes (blue dot). It is very challenging for a single point controlled network to provide quick response for the massive number of request in real time. As the generic system model of a Smart city all the sensor node gives the data to cluster head and cluster head takes decision about the sensor data for sending to single point receiver [4]. Moreover, if we need real time traffic data or real time security camera data which is very big in size because it contains some real time video or still images with the raw sensor data [3]. On the other hand the major problem of centralized network is, if somehow collapse the center part then whole Smart city network is being clampdown.

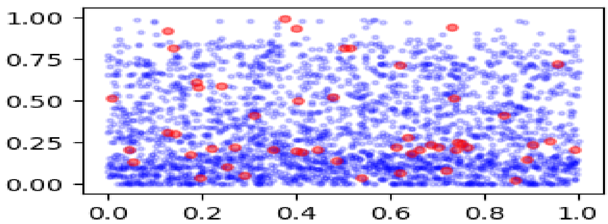

Figure 1: APs (red) and IoT nodes (blue)

Smart city has a number of smart applications, for security system there are many security camera in the city which are connected with some APs. Now at this moment the security manager needs 10 security camera real time data. In a typical IoT sensor network user need to send request to the server or center AP [1]. So, there are delayed and also it depends on a single point AP. Now the research question is, if somehow the centralized AP is clasped or large number of data request come to that AP then how the AP will provide services for the requester.

In this paper, we have proposed a fully distributed peer to peer Chord network for Smart city [5] and a Smart agent based data aggregation technique for a particular Smart city services like, smart security, smart traffic smart navigation and so on. When service fulfillment or data collection request has come to the Smart agent then it is responsible for finding the AP list for those particular IoT nodes from the chord lookup table and it calculates the shortest path for these APs. Finally, Smart agent travels via the shortest for the request fulfillment.

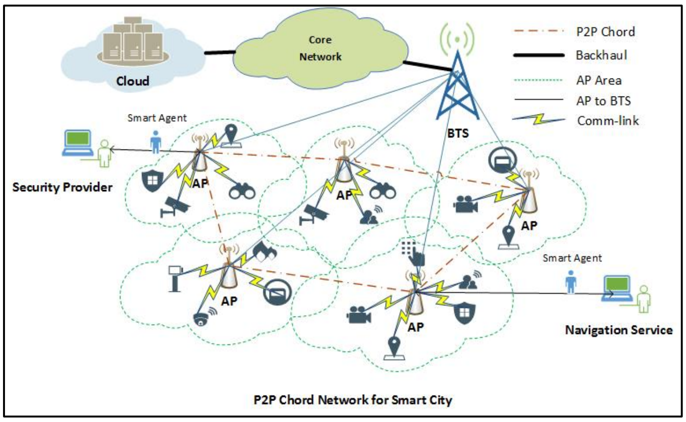

Figure 2. System Model

2. System Model

The system model of Smart agent based data aggregation for Smart city IoT network are presented in Figure 2. We have proposed a DHT based peer to peer distributed network for Smart city, where the every AP are the node and all others IoT nodes are the elements of any AP. So, the sensor devices are assigned one hash key when it connects with the AP. We maintain a finger table for the whole network. APs are connected with the BTS and there are backhaul connection between the BTS and core network. Cloud connected with the core network. Smart agent also is a part of distributed system and there would be multiple agents in a network.

3. Problem Formulation and Algorithm Design

We assume that, APs are in chord network. In this scenario, the traditional service fulfillment approach is, find all pairs shortest path and construct a simplified graph for the candidate node. By using new graph the Travelling Salesman technique solves the problem. TSP can be formulated as an integer linear program [8].Label the nodes with the numbers *1… n* and define:

$$x_{ij} = \begin{cases} 1, & \text{the path goes form node 1 to node } j \\ 0, & \text{otherwise.} \end{cases}$$

For $i = 1\ldots n$, let u_i be a dummy variable, and finally take c_{ij} to be the distance from node i to node j. Then TSP can be written as the following integer linear programming problem:

$$\min \sum_{i=1}^{n} \sum_{j\neq i, j=1}^{n} c_{ij} x_{ij}:$$

$$0 \le x_{ij} \le 1 \qquad i,j = 1,\ldots,n$$

$$u_i \in Z \qquad i = 1,\ldots,n$$

$$\sum_{i=1, i\neq j}^{n} x_{ij} = 1 \qquad j = 1,\ldots,n$$

$$\sum_{j=1, j\neq i}^{n} x_{ij} = 1 \qquad j = 1,\ldots,n$$

$$u_i - u_j + n x_{ij} \le n - 1 \qquad 2 \le i \neq j \le n$$

But this is a NP-hard problem. For this reason to solve this problem we have used a heuristic approach. Smart agent finds the AP list for candidate nodes from the Chord lookup and calculates the all pairs shortage path then finds the destination path for the requested APs. If we need to find permutation arrangement of k elements out of a given set of n elements then we have the following formula:

$$n(n-1)(n-2)\ldots(n-k+1)$$

Finally, Smart agent fulfill the request by traversing the shortest path. Smart agent service fulfillment algorithm's basic steps as follows:

Algorithm 1: *SmartAgent(reqAP, reqItems[])*

1. {
2. APList = findFingerTable(*reqAP, reqItems*)
3. AllPath = allPairShortestPath(APList)

```
PemList = findPerrmutation(APList)
ShortPath = findShortestPath(AllPath, PemList)
Data = fullFillRequest(ShortPath, reqItems)
}
```

Algorithm 2: Perrmutation(int ind, int bits, int num)

```
{
if (ind == 0) { if (bits == 0) { addToArray(num); }
Return }
if (ind-1 >= bits) Perrmutation (ind-1, bits, num);
if (bits > 0)Perrmutation (ind-1, bits-1, num | (1 << (ind-1)));
}
```

4. Performance Evaluation

Here, we have evaluated the performance of the proposed approach by using simulation with java platform. Also used python platform for the result analysis. We have developed individual java application for Smart Agent (Figure 4) algorithm evaluation.

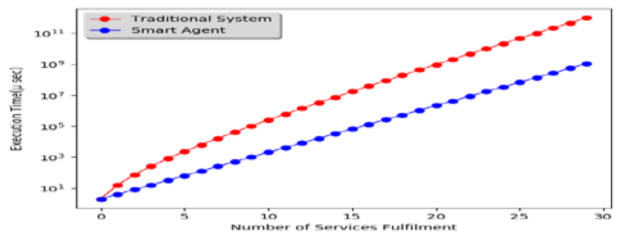

Figure 3: Execution Time Comparison for 1 to 30 request

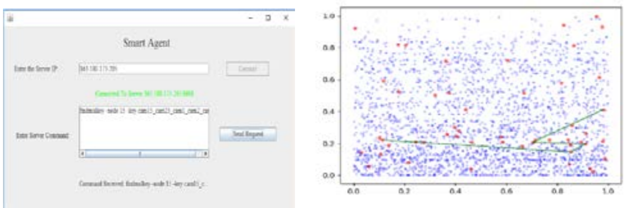

Figure 4: Smart Agent App and Smart City Network

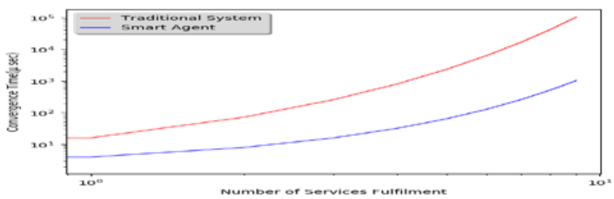

Figure 5: Convergence result previous vs proposed system

Chord network is implemented by using open chord APIs' and the complexity of N-node network, each node maintains information about only *O(log N)* other nodes, and a lookup requires *O(log N)* messages. The average time complexity of our solution is $O(2^n)$, where optimal solution TSP is $O(2^n n^2)$ and in each sub problem for this is $O(2^n n)$. For this evaluation we have considered 51 APs and 2601 sensor nodes. Figure 3 and Figure 5 have compared the result between proposed system (blue line) and traditional (red line) approach.

5. Conclusion

Smart agent based data aggregation is a novel approach that enables Smart city services. The proposed approach substantially helps reducing the network overheads by introducing decentralized network management. Additionally, the computational and data aggregation responsibilities are dispersed to multiple APs instead of single AP. This method will significantly reduce the risk of network failure in dynamic environment.

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