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An Evaluation of Topology Effect on Tiny Service Discovery Protocol for Wireless Sensor Networks

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ABSTRACT

In the literature of wireless sensor networks (WSNs), a well studied problem is that of achieving full sevice discovery within a region according to the topology model of coverage. A large waiting time of wireless sensor applications spent in node discovery, as nodes need to periodically advertise their presence and be awake to discover other nodes for services. Uniformly random distributions are widely accepted models for the location of the nodes in WSNs. Depending on the application, it may also be possible to place sensors in a four models of topologies; random, square, tringle and hexagon.

There is a rich literature on throughput capacity for WSNs topologies in general, but we want to specifically study Service Discovery Protocol and how proper node deployment scheme can reduce the complexity of problems. In this paper, the effect of node topology on the performance of Tiny Service Discovery Protocol (TinySDP) in WSNs has been analyzed. In order to measure and evaluate the performance of TinySDP within variant shapes of topologies, We compared in terms of success ratio, number of transmitted messages and average waiting time. Simulation results showed that hexagon topology has a high data success ratio and a very low average waiting time, which are major requirements for disaster management scenarios.

Indexing terms/Keywords

Wireless Sensor Network (WSN), Service Discovery Protocol (SDP), Topology models. Hexagon model, TinySDP, TOSSIM, TinyViz

Academic Discipline And Sub-Disciplines

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1. INTRODUCTION

In WSNs, the reason for checking topology model is to provide the high performance and quality of service discovery protocol. An oraganized nodes in defined topology is considered for WSN applications. To satisfy the sevice discovery of a given sensor network, every node in it must be served by at least one sensor node without allowing any unserved nodes. For example, temperature or light sensing in environmental monitoring applications, where reading at one node is adequate for part of the network since it may have the same readings in its surrounding area. A proper node deployment can reduce the complexity of problems [1] and [12] in WSNs as, for example, routing, data fusion, communication, etc. Furthermore, it can enhance the performance of WSNs by minimizing average waiting time.

There are famous implementations of service discovery protocols. In WSNs, existing service discovery protocols are Service Location Protocol (SLP) [19], Jini [42], Microsoft Universal Plug and Play (UPnP) [43], DEAPspace [36], Gossip-based Discovery [21], Pervasive Discovery Protocol (PDP) [13] and Tiny Serive Discovery Protocol (TinySDP) [14]. These protocols are commonly used in MANET (Mobile Ad-hoc Network) and WSNs. Unfortunately, are too resource intensive to be used in sensor networks.Many technical challenges are, therefore, newly addressed in WSNs. Service discovery protocols are network protocols that allow automatic detection of devices and services offered by these devices on a computer network.

In any case, the service discovery pretty much depends on the topology model of the nodes. To fulfil the desired service discovery, adjusting the topology model has its limitations due to the expensive energy consumption and restricted node capabilities. Therefore, node topology model becomes very important. There is a rich literature on throughput capacity for wireless networks [39], [41], [38] with random or regular topologies. The most popular three regular topologies are triangle, square and hexagon. Nodes that need a service, perform a discovery step, which typically initiates (limited) flooding of the network to discover nodes offering appropriate services. In some cases, nodes may directly seek the needed services themselves; in others, they may contact one or more service catalogs, which maintain directories of available services.

While the topology analysis is useful in some applications, for service discovery kind of WSN applications it must be ensured that messages indicating transmitted messages are not lost and that they arrive to the distination with minimum delay. This can be achieved by a new methodology called sensor network calculus [24]. the network topology has to be known to some degree. For example, a triangle network topology with a sink at the root and n sensor nodes can be used. Next, the network traffic has to be described in terms of the so-called arrival curves or each node. An arrival curve defines an upper bound for the input traffic of a node. Leaf nodes in the network must handle traffic according to the sensing function they perform [38].

The optimal node deployment is obtained by maximizing the lifetime under the constraints of coverage, connectivity and data success transmission rate. As the retransmission rate is highly related to the transmission distance, topology model should guarantee the coverage, connectivity and data success transmission rate, which may not be achieved simultaneously in random model.On Hexagon model for WSNs, low cost nodes distribution is presented [7]. Hexagon model also showed that is low cost to adverse effect of anchor placement [12]. Hexagon model can be implemented in a distributed fashion efficiently when the number of anchors is chosen appropriately.

In this paper, we analyze the TinySDP protocol with changing topology model to sensor networks can significantly increase the capability of the sensor network by making it resilient to failures, reactive to events, and able to support disparate missions with a common set of sensors. The rest of the paper is organized as follows: In Section II, we discuss background studies and related research. In Section III, will describe TinySDP and discuss mobility models. Our problem formulation is covered in Section IV. In section V, the experimental simulation posted in details with both network and simulation setup. In Section VI, we conclude our work.

2. RELATED WORK

In the mobile wireless sensor networks, Node move and change frequently relative to the location of their own. There are directory node TinySDP, all nodes maintain only own services. In this case, the mobility will automatically be flooding or multicast address separately the Query message to all or several node [40]. On the other hand, mobility is a challenging issue TinySDP in the directory node. What we are now discussing some of the ways to deal with mobility in TinySDP adverse effects. Periodic updates of the service information and [26] [31] [32], is one of the ways to deal with mobility. When the service provider to release its services, it also announced that after the expiration of the service information will be timed out. The mobile node cache this information.

The service provider must be published once again on the service information expired. Re-discovery service for the re-election, also handles mobility. In the Re-discover, network sniffing about the availability of the service provider and the re-election of the latest information; the service was selected based on service table only [27] the current entry. Another way to deal with the mobility is to reduce the diameter and the advertising time advertising [34] [35] interval, to compensate for fast, [22] changes the impact of nearby.

The distance from the random distribution is a challenging issue. This causes all the statistics from the moment. On the other hand, the study of the distribution of nodes distance can be traced back to 1940’s [14], [44]. At random points between the desired distance from being identified as a number of issues. 75-12 This distribution is very useful, for example, in the settlement of the question of a communications network. When one of the endpoints is fixed random distance, has also been reviewed, and the last long [46] conducted a study, distribution when the two end points of the boundary of the area on [13]. However, the problem becomes, the two endpoints are the Random day and night temperatures especially network worship.

All the results have or that the distance is random, from a fixed reference point, or distributed very specific network connection network topology[47]. In particular, often need to coordinate the independence of the node, [49] and [50] [48]. However, this assumption is not set up to six-topology. Wu et al. [18] liu. [16] and [10] Wang divided by the target area is divided into several ring and an analysis on different ring sensors in the optimized deployment scenarios. Abdul Salam [15], Chiang Kai-shek, and others. All father, fans etc. [2] And Gupta and others. [3] study of grid-based structured deployment methods, In Onur [20], the deployment of grid-based monitoring dolmabah palace in Istanbul, a wireless sensor networks. Hexagonal layout has many affected groups and will be described in the sensing zone into hexagonal grid power control to ensure that it is secure and memory requirements for the better.

In the [25], advantages and hexagonal base WSN potential applications, describes the study indicates that, from WSN hexagonal based on the topology of the coverage, energy efficient, reliability, routing design of such a deployment for the benefit of hexagonal based on the topology requires based on the coordinate system to determine the location of the sensor [5] . The potential for the next generation of the airborne network such as those used in the cabin-sensor networks have long life requirements, such as the wireless sensor network as in Yedavalli and Belapurkar [8], [5] and Wang leipold et al. and Hu [4]. This is worth following the best deployment scenarios for the deployment of the sensor.

Zou and Accra, [29] and in accordance with different coverage model, including boolean comparison with the results of the coverage model. They took advantage of the probability density function of the unit in the specified position sensor model uncertainty transducer placement of the boolean overlay mode. Dasgupta, etc. [30] with sensor boolean coverage model, where the concerns of the region as a whole must be covered. For the given zone [37] of the interference of the node for a variety of topologies. Pricing is the decentralization of research networks as a control variable.

3. BACKGROUND

In this section, we investigate networks with four topology models; random, triangle, square and hexagon. In which every node has the same number of nearest neighbors and the distance between all pairs of nearest neighbors is the same.

3.1 Random Model

The Euclidean distance between random points (X_1, Y_1) and (X_2, Y_2) is

Let the random variable Z denote the squared Euclidean distance D , $X = X_1 – X_2$ and $Y = Y_1 − Y_2$,

so that $Z(X, Y) = X^2 + Y^2$. For given X and Y, the distribution of Z is

$$D = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$$

$$P(Z \leq z) = \iint P\left(Z(X,Y) \leq z | X = x, Y = y\right) f_{X,Y}(x,y)dxdy,$$

where $f_{X,Y}(x, y)$ is the joint probability density function. Henceforth, we use X to denote a random variable, x for a sample value of X, and X to denote the set of all possible values of X. It is assumed that the probability distribution of the random points is uniform, where $U[a, b]$ is used to denote a uniform distribution over the interval $[a, b]$.

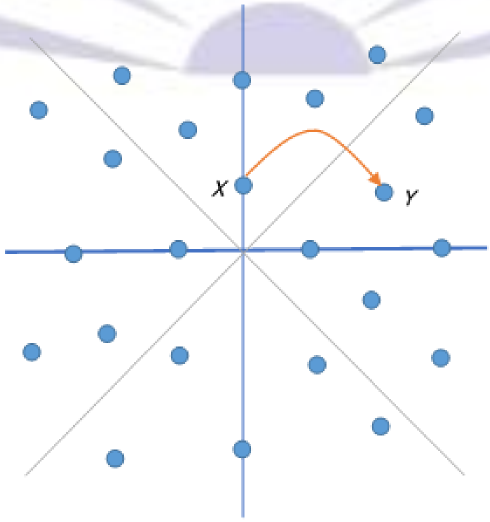

Figure 1: random model. Calculating the distance between node *X and node Y*

3.2 Square Model

Nodes in this model will be aligned to form adjasunt squares. To analyze square model with N nodes we assume that network density is 1. That is nodes are placed in the vertices of a square grid with distance 1 between all pairs of nearest nodes. The next-hop receiver of each packet is one of the four nearest neighbor nodes of the transmitter, so the transmitter-receiver distance $d_0 = 1$. If the receiver node *O* is located in the center of the network as shown in figure2 and node *A* is the desired transmitter, the success probability for node *O* can be written as:

$$P_s(p) = \left(1 - \frac{\theta_p}{i^\alpha + \theta}\right)^3 . \left(1 - \frac{\theta_p}{(\sqrt{2})^\alpha + \theta}\right)^4 . \prod_{i=1}^{\sqrt{N}/2} \left\{\left(1 - \frac{\theta_p}{i^\alpha + \theta}\right)^4 . \left(1 - \frac{\theta_p}{(\sqrt{2i^2})^\alpha + \theta}\right)^4 . \prod_{j=1}^{i=1} \left(1 - \frac{\theta_p}{(\sqrt{i^2 + j^2})^\alpha + \theta}\right)^8\right\}$$

Where

θ signal-to-interference-plus-noise-ratio SINR threshold.

α is the path loss exponent.

N total number of nodes

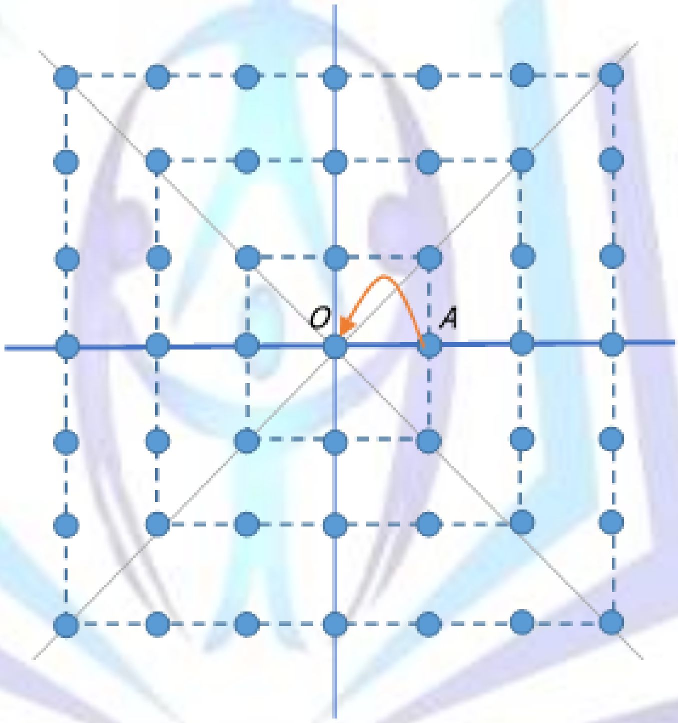

Figure 2: square model. Node *O* is reciver and node *A* is desired transmitter, where d_0 = |*OA*| = 1

3.3 Triangle Model

Some other regular topologies of interest are the triangle topology figure 3. For each triangle, there are three vertices and six nearest neighbors for each vertex, Again, the next-hop receiver of each packet is one of the nearest neighbor nodes of the transmitter, so the transmitter-receiver distance d_0 is equal to the side length of the regular polygon. In the triangle network,

each node is located in triangle with area of $\frac{\sqrt{3}}{2} d_0^2$ For node density is 1, $d_0 = \sqrt{\frac{2}{\sqrt{3}}}$

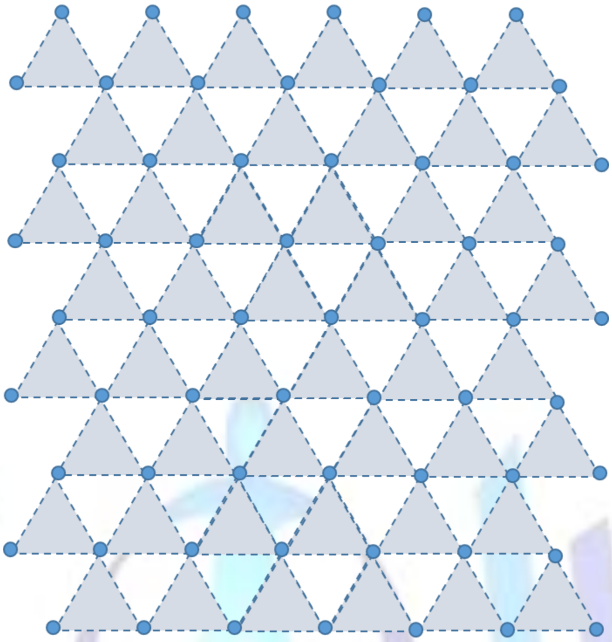

Figure 3: Triangle model.

3.4 Hexagon Model

The third strategy is based on tiling. A tiling is the covering of the entire plane with figures which do not overlap nor leave any gaps. Every vertex uses the same set of regular hexagons. A regular hexagon has the same side lengths and interior angles. We consider a semi-regular tiling that uses triangle and hexagon in the two dimensional plane, the Hexagon Tiling. The name comes from going around a vertex and listing the number of sides each regular hexagon has, as illustrated in Figure 4.

each node is located in triangle with area of $\frac{\sqrt{3}}{2} d_0^2$ For node density is 1, $d_0 = \sqrt{\frac{4}{3\sqrt{3}}}$

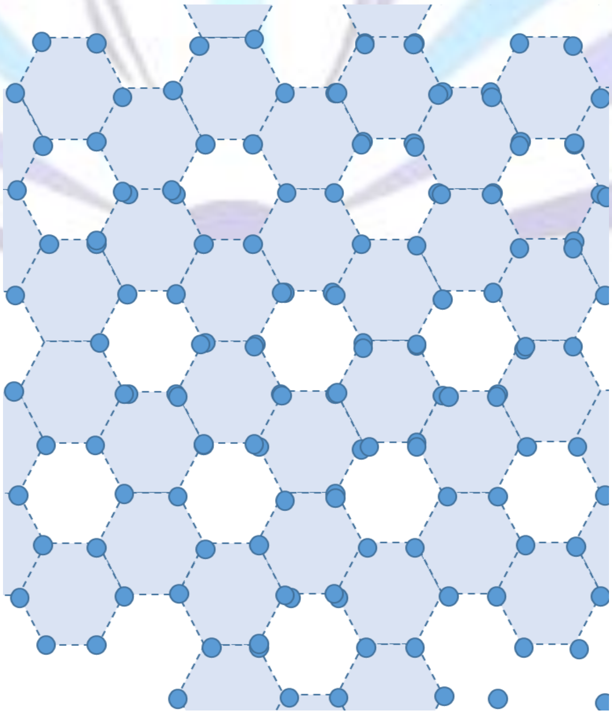

Figure 5: Hexagon model

4. PROBLEM DESCRIPTION

Service discovery in the dynamic topology of wireless sensor network is a challenging issue [1]. In wireless sensor nodes in the network provides a spontaneous and variable. In addition, a given service and the sort of services in close proximity to the amount of time the unpredictable. , a node can also provide that may be of interest to dynamic topology in the services. Thus, there is always a need to have the ability to discover and use the other equipment for services provided by the mechanism. For this purpose the service discovery technologies.

The Service Description Service Discovery Protocol is also an important aspect of the appropriate description, as well as convenient services to search. Usually these aspects of the service discovery protocol. Restrictions on service discovery of this aspect of the involved finding in neighbors in dynamic topology of wireless sensor network the specific service location. In this connection, it is our aim that the analysis in the dynamic topology of wireless sensor network TinySDP behavior. In order to analyze the results, we first define some measures [9].

We call node as the client successfully find the service as (**N_{succ}**) and the number of Service Advertisement Messages as (**M_{adv}**). The number of Service Request Messages as (**M**req) and the total number of messages sent as (**M_{total}**). Each successful client (**C**) receives message from 1 to m service reply Messages of waiting time (t1, t2, ..., tm).

- Success Ratio (**SR**): The ratio (Calculated as a Percentage (%)) of the number of nodes that successfully locate the service, over the total client number. It is calculated by the following equation:

$$SR = N_{succ} / N \times 100\ (\%)$$

- Number of Transmitted Messages (**M_{total}**): The total number of messages transmitted for a period of the simulation. This is a useful parameter for estimating the efficiency of the Protocol. It is calculated by the following equation:

$$M_{total} = \sum_{n=1}^{N} (M_{req} + M_{adv})$$

- Average Waiting Time (**AWT**): The minimum period in seconds, of time, averaged over all customers, from the message transmission service request and ending with the reception of reply message. It is calculated by the following equation:

$$AWT = \frac{\sum_{n=1}^{N} min(t1, t2, \ldots, tm)}{N}$$

TABLE 1

Network and Simulation Parameter

Network And Simulation Parameter	
Total Number Of Node	50
Topolgy Model	random, triangle, square and hexagon
Speed	1-3 m/s
Pause Time	1-10s
Area Scenario	100 X 100m
Transmission Range, R	15m
Initial positions	Uniform distributed
Simulation duration	100 minutes
Node is initialized	At a Random Location

5. SIMULATION & RESULTS

5.1 Simulation Setting

5.1.1 Network Setup

All 50 simulated nodes are assumed to have the same resources in terms of power and memory. There are 11 kinds of services offered in the network. We assume that all services follow a uniform distribution. Four models of topologies (random, triangle, square and hexagon) for the network should be used. We have assumed a convex dense network with stationary nodes. We should use a mobile radio model; all nodes have full connectivity to their neighbors. Using a more realistic radio model that includes errors would increase the number of messages that need to be transmitted, but should not alter the relative performance of the various protocols.

5.1.2 Simulation Setup

Each 3 minutes of the real time of a node, the node start executing modified TinySDP. Switching between on operational mode to another according to metric calculations. Advertisements are sent out when the network. Since we have 50 nodes in our network, a few of the service request packets get lost if all of the 50 nodes start sending out their service request together at network startup. In order to ensure that this does not happen, the nodes send out their advertisement packets only in certain slotted time intervals each 1 minute. A timer that outputs the collected information into the screen. Simulator should run for a time of 100 minutes to get the best reading of sending out request packets. The parameters are listed in Table 1.

5.2 Results Analysis and Discussion

We have to analyse and compare results of TinySDP with four models of topologies in WSN. Since we are assuming a stationary network, we compare results with those results appeared in [17] and [28] that assume a nearly stationary. A side-by-side comparison of performance results is as shown in the following Table 2 with 50 nodes.

The result of this experiment has shown that the TinySDP with random topology model in WSN has lesser values in performance metrics in terms of the Total Number of Transmitted Messages (M_{total}) and Success Ratio (SR) and lesser values in Average Waiting Time (AWT) for discovering service is a measure of the high performance metrics of TinySDP with non-random topology models WSN. In non-random topology models, TinySDP has almost the respective success ratio as triangle, square then hexagon models. This indicates that number of nodes has no effect on the performance in random topology model. In the other side, we can see clearly that success ratio directly affected by the shape of topology.

TABLE 2

Performance Comparison

Comparison	Routing Protocol	N	N_{succ}	M_{adv}	M_{req}	Max SR	M_{total}	AWT
Random model	TBF	50	29	269	355	58%	617	0.3712
Triangle model	TBF	50	39	237	309	78%	568	0.4317
Square model	TBF	50	42	216	283	84%	520	0.5084
Hexagon model	TBF	50	49	203	218	98%	417	0.5164

We visualized results in three variant figures. Performance comparison of all metrics for four models of topologies random, triangle, square and hexagon models. We compared success ratio, total number of transmitted messages and average waiting time. The hexagon model scored the best results as shown in the three figures. Figure (5) illustrated that TinySDP with non mobile 50 nodes. For hexagon model, the success ratio was 98% which is ideal and accepted. Meanwhile, triangle and square models scored 78% and 84% rescectively which considered accepted for this number of nodes. It is expected to get worse results when increasing number of nodes. Random model scored 58% which is the worst of all.

Figure 7 showed number of transmitted Messages of TinySDP with four models of topologies. As expected the total number of transmitted messages are converging to each other. Stating from 417 messasge for hexagon model up to 617 messages for random model. Indecating that the orginzed network has not to send extra messages while nodes knows exactly there neighbors. Figure 8 is the most representative. It illustrated the average waiting time of TinySDP with four models of topologies. Hexagon model scored 0.5164 seconds of waiting. Meanwhile the random model scored 0.3712 seconds of waiting. At this comparison the random model won. It seemed that the advantage gained by increasing success ratio has its affect on average waiting time.

6. CONCLUSION

Among the four topology models (random, triangle, square and hexagon), the hexagon model provides the highest throughput since every node has only three nearest neighbors which is the smallest number among the for models. which implies that at maximum throughput, the packet loss rate is about 60%, which is surprisingly high. These results hold quantitatively for the other two topology models (triangle and hexagon). For random model considered fixed transmitter-receiver distance.

In the latter case, the throughput is averaged over the actual number of success ratio and total number of messages. Conditioned on d being the same for four topology models, hexagon topology model outperform other models in terms of (per-node) throughput and transport capacity. In the case of message tansmition where the receiver selects the nearest neighbor node as its desired transmitter, the average throughput of random networks is better than that of regular ones. This is because strong signal powers resulting from very small d 0 offset the impact of interference even for high transmit probabilities. This result, however, only pertains to local data exchange. When multihop communication and effective routing is taken into account, hexagon topology model have a significant advantage in terms of end-to-end throughput.

In summary, we believe that hexagon topology model is a promising node deployment strategy, although its planning overhead must be taken into account. In three performance metrics, hexagon topology model almost always outperforms the other strategies for topology models. For coverage performance, a square model is better than the other strategies. It can also be seen that random model is not a bad strategy and it is comparable to the popular square model for the worst-case delay. Of course, we analyzed these metrics based on certain assumptions. Yet, we believe that hexagon model is a wellperforming node topology models for WSN applications.

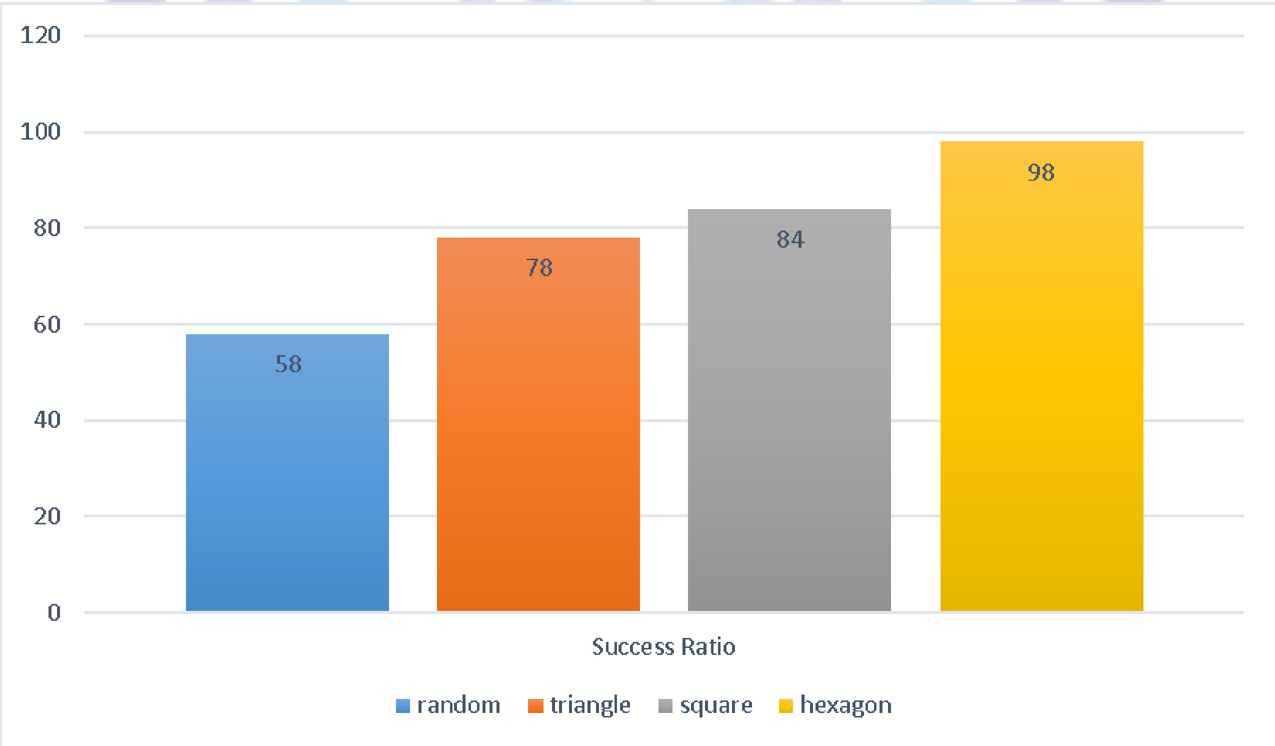

Figure 6: Success Ratio (SR) of TinySDP with four models of topologies

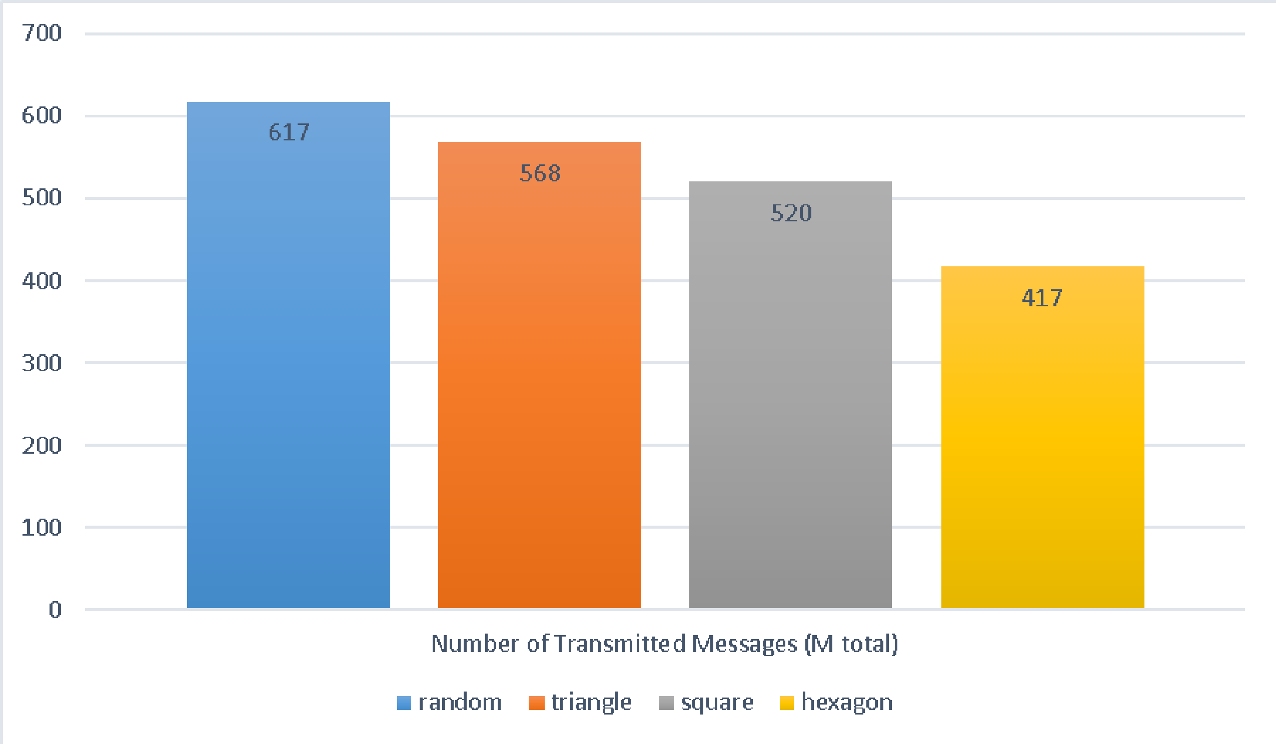

Figure 7: number of transmitted Messages of TinySDP with four models of topologies

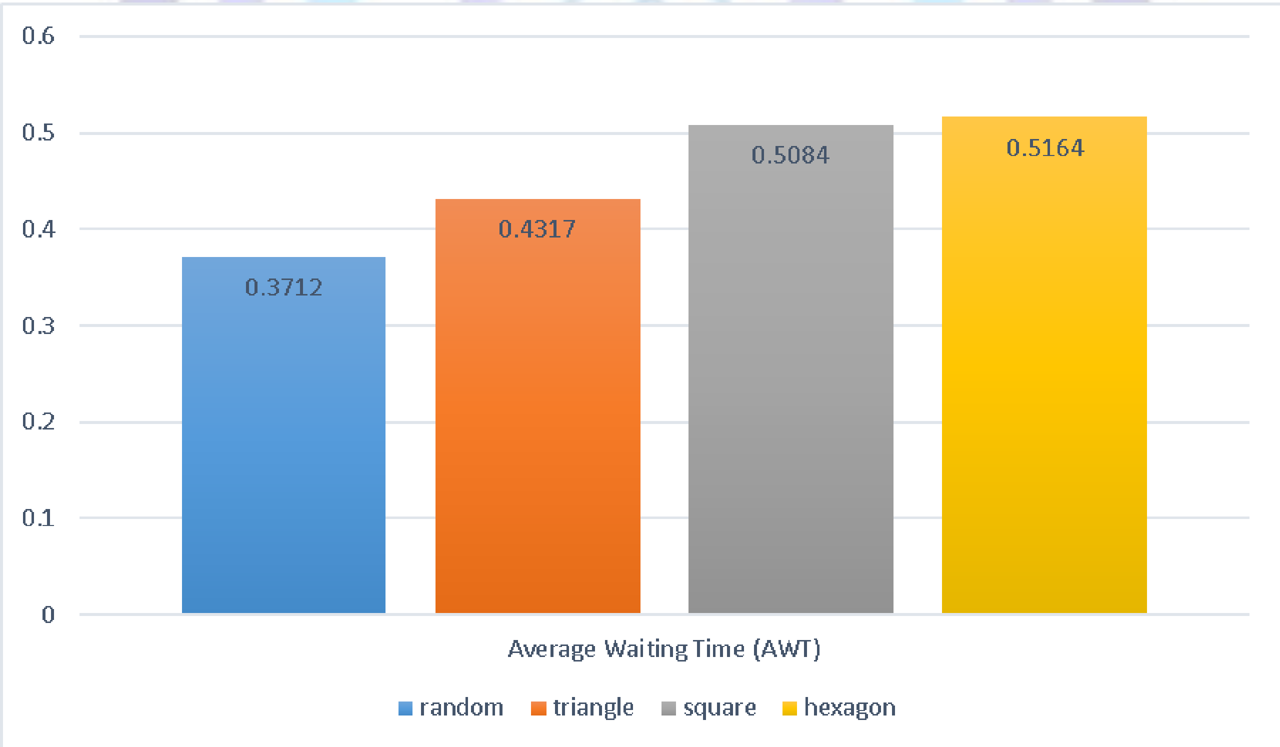

Figure 8: Average waiting time of TinySDP with four models of topologies

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