Routing Layer Design issues and Protocols for Wired and Wireless Networks

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Abstract
A Computer Network is a collection of interconnected and independent computers to provide communication among different users. The software required to operate on this computer network is organized as a set of layers: Physical, Data link, Network, Transport and Application layer. Each layer has distinctive functionalities to do. The protocols at these layers are collectively called as protocols stack. In this paper more focus is given on the issues to be considered in the design of protocols at the network layer and an overall view is given on the existing routing protocols for wired and wireless networks.

Keywords
Computer Network , Routing protocols , Wired Network, Wireless Network, Wireless Sensor Network

I. Introduction

Computer Networks are using everywhere in day to day life. A Computer Network is a collection of computers and hardware devices that are interconnected together via wired or wireless links. These networks are mainly used to provide communication and to share the resources like printers, scanners, software among multiple users. Some of the applications of these computer networks are email, video conferencing, ticket reservation system.

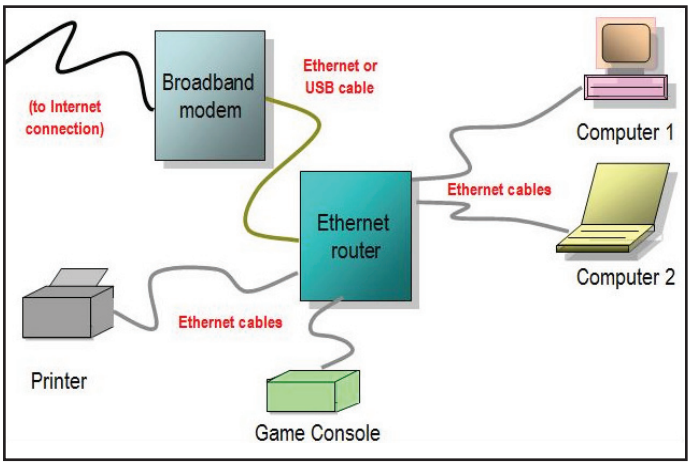

Fig. 1: Wired Network

Computer Networks can be classified based on different characteristics. Based on the physical link used to transmit the data, networks are mainly classified into wired and wireless networks [1]. Wired Networks use cables such as Ethernet, twisted pair, coaxial cable and optical fibre. Wired network is shown in fig. 1. Wireless networks use radio signals to transmit the data. Wireless Networks can be installed easily, in less time but in a moderate secure and reliable environment at a higher cost compared to wired networks due to their physical connection requirements. Wireless networks is shown in fig. 2.

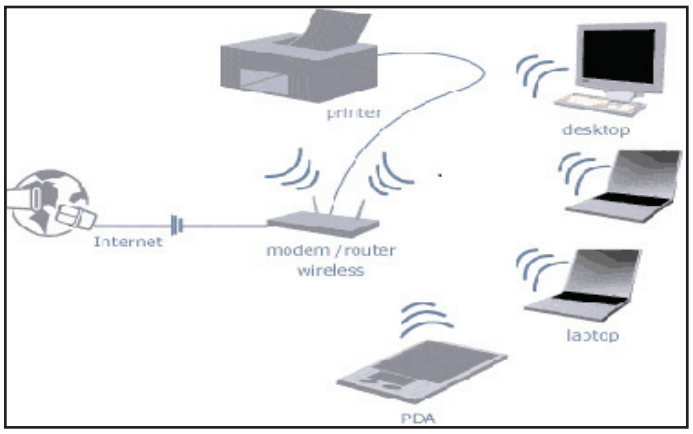

Fig. 2: Wireless Network

Based on the transmission technology used, networks can be classified into point to point and broad cast networks and are represented in fig. 3. In Broadcast networks, the communication channel is shared by all the nodes and so the message is heard by all the nodes. It is used only for shorter distances. In point to point networks the communication channel is not shared and so the message is heard only by the intended recipient. These networks are used to cover large distances.

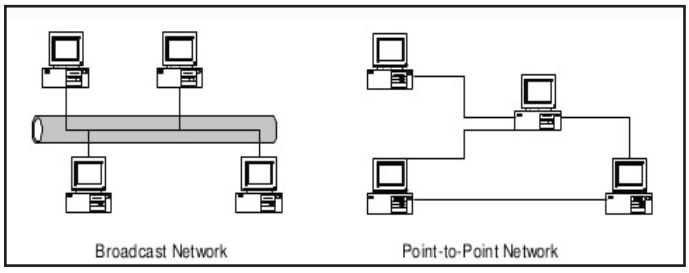

Fig. 3: Broadcast and Point to Point Networks

Another classification of networks is based on how the process execution taking place. The two types under this category are client server and peer to peer networks and are represented in fig. 4.

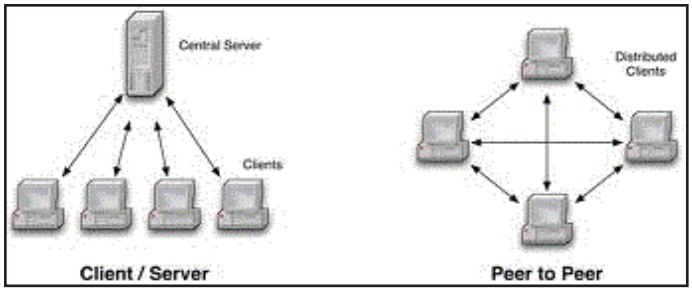

Fig. 4: Client-server and Peer to Peer Networks

Based on the geographic span and communication coverage area , networks can be classified as wired/wireless PANs, LANs, MANs, and WANs and are represented in fig. 5.

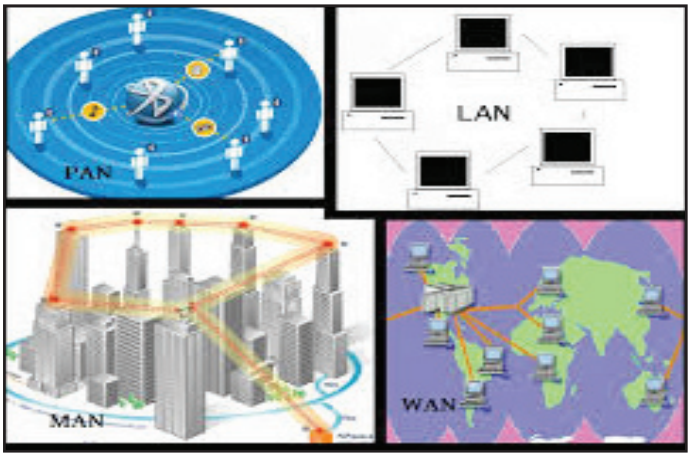

Fig. 5: PAN, LAN, MAN, WANs

Wireless Networks can be further classified into Infrastructure based and infrastructure less ad hoc wireless networks depending on the network architecture and are shown in fig. 6. Cellular networks come under the category of infrastructure dependent which are also called as single hop wireless networks. Wireless mesh networks and wireless sensor networks fall under ad hoc wireless networks that do not require any infrastructure to establish the network and use multi hop transmission technology to transmit the data. Ad hoc networks that support mobility of the nodes are termed as Mobile Ad hoc Networks (MANETs)

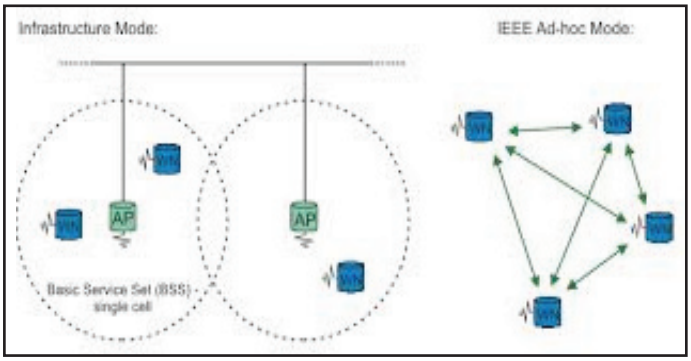

Fig 6. Infrastructure Based and Infrastructure Less Networks

Any network requires hardware and software in order to work on it. Network hardware includes cables, switches, routers, gateways, network cards etc. More research is going on in the network software to provide secured, reliable and fast communication among the users. The protocol stack consists of different protocols which operate at different layers of the network model. The network model consists of physical layer, data link layer, network layer, transport layer and application layer. Each layer has unique functionality in providing communication. In this paper , the issues involved in transmitting data from host to host considered.
The remainder of this paper is organized as follows: Sections II focuses on issues to be considered in the design of routing protocols, and in section III some of the existing protocols for Wired and Wireless networks are given. More about designing issues in routing protocols for Wireless Sensor Networks is discussed in section IV. Finally, Conclusion is presented in the last section.

II. Design Issues

Routing is the process of finding the path from source to destination to deliver data packets in the network. Routing can be done easily in wired networks with the help of routers and logical addressing concept. Wired networks support both circuit switching (connection oriented) and packet switching (connection less) routing schemes. In wired networks data can be transmitted using uni casting , multicasting, and broadcasting mechanisms.

Designing of routing protocols for wired networks is simple compared to wireless networks as the nodes are fixed and topology changes are very less [2]. The designing issues are: First, the routing protocol should deliver the data from source to the destined destination only. Second: since routing tables are constructed and maintained to forward packets, routing overhead should be minimized by automatically discovering networks that are reachable. Third: Even though the hardware like switches, routers and lines fail , the routing protocol should be able to cope with the changes in the topology and traffic and the network to be rebooted every time. Fourth: the routing algorithm should make the network to converge to equilibrium quickly and stays there for a long time. Fifth: A routing protocol should maximize the network throughput and minimize the mean packet delay. Sixth: A routing protocol should identify the best path and loop free path. So, in conclusion a routing protocol for wired network should be designed as a Simple, robust , stable, correct, fair and optimal one.

The designing of routing protocols for ad hoc wireless networks face so many challenges:

1. The routing protocols should have the ability to efficiently handle all the problems such as frequent path breaks, transient loops that occur with the presence of mobile nodes.
2. Limited bandwidth availability also poses some constraints in designing routing protocols.
3. Due to the presence of hidden and exposed terminals and broadcast nature of the radio channel, collisions and packet loss is more in MANETs. Routing protocols should take this into account.
4. Since the nodes in ad hoc networks have limited resources in computing power, battery power and buffer storage the routing protocol should be designed to optimally manage these resources.
5. Since the nodes are not uniformly distributed, routing protocols should be designed to uniformly distribute the work load across the network.
6. Since the ad hoc wireless networks are more vulnerable to attacks, the routing protocols must be designed to be resilient to threats and vulnerabilities.

Routing is simple in single hop cellular wireless networks [3] as the routing decisions are made in centralized manner and base stations are been used for routing compared to MANETs. The issues involved in designing routing protocols for WSNs are discussed in Section IV.

III. Routing protocols

Routing is done with the help of routing protocols. The routing protocols for wired networks are classified into adaptive and non adaptive based on the behavior of the protocol. Adaptive routing algorithms change their routing decisions whenever the topology changes and the traffic as well. Distance Vector Routing, Link State Routing, Routing Information Protocol (RIP) under internet are some of the adaptive routing protocols. Non adaptive routing algorithms do not change their decisions with the changes in network topology and traffic. Shortest Path Routing , Flooding are some of the examples for non adaptive routing algorithms.

Based on the network administration point of view, the protocols can be classified into interior and exterior and hierarchical routing protocols. Interior protocols are used to route the packets within the Autonomous System. Ex: RIP, Open Shortest Path First (OSPF) . Exterior protocols are used to route data packets among the Autonomous Systems. Ex: Border Gateway Porotocol (BGP). Hierarchical Routing protocols allow the segmentation of the network and scaling of the network.

Routing protocols for Mobile Ad hoc Networks can be classified as topology based and position based. The topology based routing protocols are further classified into 3 types based on how the routing information is being updated. They are table driven or proactive, reactive or on demand and hybrid protocols [4].

In proactive routing mechanism, every node maintains the network topology information and any changes in the link connections are updated periodically. Examples include Destination Sequenced Distance Vector (DSDV), Optimized Link State Routing (OLSR), Wireless Routing Protocol (WRP), Source Tree Adaptive Routing (STAR), Multipoint Relays.

Reactive routing schemes for MANETs do not maintain any network topology information at nodes , they obtain the necessary path only when it is required. Ex: Dynamic Source Routing (DSR), Ad hoc On demand Distance Vector (AODV), Temporally Ordered Routing Algorithm (TORA), Associativity Based Routing (ABR) etc.
Hybrid protocols combine the best features of both proactive and reactive schemes to achieve a higher level of efficiency and scalability. Ex: Zonal Routing Protocol (ZRP), Core Extraction Distributed Ad hoc Routing (CEDAR).

Position based routing protocols for MANETs route the data packets by utilizing the available geographical information effectively. These routing schemes can send data either using greedy forwarding strategy or restricted flooding method.

In Greedy forwarding strategy, a node selects the next hop in such a way that the no of hops required to reach the destination are minimized. In restricted flooding method, distance and angel are used in forwarding the data. Ex: Location Aided Routing (LAR). The classification of MANET routing protocols is represented in fig. 7.

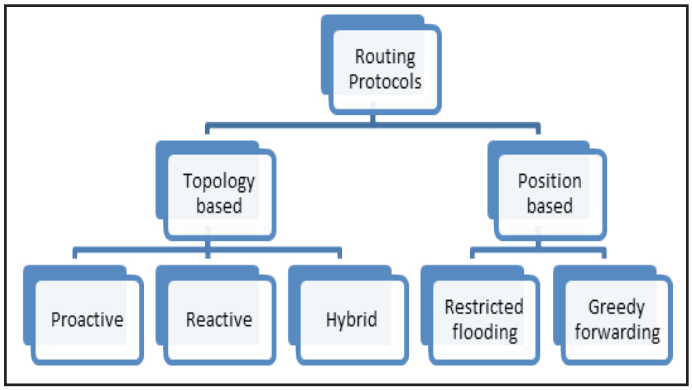

Fig. 7: MANET Routing Protocol Classification

IV. Wireless Sensor Networks

A Wireless Sensor Network (WSN) can be defined as a collection of inexpensive Sensor Nodes(SNs) having sensing, computing and communication abilities deployed in large number to monitor the environment or specific area. These SNs are small in size and have limited computational, communication and energy resources. Since these WSNs are generally deployed in harsh and hostile environments the batteries can not be replenished and recharged. These WSNs are having a variety of applications such as battlefield surveillance and monitoring, forest fire detection, flood detection, weather monitoring, habitat monitoring etc [5]. These SNs can communicate with each other directly or with an external Base Station (BS). Fig. 7 shows the architecture of a WSN. The user issues queries to the network and obtains the information with the help of node cooperation and collaboration techniques.

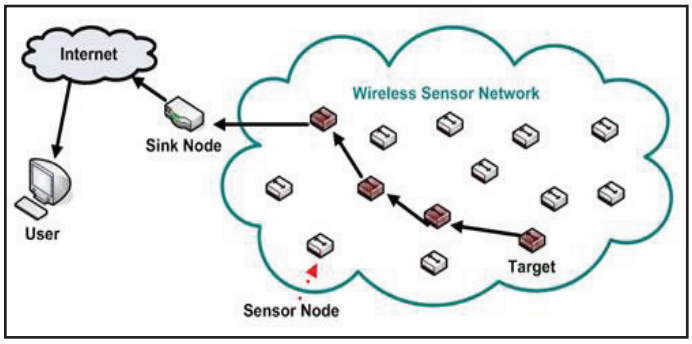

Fig. 8: WSN Architecture

While designing the routing algorithms for WSNs, more importance is to be given for energy consumption than the performance of the network in terms of quality of data sent as the energy source cannot be replaced or recharged at any time. So, the task of routing in WSN is to optimize the energy usage so that the network lifetime can be maximized.

The existing protocols for MANETs are not applicable directly for WSNs due to the unique characteristics of WSNs [6]. The challenging issues in the designing of routing protocols are:

1. The SNs are randomly deployed and largely deployed in the area to be monitored.
2. SNs have limited resources in power supply, processing power, and bandwidth.
3. Node failures are more due to physical damage, wireless links, interference and lack of power.
4. Bounded latency for data delivery is to be provided for time critical applications.
5. A trade off should exist between the security level and energy consumption as more importance is to be given on security which does not mean physical security.

Routing techniques in WSNs can be classified based on network topology and protocol operation [7]. The classification is shown in fig.9. Based on network topology they are further divided into Flat, Hierarchical and location based routing protocols. All the nodes will have equal In flat based routing protocols all the nodes will have equal functionality in flat routing scheme. The nodes will have different functionality in hierarchical based routing scheme. Location based routing approach uses geographical information is used to route the data.
Certain system parameters can be controlled to adapt to the network's current conditions and available energy levels with the routing techniques. Based on this , the routing strategies can be further classified into query based, multipath based, negotiation based, Location based and QoS based depending on principle of routing operation [8].

Most of these routing protocols are designed in such a way that they lengthen the total network life time.

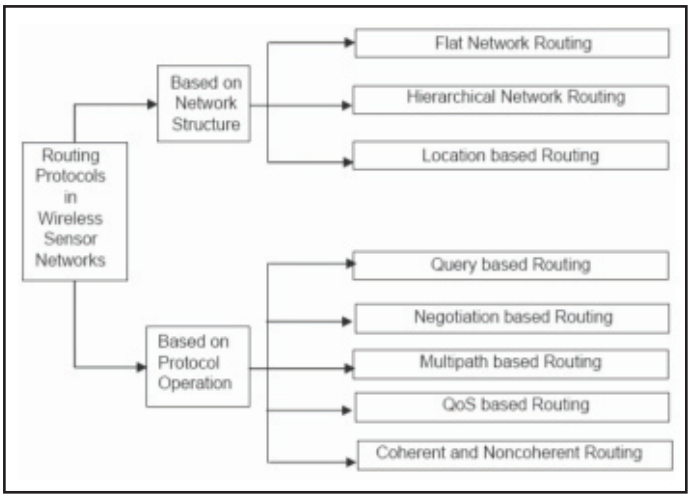

Fig. 9: WSN Routing Protocol Classification

A. Flat Routing

All the nodes are considered equally i.e., equal roles are given to each node. Flat routing protocols are also called as Data Centric routing protocols or multi hop communicating protocols. These protocols use multiple hops to send the data from target area to a remote sink. Since a large number of sensor nodes are deployed to cover the entire area of interest it is not possible to use global identification system. This consideration has led to data centric routing, where the BS issues queries to the nodes and waits for the response from the SNs positioned in the interested area [2]. Some examples which follow this multi hop communication are Sensor Protocols for Information via Negotiation (SPIN) , Directed Diffusion (DD) , Minimum Cost Forwarding Algorithm (MCFA), Rumour Routing, Gradient based Routing, COUGAR, ACQUIRE, Energy Aware Routing (EAR) etc.

B. Hierarchical Routing

The Hierarchical Routing protocols are mainly cluster based. These protocols are mainly having advantages with scalability and efficient communication. Here the nodes are grouped together and each group is called as a cluster. Each cluster will have a Cluster Head which is mainly used for collecting, aggregating and transmitting the data to the Base Station which may be far away. Generally the cluster heads are nodes with higher energy levels and lower energy nodes are used for sensing [3]. Some of the examples which follow this strategy are LEACH (Low Energy Adaptive Clustering Hierarchy),TEEN(Threshold sensitive Energy Efficient sensor Network),PEGASIS(Power Efficient Gathering in Sensor Information Systems),MECN(Minimum Energy Communication Network),SOP(Self Organizing Protocol),SAR (Sensor Aggregate Routing) etc.,

C. Location Based Routing

Using the location information of the SNs data can be transmitted from a source to BS in these protocols. The location of a SN can be obtained by either using GPS or some calculation method like triangulation technique [9]. When the region to be sensed and the location of SNs is known , BS issues queries only to that particular nodes and only those nodes will respond and all the other nodes keep their battery. In this way energy efficient routing is possible with this strategy. Some of the protocols under this category are GAF (Geographic Adaptive Fidelity), GEAR (Geographic and Energy Aware Routing), GOAFR (Greedy Other Adaptive Face Routing) etc.

D. Multipath based Routing

In order to increase the network performance multiple paths are maintained between the source and destination so that even when the primary path fails alternate path can be used. In some cases, the work load can also be evenly distributed to multiple paths in order to reduce network delay and traffic. Network resilience can be increased at the expense of increased overhead in maintaining multiple paths. Directed Diffusion is a good example for this category.

E. Query-Based Routing

With this routing strategy the destination sends queries to the remaining SNs. Each SN maintains routing tables consisting of the sensing task queries they receive, and hence they send data that match with these queries when they receive them. Generally, the destination specifies these queries in natural language or using any high-level query language. Rumour Routing is one of the examples which follow query based routing technique.

F. QoS Based Routing

While establishing the paths between source and destination end to end delay requirements in terms of delay, fault tolerance and reliability are given more importance than minimizing energy consumption with this routing strategy. Ex: SAR (Sequential Assignment Routing), Energy-Aware QoS Routing Protocol, SPEED etc.,

G. Negotiation Based Routing

Data redundancy is more due to the unique characteristics of WSNs. To minimize the energy consumption, the redundancy is to be eliminated. During data transmission high level data descriptors are used to eliminate data redundancy through negotiation with this negotiation based routing strategy. SPIN is one kind of protocol which works on this principle. Table1 gives the comparison of some of the protocols for WSNs.

Table 1 Comparison of Routing Protocols

protocol	Type	QoS Based	Query based	Scalability	Data Aggregation
SPIN	Flat	No	Yes	Limited	Yes
DD	Flat	No	Yes	Limited	Yes
EAR	Flat	No	Yes	Limited	No
LEACH	Hierarchical	No	No	Good	Yes
TEEN	Hierarchical	No	No	Good	Yes
PEGASIS	Hierarchical	No	No	Good	No
GAF	Location based	No	No	Good	No
GEAR	Location	No	No	Limited	No
GEDIR	Location	No	No	Limited	No
SAR	QoS	Yes	yes	Limited	yes
SPEED	QoS	yes	yes	Limited	No

V. Conclusion

In this paper, the classification and the designing issues of routing protocols for various computer networks is given. More on WSNs is discussed in this paper since they have a lot of applications especially in military for battlefield monitoring, detection of

attacks by weapons of mass destruction. Even though so many routing schemes are existing, still research is being done on how to improve the lifetime of MANETs, WSNs by using efficient routing schemes. So, a routing scheme that improves the network lifetime can be proposed with the survey given in this paper.

References

[1] Navpreet Kaur, Sangeeta Monga,"Comparisons of Wired and Wireless Networks A Review", International Journal of Advanced Engineering Technology, Vol. 5 , Issue 2, pp. 34-35, 2014.

[2] ShaluSraw, Gurpreet Singh,"Multicast Routing Protocols in Wired Networks: A Comprehensive Study", International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 4, Issue 5, 2014, pp. 1440-1444.

[3] Ananthapadmanabha R., B. S. Manoj, C. Siva Ram Murthy,"Multi-hop Cellular Networks: The Architecture and Routing Protocols," Tech. Rep., HPCN Lab, Indian Institute of Technology, Madras, December 2000.

[4] Harjeet Kaur et al,"A Survey of Reactive, Proactive and Hybrid Routing Protocols in MANET: A Review" , International Journal of Computer Science and Information Technologies, Vol. 4, Issue 3, pp. 498-500, 2013.

[5] H.Deepa, Avan Kumar Das,"A Study on Routing Protocols in Wireless Sensor Network", International Journal of Computer Applications, Vol. 72, No. 8, pp. 35-39, 2013.

[6] J. N. Al-Karaki, A. E. Kamal,"Routing techniques in wireless sensor networks: A survey," IEEE Wireless Commun. Mag., Vol. 11, pp. 6-28, Issue 6, pp. 6-28, 2004.

[7] Kemal Akkaya, Mohamed Younis,"A Survey on Routing Protocols for Wireless Sensor Networks", Ad-hoc Networks, Vol. 3, Issue 3, pp. 325-349, 2005.

[8] Parul Khurana, Inderdeep Aulakh,"Wireless Sensor Network Routing Protocols: A Survey", International Journal of Computer Applications, Vol. 75, No. 15, 2013, pp. 17-25.

[9] Shio Kumar Singh, M P Singh, D K Singh,"Routing Protocols in Wireless Sensor Networks –A Survey", International Journal of Computer Science & Engineering Survey (IJCSES) Vol. 1, No. 2, 2010.

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