A SURVEY OF ROUTING PROTOCOL IN VANET WITH ITS PROS AND CONS

Patel Pragnesh V*

Abstract

VANET are a special form of wireless networks made by vehicles communicating among themselves on roads. VANET has opened door to develop several new applications like, traffic engineering, traffic management, dissemination of emergency information to avoid hazardous situations and other user applications. VANETs are direct offshoot of Mobile Ad hoc Networks (MANETs) but with distinguishing characteristics like, movement at high speeds, in-sufficient storage and processing power, unpredictable node density and short link lifetime. The conventional routing protocols proposed for mobile ad hoc networks (MANETs) work poorly in VANETs. As communication links break more frequently in VANETs than in MANETs, the routing reliability of such highly dynamic networks needs to be paid special attention.

* *Student Master in Information Technology,PIET, Waghodia, Baroda*

1. Introduction

Vehicular Ad Hoc Network (VANET) is a new challenging network environment that pursues the concept of ubiquitous computing for future. They are a special form of mobile ad hoc networks (MANETs) that provide vehicle-to vehicle communications. It can be thought as each vehicle is equipped with a wireless communication facility to provide ad hoc network connectivity. VANETs tend to operate without an infrastructure; each vehicle in the network can send, receive, and relay messages to other vehicles in the network. This way, vehicles can exchange real-time information, and drivers can be informed about road traffic conditions and other travel-related information. VANETs have unique and fascinating features, different from other types of MANETs, such as normally higher computational capability, higher transmission power, and some kind of predictable mobility, with comparison with general MANETs. VANETs bring lots of possibilities for new range of applications which will not only make the travel safer but faster as well. Reaching to a destination or getting help would be much easier. The concept of VANETs is quite simple by incorporating the wireless communication and data sharing capabilities, the vehicles can be turned into a network providing similar services like the ones with which we are used to in our offices or homes. For the wide spread and ubiquitous use of VANETs, a number of technical challenges exist. Besides, VANETs are also similar to MANETs in many ways. For example, both networks are multi-hop mobile networks having dynamic topology. Both VANET and MANET are rapidly deployable, without intense of an infrastructure. Although, MANET and VANET, both are mobile networks, however, the mobility pattern of VANET nodes is such that they move on specific paths (roads) and hence not in random direction. This gives VANETs some advantage over MANETs as the mobility pattern of VANET nodes is predictable. MANETs are often characterized by limited storage capacity and low battery and processing power. VANETs, on the other hand, do not have such limitations.

2. Characteristics & Application of VANET

VANETs comprise of radio-enabled vehicles which act as mobile nodes as well as routers for other nodes. In addition to the similarities to ad hoc networks, such as short radio transmission range, self-organization and self management, and low bandwidth, VANETs can be distinguished from other kinds of ad hoc networks as follows:

[i] Highly Dynamic Topology:

Due to high speed of movement between vehicles, the topology of VANETs is always changing. For example, assume that the wireless transmission range of each vehicle is 100 m, if the distance between them is less than 200 m, there can be a link between two cars. In the worst case, if two cars with the speed of 60 mph (25 m/sec) are driving in opposite directions, the link will last only for at most 10 sec.

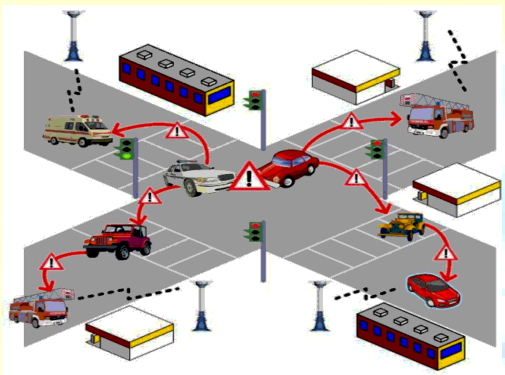


Figure 2.1 Example of a VANET

[ii] Frequently Disconnected Network:

Due to the some reason, the connectivity of the VANETs could also be changed frequently. Especially when the vehicle density is low, it has higher probability that the network is disconnected. In some applications, such as ubiquitous Internet access, the problem needs to be solved. However, one possible solution is to pre-deploy several relay nodes or access points along the road to keep the connectivity.

[iii] Sufficient Energy and Storage:

A common characteristic of nodes in VANETs is that nodes have ample energy and computing power (including both storage and processing), since nodes are cars instead of small handheld devices.

[iv] Geographical Type of Communication:

Compared to other networks that use unicast or multicast where the communication end points are defined by ID or group ID, the VANETs often have a new type of communication which addresses geographical areas where packets need to be forwarded (e.g., in safety driving applications).

[v] Mobility Modelling and Predication:

Due to highly mobile node movement and dynamic topology, mobility model and predication play an important role in network protocol design for VANETs. Moreover, vehicular nodes are usually constrained by prebuilt highways, roads and streets, so given the speed and the street map, the future position of the vehicle can be predicated.

[vi] Various Communications Environments:

VANETs are usually operated in two typical communications environments. In highway traffic scenarios, the environment is relatively simple and straightforward (e.g., constrained one-dimensional movement); while in city conditions it becomes much more complex. The streets in a city are often separated by buildings, trees and other obstacles. Therefore, there isn't always a direct line of communications in the direction of intended data communication.

[vii] Hard Delay Constraints:

In some VANETs applications, the network does not require high data rates but has hard delay constraints. For example, in an automatic highway system, when brake event happens, the message should be transferred and arrived in a certain time to avoid car crash. In this kind of applications, instead of average delay, the maximum delay will be crucial.

[viii] Interaction with On-Board Sensors:

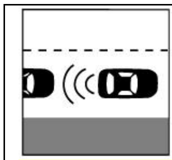
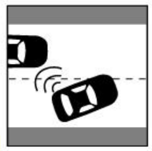
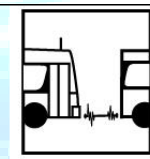
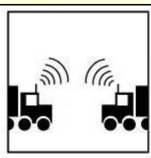
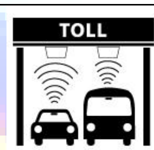
It is assumed that the nodes are equipped with on-board sensors to provide information which can be used to form communication links and for routing purposes. For example, GPS receivers are increasingly becoming common in cars which help to provide location information for routing purposes. It is assumed that the nodes are equipped with on-board sensors to provide information which can be used to form communication links and for routing purposes.

Applications of VANET

The characteristics of Vehicular networks advance the development of striking and challenging services and applications as under.

- Vehicle collision & Lane change warning
- Intersection collision warning
- Approaching Emergency vehicle

- Rollover & Work zone warning
- Electronic Toll collection
- Inter Vehicle Communication

		
Co-operative Collision Warning	Intersection Collision Warning	Lane Change Warning
		
Approaching Emergency vehicle	Work Zone Warning	Rollover Warning
		
Coupling/De coupling	Inter-Vehicle Communicati on	Electronic Toll Collection

3. Routing Protocols

Routing Protocol can be classified into 2 classes

- TRANSMISSION STRATEGIES
- ROUTING INFORMATION

TRANSMISSION STRATEGIES

Delivery of information from a source to a destination can be classified into four types:

- UNICAST
- BROADCAST
- MULTICAST
- GEOCAST

However the multicast and geocast can be merged in one class because geocast usually is a special type of multicast transmission.

ROUTING INFORMATION

This class has been divided into two subclasses:

- Topology-Based
- Position-Based Routing Protocols.

In topology-based routing, each node should be aware of the network layout, also should able to forward packets using information about available nodes and links in the network. In contrast, position-based routing should be aware of the nodes locations in the packet forwarding.

Topology-Based Routing Protocol

Topology-based routing protocol usually a traditional MANET routing protocol, it uses link's information which stored in the routing table as a basis to forward packets from source node to destination; it commonly categorized into three categories (base on underlying architecture)

- PROACTIVE (PERIODIC)
- REACTIVE (ON-DEMAND)
- HYBRID

Proactive Routing Protocols

Proactive protocols allow access to a network node to use the routing table in order to store routes information for all other nodes, where each entry in the table contains the next hop node used in the path from source to the destination, without considering whether the route is actually useful or not. The table must be updated frequently to reflect the network topology changes, and should be broadcast periodically to the neighbours. This scheme may cause more overhead especially in the high mobility network. However, routes to destinations will always be available when needed. Proactive protocols usually depend on shortest path algorithms to determine which route will be chosen; they generally use two routing strategies: Link state strategy and distance vector strategy.

Pros

- No Route Discovery is required.
- Latency for real time applications is low.

Cons

- Unused paths occupy a significant part of the available bandwidth.

Reactive Routing Protocols

Reactive routing protocols (also called on-demand) reduce the network overhead; by maintaining routes only when needed, that the source node starts a route discovery process, if it needs a non existing route to a destination, it does this process by flooding the network by a route request message. When the message reaches the destination node (or to node which has a route to destination), this node will send a route reply message back to the source node using unicast communication method. Reactive routing protocols are applicable to the large size of the mobile ad hoc networks which are highly mobility and frequent topology changes. Many reactive routing protocols have been developed, the following sections will illustrate characteristic of some reactive protocols, as well as illustrates the existing enhancement protocols. Reactive routing protocols also suffer from the initial latency incurred in the route discovery process, which potentially makes them unsuitable for safety applications. AODV, DSR are the examples of reactive routing protocols whereas OLSR, TBRPF and FSR are the examples of proactive routing protocols.

Pros

-To update routing table not require periodic flooding the network. Flooding requires when it is demanded.

-Beaconless so it saves the bandwidth.

Cons

- For route finding latency is high.
- Excessive flooding of the network causes disruption of nodes communication.

4 Proactive (table-driven)

Proactive routing protocols are mostly based on shortest path algorithms. They keep information of all connected nodes in form of tables because these protocols are table based. Furthermore, these tables are also shared with their neighbours. Whenever any change occurs in network topology, every node updates its routing table.

Pros

- No Route Discovery is required.
- Low Latency for real time applications.

Cons

- Unused paths occupy a significant part of the available bandwidth.

4.1 Fisheye State Routing

FSR [8] is a proactive or table driven routing protocol where the information of every node collects from the neighbouring nodes. Then calculate the routing table. It is based on the link state routing & an improvement of Global State Routing.

Pros

- FSR reduces significantly the consumed bandwidth as it exchanges partial routing update information with neighbours only.
- Reduce routing overhead.
- Changing in the routing table will not occur even if there is any link failure because it doesn't trigger any control message for link failure.

Cons

-Very poor performance in small ad hoc networks.

-Less knowledge about distant nodes.

-The increase in network size the storage complexity and the processing overhead of routing table also increase.

- Insufficient information for route establishing.

4.2 Reactive (On Demand)

Reactive routing protocol is called on demand routing because it starts route discovery when a node needs to communicate with another node thus it reduces network traffic.

Pros

-To update routing table not require periodic flooding the network. Flooding requires when it is demanded.

-Beaconless so it saves the bandwidth.

Cons

- For route finding latency is high.

- Excessive flooding of the network causes disruption of nodes communication.

4.2.1 AODV

Ad Hoc on Demand Distance Vector routing protocol [9] is a reactive routing protocol which establish a route when a node requires sending data packets. It has the ability of unicast & multicast routing. It uses a destination sequence number (DestSeqNum) which makes it different from other on demand routing protocols.

Pros

- An up-to-date path to the destination because of using destination sequence number.

- It reduces excessive memory requirements and the route redundancy.

- AODV responses to the link failure in the network.

- It can be applied to large scale adhoc network.

Cons

-More time is needed for connection setup & initial communication to establish a route compared to other approaches.

-If intermediate nodes contain old entries it can lead inconsistency in the route.

-For a single route reply packet if there has multiple route reply packets this will lead to heavy control overhead.

- Because of periodic beaconing it consume extra bandwidth.

4.2.2 Dynamic Source Routing

The Dynamic Source Routing (DSR) protocol represented in [10] which utilize source routing & maintain active routes. It has two phases route discovery & route maintenance.

Pros

-Beacon less.

-To obtain route between nodes, it has small overload on the network. It uses caching which reduce load on the network for future route discovery.

-No periodical update is required in DSR.

Cons

-If there are too many nodes in the network the route information within the header will lead to byte overhead.

-Unnecessary flooding burden the network.

-In high mobility pattern it performs worse.

-Unable to repair broken links locally.

4.2.3 Temporally Ordered Routing Protocol (TORA)

Temporally Ordered Routing Protocol [11] is based on the link reversal algorithm that creates a direct acyclic graph towards the destination where source node acts as a root of the tree. In TORA packet is broadcasted by sending node, by receiving the packet neighbour nodes rebroadcast the packet based on the DAG if it is the sending node's downward link.

Pros

-It creates DAG (Direct acyclic graph) when necessary.

-Reduce network overhead because all intermediate nodes don't need to rebroadcast the message.

-Perform well in dense network.

Cons

-It is not used because DSR & AODV perform well than TORA.

-It is not scalable.

5. PROS & CONS OF GEOGRAPHIC ROUTING PROTOCOLS

Geographic routing is a routing that each node knows it's own & neighbour node geographic position by position determining services like GPS. It doesn't maintain any routing table or exchange any link state information with neighbor nodes.

Information from GPS device is used for routing decision.

Pros

- Route discovery & management is not required.

-Scalability.

-Suitable for high node mobility pattern.

Cons

-It requires position determining services.

-GPS device doesn't work in tunnel because satellite signal is absent there.

5.1 DTN

Delay Tolerant Network (DTN) uses carry & forward strategy to overcome frequent is connection of nodes in the network. In carry & forward strategy when a node can't contact with other nodes it stores the packet & forwarding is done based on some metric of nodes neighbours.

5.2 BEACON

Beacon means transmitting short hello message periodically. It exposes presence and position of a node. An entry will be removed from neighbour table of a receiving node if it fails to receive a beacon after a certain period of time from the corresponding node.

5.3 OVERLAY

Overlay is a network that every node is connected by virtual or logical links which is built on top of an existing network.

5.3.1 VADD (Vehicle-Assisted Data Delivery)

Vehicle-Assisted Data Delivery [12] is based on the idea of carry & forward approach by using predicable vehicle mobility. Among proposed VAAD protocols H-VAAD shows better performance.

Pros

-Comparing with GPSR (with buffer), epidemic routing and DSR, VADD performs high delivery ratio.

-It is suitable for multi-hop data delivery.

Cons

- Due to change of topology & traffic density it causes large delay.

5.3.2 Geographical Opportunistic Routing (GeOpps)

Geographical Opportunistic Routing (GeOpps) [13] protocol utilizes the navigation system suggested routes of vehicles for selecting the forwarding node which is closer to the destination. During this process if there is any node which has minimum arrival time the packet will be forwarded to that node.

Pros

-By comparing with the Location-Based Greedy routing and MoVe routing algorithm GeOpps has high delivery ratio.

-To find a vehicle which is driving towards near the destination GeOpps need few encounters.

- The delivery ratio of GeOpps rely on the mobility patterns & the road topology but not dependent on high density of vehicles.

Cons

-Privacy is an issue because navigation information is disclosed to the network.

5.3.3 Greedy Perimeter Stateless Routing (GPSR)

Greedy Perimeter Stateless Routing [14] selects a node which is closest to the final destination by using beacon. It uses greedy forwarding algorithm if it fails it uses perimeter forwarding for selecting a node through which a packet will travel.

Pros

-To forward the packet a node needs to remember only one hop neighbour location.

-Forwarding packet decisions are made dynamically.

Cons

-For high mobility characteristics of node, stale information of neighbour's position is often contained in the sending nodes neighbour table.

-Though the destination node is moving its information in the packet header of intermediate node is never updated.

5.3.4 Greedy Perimeter Coordinator Routing (GPCR)

Greedy Perimeter Coordinator Routing [17] is a position-based routing protocol uses greedy algorithms to forward packet based on a pre-selected path which has been designed to deal with the challenges of city scenarios. No global or external information like static map does not require in GPCR.

Pros

- Does not require any global or external information.

-For representing the planar graph it uses the underlying roads though it is based on the GPSR.

-It has no as usual a planarization problem like unidirectional links, planar sub-graphs & so on.

Cons

- Depends on junction nodes.

-There has a problem in the Junction detection approach in which first approach fails on curve road & second approach fails on a sparse road.

5.4 CAR (Connectivity-Aware Routing)

For city and/or highway environment Connectivity-Aware Routing (CAR) [19] is designed which uses AODV for path discovery and uses PGB for data dissemination mode. It uses guard concept to maintain the path.

Pros

-No digital map is required.

-It has no local maximum problem.

- CAR ensures to find the shortest connected path because CAR has higher packet delivery ratio than GPSR and GPSR+AGF.

Cons

-Unnecessary nodes can be selected as an anchor.

-It cannot adjust with different sub-path when traffic environment changes.

5.5 Greedy Traffic Aware Routing protocol (GyTAR)

Greedy Traffic Aware Routing protocol [23] gives a new concept of intersection-based routing protocol which aims to reduce the control message overhead & end-to-end delay with low packet loss.

Pros

- For high mobility topology changes rapidly and often occurring network fragmentation which is efficiently handle by GyTAR.

-Performance shows that throughput, delay and routing overhead are better than GSR.

Cons

- GyTAR depends on roadside units because it assumes that the number of cars in the road will be given from road side units.

-GyTAR cannot avoid void.

6. Conclusion

In this paper, we have investigated the pros and cons of different routing protocols for inter-vehicle communication in VANET. By studying different routing protocol in VANET we have seen that further performance evaluation is required to verify performance of a routing protocol with other routing protocols based on various traffic scenarios. Comparison can be done among the routing protocols in the Overlay and so on.

7. References

[1] "Survey of Routing Protocols in Vehicular Ad Hoc Networks," Kevin C. Lee, Uichin Lee, Mario Gerla, Advances in Vehicular Ad-Hoc Networks: Developments and Challenges, IGI Global, Oct, 2009.

[2] Ericson, "Communication and Mobility by Cellular Advanced Radio", ComCar project, www.comcar.de, 2002.

[3]Prabhakar Rajan & Kamalkant Ahirwar, "Comparative Study Of Manet And Vanet Routing Protocols", Amity University, Noida (2011).

[4] W. Franz, H. Hartenstein, and M. Mauve, Eds., Inter- Vehicle-Communications Based on Ad Hoc Networking Principles-The Fleet Net Project. Karlshue, Germany: Universitatverlag Karlsuhe,November 2005.

[5] A. Festag, et. al., "NoW-Network on Wheels: Project Objectives,Technology and Achievements", Proceedings of 6th InternationalWorkshop on Intelligent Transportations (WIT), Hamburg, Germany,March 2008.

[6] Reichardt D., Miglietta M., Moretti L., Morsink P., and Schulz W.,"CarTALK 2000 – safe and comfortable driving based upon inter-vehicle-communication," in Proc. IEEE IV'02.

[7] Morris R., Jannotti J., Kaashoek F., Li J., Decouto D., "CarNet: A scalable ad hoc wireless network system," 9th ACM SIGOPS European Workshop, Kolding, Denmark, Sept. 2000.

[8] Pei, G., Gerla, M., and Chen, T.-W. (2000), "Fisheye State Routing: A Routing Scheme for Ad Hoc Wireless Networks," Proc. ICC 2000, New Orleans, LA, June 2000.

[9] Perkins, C.; Belding-Royer, E.; Das, S. (July 2003)"Ad hoc On-Demand Distance Vector (AODV) Routing".

[10] Johnson, D. B. and Maltz, D. A. (1996), "Dynamic Source Routing in Ad Hoc Wireless Networks," Mobile Computing, T. Imielinski and H. Korth, Eds., Ch. 5, Kluwer, 1996, pp. 153–81.

[11] Park, V.D., Corson, M.S. (1997), "A highly adaptive distributed routing algorithm for mobile wireless networks," INFOCOM '97. Sixteenth Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings IEEE , vol.3, no., pp.1405-1413 vol.3, 7-12 Apr 1997.

[12] Zhao, J.; Cao, G. (2006), "VADD: Vehicle-Assisted Data Delivery in Vehicular Ad Hoc Networks," INFOCOM 2006. 25th IEEE International Confrence on Computer Communications. Proceedings , vol., no., pp.1- 12, April 2006.

[13] Leontiadis, I., Mascolo, C. (2007), "GeOpps: Geographical Opportunistic Routing for Vehicular Networks," World of Wireless, Mobile and Multimedia Networks, 2007. WoWMoM 2007. IEEE International Symposium on a , vol., no., pp.1-6, 18-21 June 2007.

[14] Karp, B. and Kung, H. T (2000), "GPSR: greedy perimeter stateless routing for wireless networks." In Mobile Computing and Networking, pages 243-254, 2000.

[15] Naumov, V., Baumann, R., Gross, T. (2006), “An evaluation of Inter-Vehicle Ad Hoc Networks Based on Realistic Vehicular Traces,” Proc. ACM MobiHoc’06 Conf., May, 2006.

[16] Schnaufer, S., Effelsberg, W. (2008), "Position-based unicast routing for city scenarios," World of Wireless, Mobile and Multimedia Networks, 2008. WoWMoM 2008. 2008 International Symposium on a , vol., no., pp.1-8, 23-26 June 2008.

[17] Lochert, C., Mauve, M., F¨ussler, H., and Hartenstein, H., “Geographic routing in city scenarios,” SIGMOBILE Mob. Comput. Commun. Rev., vol. 9, no. 1, pp. 69–72, 2005.

[18] Lee, K. C., Haerri, J., Lee, U., and Gerla, M. (2007), “Enhanced perimeter routing for geographic forwarding protocols in urban vehicular scenarios,” Globecom Workshops, 2007 IEEE, pp. 1–10, 26-30 Nov. 2007.

[19] Naumov, V., Gross, T.R. (2007), "Connectivity-Aware Routing (CAR) in Vehicular Ad-hoc Networks," INFOCOM 2007. 26th IEEE International Conference on Computer Communications. IEEE , vol., no., pp.1919- 1927, 6-12 May, 2007.

[20] Jerbi, M., Senouci, S.-M., Meraihi, R., and Ghamri- Doudane, Y. (2007), “An improved vehicular ad hoc routing protocol for city environments,” Communications, 2007. ICC ’07. IEEE International Conference, pp. 3972–3979, 24-28 June 2007.

[21] Lochert, C., Hartenstein, H., Tian, J., Fussler, H., Hermann, D., Mauve, M. (2003), “A routing strategy for vehicular ad hoc networks in city environments,” Intelligent Vehicles Symposium, 2003. Proceedings. IEEE , vol., no., pp. 156-161, 9-11 June 2003.

[22] Seet, B.-C., Liu, G., Lee, B.-S., Foh, C. H., Wong, K. J., Lee, .-K. (2004), “A-STAR: A Mobile Ad Hoc Routing Strategy for Metropolis Vehicular Communications.” NETWORKING 2004, 989-999.

[23] Forderer, D (2005). “Street-Topology Based Routing.” Master’s thesis, University of Mannheim, May 2005.

[24] Lee, K., Le, M., Haerri J., and Gerla, M. (2008), “Louvre: Landmark overlays for urban vehicular routing environments,” Proceedings of IEEE WiVeC, 2008.

[25] F¨ußler, H., Hannes, H., J¨org, W., Martin, M., Wolfgang, E. (2004), “Contention-Based Forwarding for Street Scenarios,” Proceedings of the 1st InternationalWorkshop in Intelligent Transportation (WIT 2004), pages 155–160, Hamburg, Germany, March 2004.

[26] Lee, K.C.; Lee, U.; Gerla, M. (2009), "TO-GO: TOpology-assist geo-opportunistic routing in urban vehicular grids," Wireless On-Demand Network Systems and Services, 2009. WONS 2009. Sixth International

Conference on , vol., no., pp.11-18, 2-4 Feb. 2009.

[27] Cheng, P.-C., Weng, J.-T., Tung, L.-C., Lee, K. C., Gerla M., and Härri J. (2008), "GeoDTN+NAV: A Hybrid Geographic and DTN Routing with Navigation Assistance in Urban Vehicular Networks," Proceedings of the 1st International Symposium on Vehicular Computing Systems (ISVCS'08), Dublin, Irland, July.

[26] Mahmoud Hashem Eiza and Qiang Ni, Senior Member, IEEE "An Evolving Graph-Based Reliable Routing Scheme for VANETs" May 2013

[27] Ehsan Mostajerani, Rafidah Md Noor2 and Hassan Keshavarz3 "A Novel Improved Neighbor Discovery Method for an Intelligent-AODV in Mobile Ad hoc Networks" International Conference of Information and Communication Technology (lCoICl) 2013

[28] S. Mohapatra, P. Kanungo "Performance analysis of AODV, DSR, OLSR and DSDV Routing Protocols using NS2 Simulator" International Conference on Communication Technology and System Design 2011

[29] Christos Liaskos, Graduate Student Member, IEEE, Andreas Xeros, Georgios I. Papadimitriou, Senior Member, IEEE, Marioslestas, Member, IEEE And Andreas Pitsillides, Senior Member, "Balancing Wireless Data Broadcasting And Information Hovering For Efficient Information Dissemination " IEEE (March 2012).