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**Survey on clustering method in Wireless Sensor Network and routing method in Mobile Ad Hoc Network**

**Abstract --- Our project mainly focuses on exploring data collection and routing mechanism in IoT island, where IoT devices are isolated with outside network due to lack of network infrastructures. To achieve the connectivity between the disconnected devices and the outside network access point, we will present a clustering method which aims to choose the cluster heads and the rendezvous points inside the IoT clusters and a data routing protocol which regulate the data collection and forwarding processes. This paper lists some past researches on clustering method in Wireless Sensor Network and the Position Based Data routing protocols in Mobile Ad hoc network. In which the rendezvous point-based clustering mechanism is our main reference for clustering method in our simulation. Also, the proposed shortest path-based routing method in urban bus system inspired a lot by the position-based routing mechanisms in Vehicular Ad Hoc Network.**

**1. Introduction**

In this project, we are exploring data collection and transmission in IoT island, where IoT devices are isolated with outside network (cannot connect to network access point directly) due to lack of network infrastructures. In order to achieve the connectivity between the IoT devices and the outside network, we are going to propose a clustering method first, which can partition IoT devices into multiple clusters depending on their spatial location and choose the cluster head which will act as a local sink to gather data form surrounding neighboring nodes. Then, we will elect the rendezvous point (the wayside local sink) according to the predefined trajectory of mobile sinks, which enables the pre-stored data can be transmitted to mobile sinks in a single hop way. After IoT data being gathered, we will dispatch the mobile sinks to collect data from the rendezvous points. With the help of public transport system, we will enable bus to act as the mobile data sink whose movement routes are predefined and come from real urban bus system. With the purpose of routing the data loaded on the mobile sink to the network access point (the data sink connecting to the outside network) with minimal data transmission delay, we proposed a shortest path-based routing method with the help of the urban bus system and depository point in intersections. Using the knowledge of graphics, we abstract the real bus route network into a directed graph, in which nodes denote the intersection of paths, and each link directs to the node which owns shorter shortest path length to destination node (the network access point) than that of the other endpoint. Besides, each node maintains an outgoing direction, which is the direction of the next link in its shortest path to destination node. And we rule that, the mobile sink currently locating in one link can collect data from rendezvous point only if it moves following the direction of that link. Moreover, in each intersection, we will deploy a depository point which will work in a store-and-forward mode. If a mobile sink going across one intersection with an ongoing direction which is not the outgoing direction of that node, then the depository point in that intersection will store the data carried by the mobile sink and try to forward that message to another mobile sink which is going toward its outgoing direction later. Otherwise, it do nothing. This paper lists the main reference of our research. Section 2 shows some related work of clustering method in Wireless Sensor Network in which the rendezvous point-based clustering mechanism is our main reference for clustering method in our simulation. Section 3 demonstrates some existing work on position-based data routing methods in Mobile Ad hoc network which are the reference for our proposed Shortest path length-based routing method in urban bus system.

**2. Mobile Sink Based Data Gathering Approaches**

The adaptive behavior of MS can minimize the wastage of energy in data forwarding even though these advantages are MS path trajectory dependent because sensed buffered data should be gathered within a given time limit especially in delay-sensitive applications.

[2] proposed a routing protocol which is based on adaptive and biased sink mobility along with need-based clustering. Firstly, they use mobile sink to traverse from dense region to sparse region according to the density of nodes for ensuring efficient big data collection. Then they use need-based clustering to minimize the data collection time or power consumption of the nodes.

[3] tried to reduce the MS route length in WSNs by considering rendezvous points (RPs) approach. RPs are used to store the data from normal nodes and communicate buffered data to MS. The MS must arrive at stop points to accumulate data from the WSN. This algorithm alleviates the data latency problem by optimizing the density of stop points of MS while ensuring whole network coverage.

[4] utilized Closest Rendezvous Points (CRPs) technique instead of random RPs selection. This approach has shorter data collection path and it is further decreased while multiple mobile elements (MEs) are used.

[5] made MS visit only selected points (which is also termed as RPs) in appropriate time instead of normal nodes or all the nodes. The normal nodes just need to transfer data via multi-hopping to their nearest RPs. Weighted Rendezvous Planning (WRPs) heuristic is used in [13] to compute the MS tour that stops at these RPs and weights each node according to its hop distance from the MS path trajectory and the amount of data it forward to its closest RPs.

[6] used a clustering method to minimize the data propagation delay. In this approach, each node maintains a one hop distance from their closest Cluster Head (CH). CHs firstly perform data fusion of cluster nodes data as a collection point (CP) and then the MS reaches all selected CPs for capturing the whole data.

[7] introduced an adaptive route adjustment schema for grid formation for periodic data collection from WSNs. The algorithm finds optimal routes to the latest updated location of the MS and decreases the network overhead. The algorithm also makes use of virtual backbone network (VBN) to timely update the minimal cost route by tracking the MS current location position and its movement.

[8] collected the big data load from a great number of servers using RPs method. MobiCluster protocol here uses he urban buses to carry MS for retrieving sensed data from the remote area of WSNs. Multi-sized clustering mitigates the hot-spot problem and improves network throughput while rendezvous node (RNs) selection guarantees connectivity of sensor domain with MSs and enables timely data collection. The selection process is done based on remaining node energy and Euclidean distance among SNs and the MS.

[9] adopted tree topology along with clustering approach with the help of MS. The algorithm consists of three parts: tree construction (calculating weight of each node according to its residual energy, distance to BS, number of two hop neighbor and average residual energy of one hop neighbor), RP and SRPs selection (choosing highest weight nodes to be RPs and SRPs in respective cluster) and data collection (using MS to gather data from RPs and SRPs).

**3. Position Based Routing Protocols in Vehicular Ad Hoc Network**

VANET is the wireless network that exists between moving vehicles and nearby roadside equipments. It is a wireless Ad hoc network which allowing short and medium range communication. VANET differ from the existing Mobile Ad hoc network (MANETs) by some of it characteristics. One of them is high speed of vehicles in VANET, which makes it a challenging class of Ad hoc network. With this high speed of vehicles routing protocols play an important role for successful delivery of packet to destination.

VANET has three type of architecture, pure cellular, pure Ad hoc and hybrid. In pure cellular architecture the communication among vehicles cannot take place directly. For this, road side units (RSUs) are required. This communication comes under infrastructure to vehicle (I2V) communication. In pure Ad hoc architecture, vehicles don’t take the help of RSUs to facilitate the vehicular communication. It is an infrastructure less network in which vehicles communicate directly with the help of sensors. This is vehicle to vehicle (V2V) kind of communication. Hybrid architecture of VANET is the mixture of both cellular and Ad hoc architecture. Here, if RSU is available then vehicles take the help of it otherwise direct communication takes place.

**3.1.1 Greedy Perimeter Stateless Routing (GPSR)**

GPSR is a novel routing algorithm which uses location of destination and intermediate nodes to take the forwarding decisions. It uses greedy approach to select a node from its immediate neighbors as a next forwarding node. Beaconing method is used to find out the location of neighbors.

**3.1.2 Greedy Perimeter Stateless Routing with Advanced Greedy Forwarding**

**(GPSR + AGF)**

To overcome the inconsistence of neighbor table and the moving destination node, advanced greedy forwarding was added. In this algorithm both the source and destination node inform each other about their velocity vectors. Sending node also adds their packet processing time into packet header to update the packet travelling time. After receiving a packet, the node searches in neighbor table whether the destination is listed in it or not. If destination is present in neighbor table, then the packet will deliver to destination. Otherwise, a new location of destination will be calculated by considering velocity vector and the packet will forward to a neighbor node, making maximum progress towards destination.

**3.1.3 Greedy Perimeter Coordinate Routing (GPCR)**

GPSR + AGF doesn’t work well in city scenarios due to the need of another algorithm to planarize the graph. GPCR takes the advantage of the fact that roads and junctions form planner graph and hence there is no need of any other algorithm to make planner graph.

**3.1.4 Connectivity Aware Routing (CAR)**

CAR is a novel routing protocol which can not only find out the position of destination but also finds paths between source and destination. Most routing protocols in VANET required the position of destination. If we evaluate routing protocols with this assumption, then it may hide the several overheads. To overcome this problem and to validate the routing protocols more accurately, connective aware routing protocol (CAR) is proposed.This protocol consists of destination location, path discovery, data packet forwarding, path maintenance and error recovery modules. Adaptive beaconing method is used in CAR, in which frequency of hello beacons depends upon the number of neighbors. During path discovery any node can add itself as an anchor if its velocity vector is different from previous forwarder. After path discovery CAR forwards the packed in greedy manner on the anchored path.

**3.1.5 Contention Based Forwarding (CBF)**

The high speed vehicles would cause VANET highly dynamic beacons providing inaccurate position of vehicles. To avoid this situation, CBF follows greedy forwarding with all available neighbors participating in next forwarding hop selection process. Next forwarding hop selection process is based on the actual position of neighbor nodes and this process is known as distributed contention process. In this protocol each forwarding node broadcast the packet with last hop ID, destination ID and packet ID to all of its neighbors. After receiving a packet, neighbor nodes start a timer. A node whose timer expires early will suppress all other competing nodes.

**3.1.6 A Map-Based Stateless VANET Routing (GeoSVR)**

GeoSVR is a routing which considers local maximum, sparse connectivity and wireless channel conditions. This routing protocol combines two algorithms: optimal forwarding path selection and restricted forwarding algorithms. Optimal forwarding path selection algorithm removes the problem of local maximum and sparse connectivity. Restricted forwarding algorithm removes the impact of unreliable wireless channel.

**3.1.7 RIVER: A Reliable Inter Vehicular Routing Protocol for Vehicular Ad Hoc Network**

RIVER uses undirected graph and selects the street as a forwarding path by real time traffic information. This is a position based routing protocol which forwards the packet in greedy manner up to nearest anchor point. Position of neighbors is identified through beacon messages and it also uses preloaded street maps to identify the location of anchor points and destination. RIVER uses active and passive monitoring to find out whether a message can be sent through a particular route. Probe message is used for active traffic monitoring while passive monitoring is performed by each vehicle which is receiving packets. A crucial component of RIVER is reliability and hence each node assigns weight to every known edge with the help of active and passive monitoring. A small weight to an edge shows higher reliability, large weight indicates unreliable path and a maximum weight shows path is not traversable. Compare to other protocol, RIVER has more throughput but also more delay due to additional hops in the algorithm.

**3.1.8 VWCA: An Efficient Clustering Algorithm in Vehicular Ad Hoc Network**

Scalability is one of the challenges in VANET. Clustering can be used as a solution for scalability problem. This is a clustering algorithm and it is the combination of three algorithms which are the vehicular clustering based on weighted clustering, adaptive allocation of transmission range (AATR), and monitoring of malicious vehicles (MMV).

**(a)Vehicular clustering based on weighted clustering**

This algorithm is proposed to optimize the process of cluster head election. Cluster head election process is based upon the distrust value of vehicles. This algorithm creates the neighbor list then determine the priority and direction of vehicles. Next, it calculates entropy and the weighted clustering values.

**(b) Adaptive allocation of transmission range (AATR)**

Due to the high speed of vehicles, VANET topology changes very frequently. Vehicles leave a cluster and join another one very frequently. Considering this nature of VANET the algorithm AATR is framed so that vehicles in VANET can adjust their transmission range on the basis of their surroundings.

**(c) Monitoring of malicious vehicles (MMV)**

There is no central unit in VANET to insure the security, so that vehicles should cooperate with each other to ensure the same. A vehicle uses distrust value of neighbor vehicles to update its black and white list. The performance of VWCA is better than all the direction base clustering algorithms and improves the security of network, also, the percentage of selecting a malicious vehicle as cluster head is very low in VWCA.

**3.1.9 PassCAR: A Passive Clustering Aided Routing Protocol for Vehicular Ad Hoc Network**

Passive clustering (PC) does not use any protocol specific beacons/signals to form a cluster. A node which claims itself as a cluster head dominates other node within its transmission range and cluster gateway selection is to find out the minimum number of gateways to ensure the connectivity. This mechanism reduces the overheads of route discovery and maintenance. PassCAR mechanism contains three phases; route discovery, route establishment and data transmission. When a node wants to transmit a data packet then it checks its routing table first, if path is available then forward the packet to next hop. Otherwise, it initiates the route discovery phase and find out the cluster head and cluster gateway to forward the packet.

**3.1.10 Contention Based Forwarding with Multi-hop Connectivity Awareness in Vehicular Ad Hoc Networks (TOPOCBF)**

Road Topology-Aware Contention-Based Forwarding (TOPOCBF) algorithm dynamically selects road segments on the basis of multi-hop connectivity. A road segment is called multi-hop connected if there are sufficient number of nodes available to deliver a packet from one end to another end of road segment. TOPOCBF would select the most appropriate path by considering path availability and the lowest virtual distance. After selecting next forwarding road segment, sender will broadcast the packet with its coordinate.

**4. Conclusion and Future Work**

This paper lists some past researches on clustering method in Wireless Sensor Network and the Position Based Data routing protocols in Mobile Ad hoc network. The main difference from clustering mechanism in IoT scenario to the traditional wireless sensor network is the heterogeneity in network media and data information. IoT scenarios consist of heterogeneous network protocols such as WiFi, Zigbee, and Bluetooth, and the multiple kinds of data information with various QoS requirements on the degree of data tolerance, data delivery ratio and life time, etc. So, considering the characteristic of data information during the process of data buffering and transmission is a noticeable issue in the future design of the clustering mechanism in IoT scenario. Besides, the position-based routing protocol only route the data message among the mobile nodes based on the spatial locations of the mobile node and physical length of roads. While, in real-world traffic system, the road network also will be impact by other factors such as the traffic flow, the limited speed, the road condition or the time period like traffic peak hour. So, how to real-timely perceive and evaluate the road condition is another issue should be considered when we are going to give the cost to every path and choose the shortest path in our road network. All the above need to be explored in our future work.

**Reference:**

[1] B. Nazir and H. Hasbullah, “Mobile sink-based routing protocol for prolonging network lifetime in clustered wireless sensor network,” International Conference on Computer Applications and Industrial Electronics(ICCAIE), pp. 624-629, December 2010.

[2] A.H. Khan et al, “Dynamic joint sink mobility with need-based clustering in wsns,” International Conference on Advanced Information Networking and Applications Workshops (WAINA), pp.320-325, March 2015.

[3] J. Xu, L. He, Z. Chen, G. Huang, and T. Yuan, “Reducing the path length of a mobile bs in wsns,” IEEE International Seminar on Future BioMedical Information Engineering, pp. 241-274, December 2008.

[4] A. Alomari, N. Aslamy, W. Phillips, and F. Comeau, “A scheme for using closest rendezvous points and mobile elements for data gathering in wireless sensor networks,” IFIP Wireless Days, pp. 1-6, November 2014.

[5] H. Salarian, K. Chin, and F. Naghdy, “An energy-efficient mobile-sink path selection strategy for wireless sensor networks,” IEEE Trans. on Vehicular Technology, vol. 63, pp. 2407-2419, June 2014.

[6] Prashanth and S. V. Nandury, “Cluster-based rendezvous points selection for reducing tour length of mobile element in WSN,” IEEE International Advance Computing Conference IACC, pp. 1230-1235, June 2015.

[7] A. W. Khan, A. H. Abdullah, M. A. Razzaque, and J. I. Bangash, “A virtual grid-based dynamic routes adjustment scheme for mobile sink- based wireless sensor networks,” IEEE Sensor Journal, vol. 15, pp. 526- 534, January 2015.

[8] C. Konstantopoulos, G. Pantziou, D. Gavalas, A. Mpitziopoulos, and B. Mamalis, “Rendezvous-based approach enabling energy-efficient sensory data collection with mobile sinks,” IEEE Trans. On Parallel and Distributed Systems, vol. 23, pp. 809-817, May 2012.

[9] C. Zhu, S. Wu, G. J. Han, L. Shu, and H. Wu, “A tree-cluster-based data gathering algorithm for industrial wireless sensor networks with mobile sink,” IEEE Access, vol. 3, pp. 381-396, April 2015.

[10] Karp, B., & Kung, H. T. (2000, August). GPSR: Greedy perimeter stateless routing for wireless networks. In Proceedings of the 6th annual international conference on mobile computing and networking (pp. 243–254). ACM.

[11] Naumov, V., Baumann, R., & Gross, T. (2006, May). An evaluation of inter-vehicle ad hoc networks based on realistic vehicular traces. In Proceedings of the 7th ACM international symposium on Mobile ad hoc networking and computing (pp. 108–119). ACM.

[12] Lochert, C., Hartenstein, H., Tian, J., Fussler, H., Hermann, D., & Mauve, M. (2003, June). A routing strategy for vehicular ad hoc networks in city environments. In Intelligent vehicles symposium, 2003, proceedings IEEE (pp. 156–161). IEEE.

[13] Naumov, V., & Gross, T. R. (2007, May). Connectivity-aware routing (CAR) in vehicular ad hoc networks. In InfoCOM (Vol. 26, pp. 1919–1927).

[14] Fu¨ßler, H., Hartenstein, H., Mauve, M., Effelsberg, W., & Widmer, J. (2004). Contention-based forwarding for street scenarios. In 1st International workshop in intelligent transportation (WIT 2004) (No. LCA-CONF-2004-005).

[15] Xiang, Y., Liu, Z., Liu, R., Sun, W., & Wang, W. (2013). GeoSVR: A map-based stateless VANET routing. Ad Hoc Networks, 11(7), 2125–2135.

[16] Bernsen, J., & Manivannan, D. (2012). RIVER: A reliable inter-vehicular routing protocol for vehicular ad hoc networks. Computer Networks, 56(17), 3795–3807.

[17] Daeinabi, A., Pour Rahbar, A. G., & Khademzadeh, A. (2011). VWCA: An efficient clustering algorithm in vehicular ad hoc networks. Journal of Network and Computer Applications, 34(1), 207–222.

[18] Wang, S. S., & Lin, Y. S. (2013). PassCAR: A passive clustering aided routing protocol for vehicular ad hoc networks. Computer Communications, 36(2), 170–179.

[19] Rondinone, M., & Gozalvez, J. (2013). Contention-based forwarding with multi-hop connectivity awareness in vehicular ad-hoc networks. Computer Networks, 57(8), 1821–1837.