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SURVEY OF OPTIMISTIC POWER AWARE ROUTING PROTOCOLS IN MOBILE DATACENTER NETWORKS

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ABSTRACT

A Mobile Datacenter Network (MDNET) is a self configuring network composed of movable nodes without any fixed infrastructure like Ad-hoc. The mobile data center is a type of data center that is designed and packaged in a small and mobile facility, usually in a standard shipping container. These small-scale data centers can easily be transported and deployed to remote and mobile locations. A mobile data center is also known as a modular data center. The very basic and closely watchable important issue for mobile datacenter networks is to find the route between source and destination that is a major technical challenge due to the dynamic topology of the network. Routing protocols in MDNETs could be differing depending on the application, infrastructure and network architecture. This paper presents a survey on power aware routing protocols for wireless mobile datacenter networks. Survey focus on recent development and modifications in this widely used field. This discussion is centered on proposed power saving algorithms. Furthermore we will discuss about the conventional protocols and in addition to we also see how these are customized to make these protocols efficient power utilizer.

Keywords: mobile datacenter network (MDNET), routing protocols, power aware algorithm, energy.

1. INTRODUCTION

Communication is playing a vital role for exchanging of information between people from and to anywhere at any time. With the widespread rapid development of computers and the wireless communication, the Movable computing named mobile computing has already become the field of computer communications. In basic, types of networks for communicate to remote are wired and wireless. Our full attention is on wireless networks. Wireless networks are classified into four different types. The first and foremost class is cellular networks. Another class of wireless networks is wireless local area networks (WLANs). These networks are truly and entirely wireless, but require only single-hop transmission. Typical wireless LANs involves laptops with Bluetooth. The third class consists of networks that utilize satellite links. The fourth and most interesting class is ad hoc networks. The wireless network can be broadly classified into two types: Well Infrastructure and Infrastructure less.

In Infrastructure wireless networks, the base stations are fixed and the node may go out of the range of a base station while it is in mobile and gets into the range of another base station [2]. In Infrastructure less or mobile datacenter wireless network, the mobile center can move while communicating, there are no fixed base stations and the entire centers in the network act as routers. The mobile centers in the Ad Hoc network dynamically establish routing among themselves to form their own network and there is no predefined infrastructure. The centers in ad hoc network have routing capabilities and forward traffic for other communicating parties that are not within each other's transmission range. A modular data center system is a portable method of deploying data center capacity. An alternative to the traditional data center, a modular data center can be placed anywhere data capacity is needed. They are characterized by lower computing and energy resources. Therefore, infrastructure less network routing is challenged by power and bandwidth constraints, as well as by frequent changes in topology, to which it must adapt and converge quickly. centers can be shipped anywhere in the world to be added, integrated or retrofitted into the customer's existing data center footprint, or combined into a system of modules. Modular data centers typically consist of standardized components, making them easier and cheaper to build [9].

Another form of modular data center fits data center equipment into a facility composed of prefabricated components that can be quickly built on a site and added to as capacity is needed. For example, HP's version of this type of modular data center, which it calls Flexible Data Center, is constructed of sheet metal components that are formed into four data center halls linked by a central operating building [12].

Applications

Mobile datacenter network has applications in

- Emergency search and- rescue operations
- Decision making in the battlefield
- Data acquisition operations in hostile terrain, etc.

Modular data centers come in two types of form factors. The more common type, referred to as containerized data centers or portable modular data centers, fits data center equipment (servers, storage and networking equipment) into a standard shipping container, which is then transported to a desired location [10]. Containerized data centers typically come outfitted with their own cooling systems. Cisco makes an example

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of this type of data center, called the Cisco Containerized Data Center [11]. Though the route setting to all centers are end to end monitored as the energy efficiency would disappointed.

Challenges

- Dynamic topology
- Multi-hop communication
- Limited resources (bandwidth, CPU, battery, etc.)
- Limited security

These above characteristics put special challenges in routing protocol design. The one of the most important objectives of MDNET routing protocol is to maximize energy efficiency, since center in MDNET depend on limited energy resources. Devices used in the mobile ad hoc wireless networks in most cases require portability and hence they also have size and weight constraints along with the restrictions on the power source. Increasing the battery power may make the center bulky and less portable. The energy efficiency remains an important design consideration for these movable networks. Routing is the process of establishing path and forwarding packets from source node to destination centers. It consists of two steps, route selection for various source-sink pair's centers and delivery of data packets to the correct destination centers.

Objectives of MANET routing protocols

- To maximize network throughput
- To maximize network lifetime
- To minimize delay.

The network throughput is usually measured by packet delivery ratio while the most significant contribution to energy consumption is measured by routing overhead which is the number or size of routing control packets. A major challenge that a routing protocol designed for mobile datacenter networks faces is resource constraints.

2. CLASSIFICATION OF ROUTING PROTOCOLS

MDNET routing protocols could be broadly classified into three major categories: proactive, reactive and hybrid, Hierarchical.

2.1 Proactive routing protocols

Proactive protocols continuously learn the topology of the network by exchanging topological information among the network centers. Thus, when there is a need for a route to a destination, such route information is available immediately. If the network topology changes too frequently, the cost of maintaining the network might be very high. If the network activity is low, the information about actual topology might even not be used. Proactive protocols continuously evaluates the routes within the network so that when we are required to forward the packet route is already known and immediately ready for use. So there is no time delay. So a shortest path can be find without any time delay however these protocols are not suitable for very dense mobile datacenter networks because in that condition problem of high traffic may arise. Several modifications of proactive protocols have been proposed for removing its shortcomings and use in less infrastructure networks. It maintains the unicast routes between all pair of centers without considering of whether all routes are actually used or not.

2.2 Reactive routing protocols

The reactive routing protocols are based on some sort of query-reply dialog. It is also called on demand routing. It is more efficient than proactive routing and most of the current work and modifications have been done in this type of routing for making it more and more better. The main idea behind this type of routing is to find a route between a source and destination whenever that route is needed whereas in proactive protocols we were maintaining all routes without regarding its state of use. So in reactive protocols we don't need to bother about the routes which are not being used currently. This type of routing is on demand. Discovering the route on demand avoids the cost of maintaining routes that are not being used and also controls the traffic of the network because it doesn't send excessive control messages which significantly create a large difference between proactive and reactive protocols. Time delay in reactive protocols is greater comparative to proactive types since routes are calculated when it is required. e.g. Modular datacenters Ad-hoc On Demand Distance Vector (MDAODV), Dynamic Source Routing (DSR) etc.

2.3 Hybrid routing protocol

Both of the proactive and reactive routing methods have some pros and cons. In hybrid routing a well combination of proactive and reactive routing methods are used which are better than the both used in isolation. It includes the advantages of both protocols. As an example facilitate the reactive routing protocol such as MDAODV with some proactive features by refreshing routes of active destinations which would definitely reduce the delay and overhead so refresh interval can improve the performance of the network and datacenter. So these types of protocols can incorporate the facility of other protocols without compromising with its own advantages. Examples of hybrid protocols are Zone Routing Protocol (ZRP).

2.4 Hierarchical routing protocol

With this type of protocol the choice of proactive and of reactive routing depends on the hierarchic level in which a node resides. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated center through

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reactive flooding on the lower levels. The choice for one or the other method requires proper attribute for respective levels. The main disadvantages of such algorithms are:

1. Advantage depends on depth of nesting and addressing scheme.
2. Reaction to traffic demand depends on meshing parameters.

Higher-energy datacenter are used to process and send the information, while low-energy center are used to perform the sensing in the proximity of the target. The creation of clusters and assigning special tasks to cluster heads can greatly contribute to overall system scalability, lifetime, and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster, performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink center [13].

2.5 Power model

A wireless network interface can be in one of the following four states: Send, Receive, Idle or Sleep. Each state represents a different level of power consumption.

- **Send:** A datacenter client is transmitting a frame with some transmission power.
- **Receive:** A receiver from destination is receiving a frame with some reception power. That power is consumed even if the frame is discarded by the center because it was intended for another destination, or it was not correctly decoded.
- **Idle** (listening): Even when no messages are being transmitted over the medium, the center process stay idle and keep listening the medium.
- **Sleep:** when the radio is turned off and the center system is not capable of detecting signals, no communication is possible. The server or system in MDNET uses the power that is largely smaller than any other power

Power aware metrics

The majority of power aware routing protocols for MDNET try to reduce power consumption by means of powerful routing metric, used in routing table computation instead of the minimum-hop metric there are four possibilities to save power from the mobile datacenter:

1) Minimal power consumption per packet

The power consumption is the sum of power consumed on every system in the route from a packet. The power consumption on a device is a function of the distance between the neighbor and the load of current system devices. So it is interesting to choose a route where the distance between the mobile centers is not too long and also it is interesting to take a shorter route so there are not too much confident on the route where the power level gets down.

2) Maximize network connectivity

This metric tries to balance the load on all movable networks. This assumes significance in environment where the network connectivity is to be ensured.

3) Minimum variance in datacenter power levels

This metric proposes to distribute the load among all centers so that the power consumption remains uniform to all systems. This problem is very complex when the rate and size of data packets vary.

When every system hasn’t the same level in power, you can be sure that the network functions longer. Because when there is a node which has to switch off because of the power level the whole network is in danger and it can break down the connectivity between the datacenters.

4) Minimize maximum node cost

This metric minimizes the maximum cost per system for a packet after routing a number of packets or after a specific period. So a datacenter server can be blocked for routing to save battery power. This metrics saves the connectivity from every datacenter systems. When a system has been used several times for route, it blocks itself to save the power.

Power aware routing

The aim of power-aware routing protocols is to reduce power consumption in transmission of packets between source and a destination, to avoid routing of packets through system with low residual power, to optimize flooding of routing information over the network and to avoid interference and medium collisions.

A single system failure in sensor networks is usually unimportant because it does not lead to a loss of sensing and communication coverage whereas datacenter wireless networks are oriented towards personal communication and the loss of connectivity to any center is significant.

3. RELATED WORK

Many research works has carried out and so much innovation and novel ideas in this field. We have discussed reactive, proactive, hybrid and hierarchical approaches. Most of the work today is based on power aware routing because power is main concern in MDNET networks. Each and every protocol has some advantages and shortcomings. None of them can perform better in every condition. It depends upon the network parameters which decide the protocol to be used. Several protocols have been given regarding power aware routing and their modifications have also been proposed for use in mobile networks.

3.1 Proactive power aware routing

3.1.1 Destination-sequenced distance vector (DSDV)

DSDV [3] is the most obvious proactive protocol. It is based on Bellman ford algorithm. It removed the

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shortcomings (loops, count to infinity problem) of contemporary distance vector protocol which was not suited for less infrastructure networks. It is a destination based distance vector routing protocol in which every centers maintains a routing table. This routing table contains all available destinations, the next center to reach to destination, and the no of servers between it. Whenever any node changes its position it broadcast the routing updates to the other centers. Sequence number is used to avoid loop problems.

Keeping the simplicity of distance vector protocol it guarantees loop freeness it reacts immediately on topology changes. Since the route for destination is always available at the routing table of each center so there is no latency caused by route discovery. But broadcasting of routing updates may cause high traffic load between the centers if the density of the datacenters are high. So this protocol is best suited if the density of the less structured mobile datacenter network is low. However if the mobility of the datacenter is too high broadcasting updates may cause time delay.

Advantages of DSDV

- DSDV protocol guarantees loop free paths.
- Count to infinity problem is reduced in DSDV.
- We can avoid extra trace with incremental updates instead of full dump updates. The path selection in DSDV maintains only the best path instead of maintaining multiple paths to every destination; with this the amount of space in routing table is reduced.

Limitations of DSDV

- Wastage of bandwidth due to unnecessary advertising of routing information even if there is no change in the network topology.
- DSDV doesn't support Multi path Routing.
- In DSDV it is difficult to determine a time delay for the advertisement of routes and also it is difficult to maintain the routing table's advertisement for larger network.

In DSDV each and every source in the network should maintain a routing table for advertising. But for larger network this would lead to overhead, which consumes more bandwidth.

3.1.2 OLSR (Optimized Link State Routing Protocol)

Optimized Link State Routing OLSR [4] incorporates two optimizations over the conventional link state routing in mobile datacenter networks. Each center selects a set of neighbor center called multi-point relays (MPRs). Furthermore, when exchanging link-state routing information, a center lists only the connections to those neighbors that have selected it as MPR, i.e., its Multipoint Relay Selector set .Further, the link state updates are diffused throughout the network only using these MPRs thus significantly reducing the number of retransmissions. The MPRs of a center are basically the smallest set of neighbors who can effectively reach all the two sever neighbors of that center. The MPRs of a center changes with center mobility and are updated using periodic HELLO messaging. A source-destination route is basically a sequence of hops through the multipoint relay nodes. Routes selected are shortest distance center as in the conventional link state algorithm. The protocol selects bi-directional links for routing.

Advantages of OLSR

- OLSR has less average end to end delay.
- OLSR is a flat routing protocol, which does not need central administrative system to handle its routing process.
- OLSR is well suited for an application which does not allow long delays in the transmission of data packets.

Limitations of OLSR

- OLSR needs more time re-discovering the broken link.
- Wider delay distribution.
- OLSR requires more power when discovering alternative route.

3.1.3 PW-OLSR (Power Aware OLSR Routing Protocol)

With PW-OLSR [5] (Power-Aware OLSR) is a routing protocol obtained by modifying OLSR[4] in order to improve its energy behaviour, without loss of performance. We have two mechanisms for this protocol: i) The Power Aware Willingness Setting and ii) the Overhearing Exclusion.

i) EA-Willingness setting mechanism

The Power Aware Willingness Setting is a mechanism to involve power considerations in MPR selection. The OLSR specification has a variable, the "willingness" of a center, representing the availability of that node to act as a MPR for its neighbours. By default, each center declares a default willingness value. In PW-OLSR, each center, calculating its own power status, and can declare an appropriate willingness. The decision to base the willingness selection is on both metrics the battery capacity and the predicted lifetime of a center. The heuristic used to associate a willingness ("default", "low" or "high") to a pair (battery, lifetime)

ii) Overhearing exclusion

Another mechanism that allows power saving in OLSR protocol is the Overhearing Exclusion. Turning off the device when a unicast message exchange happens in our neighborhood, can save a large amount of energy. This can be achieved using the signaling mechanisms of the lower layers and do not affect the protocol performance. In

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fact, OLSR does not take any advantage from unicast network information directed to other centers. After the MPR election it is important to select the next server for data packet forwarding (among the MPR neighbours set).

3.2 Reactive power efficient routing

3.2.1 DSR (Dynamic Source Routing Protocol)

DSR is a loop-free, source based, on demand routing protocol. This protocol is source-initiated rather than center-by-center. This is particularly designed for use in multi hop wireless mobile networks of mobile datacenter. Basically, DSR protocol does not need any existing network infrastructure or administration and this allows the network to be completely self-organizing and self-configuring.

This protocol is composed of two essential parts of route discovery and route maintenance. Every center maintains a cache to store recently discovered paths. When a node desires to send a packet to some center, it first checks its entry in the cache. If it is there, then it uses that path to transmit the packet and also attach its source address on the packet. If it is not there in the cache or the entry in cache is expired, the sender broadcasts a route request packet to all of its neighbors asking for a path to the destination. The sender will be waiting till the route is discovered. During waiting time, the sender can perform other tasks such as sending/forwarding other packets. As the route request packet arrives to any of the centers, they check from their neighbor or from their caches whether the destination asked is known or unknown. If route information is known, they send back a route reply packet to the destination otherwise they broadcast the same route request packet [7]. When the route is discovered, the required packets will be transmitted by the sender on the discovered route. Also an entry in the cache will be inserted for the future use.

The datacenter will also maintain the age information of the entry so as to know whether the cache is fresh or not. When a data packet is received by any intermediate center server, it first checks whether the packet is meant for itself or not. If it is meant for itself, the packet is received otherwise the same will be forwarded using the path attached on the data packet. Since in mobile datacenter network, any link might fail anytime. Therefore, route maintenance process will constantly monitors and will also notify the centers if there is any failure in the path. Consequently, the centers will change the entries of their route cache.

Advantages of DSR

One of the main benefits of DSR protocol is that there is no need to keep routing table so as to route a given data packet as the entire route is contained in the packet header.

Limitations of DSR

The limitations of DSR protocol is that, it is not scalable to large networks and even requires significantly more processing resources than most other protocols. Basically, in order to obtain the routing information, each node must spend lot of time to process any control data it receives, even if it is not the intended recipient.

Power dependent DSR

PDDSR is Power dependent DSR algorithm which helps center from sharp and sudden drop of battery power. PDDSR provides better power utilization compare to LEAR (least energy aware routing) and MDR (minimum drain rate). PDDSR avoids use of center with less power supply and residual power information of center is useful in discovery of route. Residual battery power of each node is computed by itself and if it is above the specific threshold value then node can participate in routing activities otherwise center delays the rebroadcasting of route request message by a time period which is inversely proportional to its predicted lifetime. PDDSR has further advantage over MDR because it can use route cache used by DSR.

3.2.2 AODV(Ad hoc On Demand Distance Vector Protocol)

Ad hoc On Demand Distance Vector AODV [8] is a variation of Destination-Sequenced Distance-Vector (DSDV) routing protocol which is collectively based on DSDV and DSR. It aims to minimize the requirement of system-wide broadcasts to the greater extent. It does not maintain routes from every node to every other node in the network rather they are discovered as and when needed and are maintained only as long as they are required. The key steps used by AODV for establishment of unicast routes are Route discovery and Route maintenance.

i) Route discovery

When a node wants to send a data packet to a destination node, the entries in route table are checked to ensure whether there is a current route to that destination node or not. If it is there, the data packet is forwarded to the appropriate next server toward the destination. If it is not there, the route discovery process is initiated. AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create a RREQ packet containing its IP address, its current sequence number, the destination's IP address, the destination's last sequence number and broadcast ID. The broadcast ID is incremented each time the source node initiates RREQ. Basically, the sequence numbers are used to determine the timeliness of each data packet and the broadcast ID & the IP address together form a unique identifier for RREQ so as to uniquely identify each request. The requests are sent using RREQ message and the information in connection with creation of a route is sent back in RREP message. The source node broadcasts the RREQ packet to its neighbors and then sets a timer to wait for a reply. To process the RREQ, the node sets up a reverse route entry for the source node in its route table. This helps to know how to forward a RREP to the source. Basically a lifetime is associated with the reverse route

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entry and if this entry is not used within this lifetime, the route information is deleted. If the RREQ is lost during transmission, the source node is allowed to broadcast again using route discovery mechanism.

ii) Route maintenance

As long as the route remains active, it will continue to be maintained. A route is considered active as long as there are data packets periodically travelling from the source to the destination along that path. Once the source stops sending data packets, the links will time out and eventually be deleted from the intermediate node routing tables. If a link break occurs while the route is active, the center upstream of the break propagates a route error (RERR) message to the source node to inform it of the now unreachable destination(s). After receiving the RERR, if the source center still desires the route, it can reinitiate route discovery.

Advantages of AODV

- The benefits of AODV protocol are that it favors the least congested route instead of the shortest route and it also supports both unicast and multicast packet transmissions even for center in constant movement.
- It also responds very quickly to the topological changes that affects the active routes.
- AODV does not put any additional overheads on data packets as it does not make use of source routing.

Limitations of AODV

- The limitation of AODV protocol is that it expects/requires that the center in the broadcast medium can detect each others' broadcasts. It is also possible that a valid route is expired and the determination of a reasonable expiry time is difficult. The reason behind this is that centers are mobile and their sending rates may differ widely and can change dynamically from center to center. In addition, as the size of network grows, various performance metrics begin decreasing.
- AODV is vulnerable to various kinds of attacks as it based on the assumption that all centers must cooperate and without their cooperation no route can be established.

3.2.3 Power-aware algorithm for AODV in mobile datacenter networks

This is a new Power optimized algorithm that can be applied to current infrastructure less routing protocols such as AODV. A cost function has been deduced based on both the propagation power loss and datacenter battery capacity information and routes are optimized based on the cost functions of links and datacenter. In particular, a low-battery alert mechanism is introduced to improve the routing update behavior, preventing overuse of critical centers. Network throughput is not affected much, which is a trade-off issue with the low-battery alert level. The power consumption is balanced among the network and the limited battery resources are utilized efficiently.

Power Aware AODV (PAAODV) protocol

PAAODV protocol is an enhancement of AODV routing protocol, which implements power control information during route discovery. PAAODV incorporates two mechanisms: (i) multiple power level route discovery (ii) link-by-link power control.

During route discovery, route request packets are used to find a route that is power efficient and route reply packets are used for link-by-link power transmit control. PAAODV employs several power levels during route discovery. The datacenter servers attempt to find a route to the destination initially with low power levels. If it does not succeed, then the power level is increased. It continues until route discovery succeeds. Two power levels are used, i.e. one low and one high, are used.

3.3 Hybrid routing power aware routing protocol

3.3.1 Zone Routing Protocol (ZRP)

ZRP is a hybrid protocol taking advantage of a proactive routing strategy within a datacenter local neighborhood and a reactive routing protocol for communication between the neighborhoods. Each datacenter server defines a zone around itself and the zone radius is the number of servers to the perimeter of the zone. The reactive global search is done efficiently by querying only a selected set of datacenter server in the network. The number of DC server queried is in the order of [r zone / r network]2 of the number of center queried using a network-wide flooding process .

Unless the zone radius is carefully chosen, a center can be in multiple zones and zones overlap. As a result, the efficiency in route discovery decreases. Also, in the presence of datacenter mobility, the zone radius may fluctuate rapidly and also affect the functionality of center within and at the periphery of the zone. The intra zone routing protocol (IARP) used within a zone is not a specific routing protocols, it is rather a family of limited-depth table-driven pro-active routing protocols. Similarly, the Inter zone routing protocol (IERP) is a family of reactive routing protocols which could provide enhanced route discovery and maintenance services using the local connectivity information provided by IARP. Thus, we do not classify ZRP into neither of the two categories and view it as a framework for the proactive and reactive routing protocols [6].

3.3.2 Optimizing power-aware routing using zone routing Protocol in MANET

The lifetime of routing path differ with the power control method. A routing model Optimizing Power-Aware Routing using Zone Routing Protocol using PARO (Power-Aware Routing Optimization) and ZRP (Zone Routing Protocol) has been developed for effective power control and transmission. This routing algorithm tries to

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minimize the power consumed in transmitting a packet from the lifetime of the network by avoiding centers that have a shorter lifetime remaining.

4. CONCLUSIONS

In this Survey Paper we have discussed about various protocols and their modification which includes power aware with the importance of power aware routing protocols. We conclude that there is not a single protocol which can give the best performance in mobile datacenter network. Performance of the protocol varies according to the variation in the network parameters. Sometimes the mobility of the server in the network is high and sometimes it is low but power usage of the mobile datacenter is our prime concern.

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