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# GSZRP: Graphics-hardware based Optimized Secure Zone Routing protocol

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## ABSTRACT

*SZRP or Secure Zone Routing Protocol is an important step for securing communication in a MANET [1]. However, because of growing computational load on the mobile nodes, it has become difficult to meet the computational load. Many factors are responsible for this increased complexity, such as growing number of user-base, growing number of smart devices[2], growing number of user centric applications, and the advent of IoT. Applications based on IoT or Internet-of -Things has been applied in a number of areas including commercial business applications and also in consumer applications [3]. These applications often rely on forming an ad-hoc network for communication and we can envision how MANET routing is crucial. Not only that the communication should meet security goals, it has to meet very deadlines related to timing as well. This necessitates a strict requirement of having low complexity algorithms at very stages in communication in MANET. In this work we addressed these issues of optimization of SZRP. We termed our approach as GSZRP, where G stands for Graphics-hardware or it can be GPU (Graphics Processing Unit). We proposed and demonstrated our approach of using a GPU, (which is a massively parallel architecture having thousands of processing cores or computational units,) can be used for various processing using less computational load, making real time requirement of many applications in MANET, possible. We proposed two algorithms, one based on coarse grain parallelism and another based fine grained parallelism. We also investigated what are the conditions that should be met for exploiting the resources of a GPU for implementing various protocols on it and get a performance benefits. We also explained when a CPU based solutions is better option.*

***Keywords—GPU; SZRP; MANET; ZRP; Ad-hoc; Wireless***

## I.INTRODUCTION

In this section we give more explanation about a GPU, its applications and its advantages and limitations.

*A. What is a GPU?*

A GPU or Graphics Processing Unit is originally specially designed processor for handling graphics related computations of a graphics based application. But a GPU can also be used for doing non-graphical processing. Since it has huge number of processing cores, it can be used as means for fast calculation on huge data set[**4**].

Fig. 1 below explains the main difference between a CPU and GPU. It can be seen that most of the silicon area in a GPU is devoted to computational units (shown in green) unlike a CPU where it has more units for controlling and cache (shown in orange and yellow color).

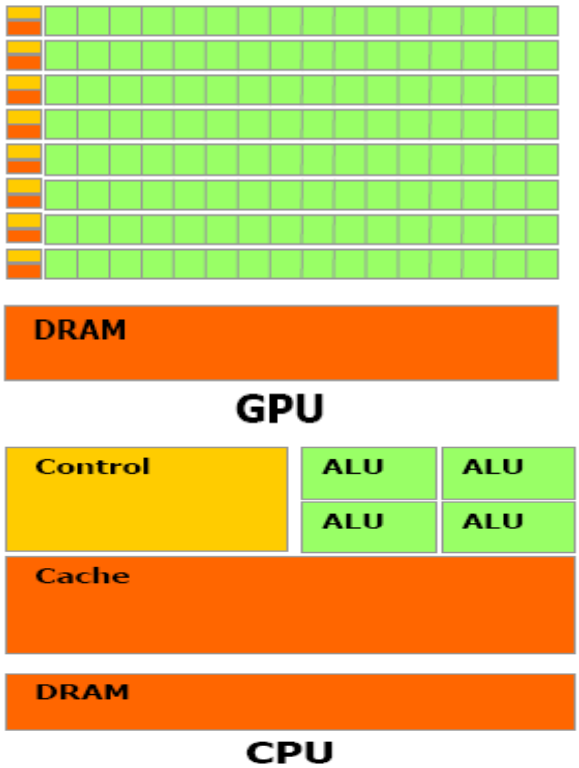


**Fig. 1.CPU Vs. GPU**

*B. Why we use a GPU?*

A GPU can be used for non-graphical computationally expensive applications because it has a large number of computational units called cores. These cores are utilized in parallel by a large number of threads to get results in parallel. All cores are clocked by a low frequency clock source therefore expected power dissipation is normally assumed low.

*C. Advantages & Limitations*

The inherent parallelism in a GPU makes it an excellent candidate for parallel applications. Especially embarrassingly parallel application best utilizes these computational resources. Not many applications are fully parallel and many a time only a small fraction is parallelizable **[5]**. In such case performance gain may not be very good.

Another issue with GPU is that we need to copy data to and from GPU. This copying operation is normally very costly as compared to calculations, which might degrade the over system performance. **[6]**

## II.SECURING ROUTING IN MANET

There are many protocols used for routing in MANET[7][8][9][10][11]12]. Because there is no central certification authority in a Mobile Wireless Adhoc Network or MANET, security becomes most important concern, especially for applications that share sensitive user data, including lifesaving critical applications. A malicious node for example pretend as an authorized node and send fake data to other nodes, giving rise to many attacks, including Denial-of-Service attacks**[13]**.

Though MANET has several advantages, it lacks proper mechanism for security, we describe below those security related aspects and challenges in this section.

The communication in MANET relies completely on radio transmissions, which is susceptible to eavesdropping by an unauthorized node. This makes it mandatory to deploy an end-to end encryption to prevent eavesdropping. Because there is no central monitoring system, nodes participating in defining topology, may involve in Denial of Service attacks and might become black hole stalling all communications.

Further, many nodes are non-participating and any communication with such nodes results in wastage of CPU-time, bandwidth and battery power which are often limited in MANET nodes. MANETs behavior is highly dynamic, where non-participation and exits are highly unpredictable. In such dynamic environment, any static security mechanism is insufficient. A dynamic security approach, where security related parameters are adjusted on-demand is a must have in such situation. The Zone Routing Protocol **[14]** has no security enabling feature and thus it is its biggest limitations. That is why SZRP [2] is proposed which adds a security layer to make communication in a MANET secure.

## III.OPTIMIZATION AND PERFORMANCE ISSUES IN MANET ROUTING PROTOCOLS

In MANETs participating nodes are dynamically connected in an arbitrary manner which changes various network parameters. The rate of change of these parameters depends on how fast these participating nodes move. Routing protocols heavily rely on huge number of calculations at various stages during packet transmission and final delivery. MANET comprises of mobile devices which are often limited in power backups and computational capabilities. For a real-time application in MANET any delay in a transmission or reception of data packets could be disastrous especially for safety application.

In MANET the topology is highly dynamic because of exit or entry of new nodes in the network. These networks comprise of huge number of nodes, especially due to advent of recent advancement in IoT (Internet-of-Things) and similar technologies. Today we have huge number of mobile devices and a use of smart phones is very common these days. This further puts computational pressure on these small hand-held devices. Also the number of such devices is growing rapidly [3], Further Zones in MANET are also increasing in size, further

increasing the complexity of the network as a whole. This demands more computation per second. Therefore, meeting the computational goal is crucial for successful use of the applications.

As discussed earlier this paper proposes a technique to solve such optimization issue in MANET using a GPGPU approach [15]. GPGPU stands for General Purpose Programming on Graphical Processing Units, i.e. we intent to use the computational capability a GPU for doing a non-graphics problem of optimization of SZRP in a MANET.

## IV. GSZRP: GRAPHICS-HARDWARE BASED OPTIMIZED SECURE ZONE ROUTING PROTOCOL

The proposed solution based on GPU can be seen in the following figure.

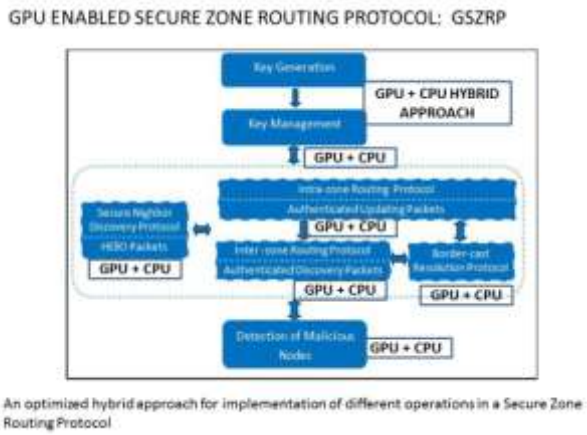


**Fig. 2.CPU Vs. GPU**

As can be seen here our proposal is based on a CPU-GPU hybrid approach where we try to exploit parallelism as much as possible. We propose that we should look for the opportunity to port parallel jobs on a GPU and serial controlling jobs on a CPU. In the previous section we have already described various conditions when a GPU can substantially outperform CPU performance.

### *D. Basic idea*

To prove our concept we have chosen the problem of Neighbor Discovery Protocol (NDP) **[16]**. The basic idea of our approach in using a GPU for NDP is discussed now. In NDP one of the most computationally expensive jobs among the three rounds is the calculation of the distances based on T (time) and L (Location). These measurements are done independently corresponding to each node by the querying node. Also because the computational load is huge, we estimate an Arithmetic Intensity ( no. of calculations per communication) is very high. One of the first conditions for applicability of a GPU for an application is that it should have higher Arithmetic Intensity, and the problem of NDP satisfies this. The following figure shows how we are solving NDP distance calculation on a GPU.

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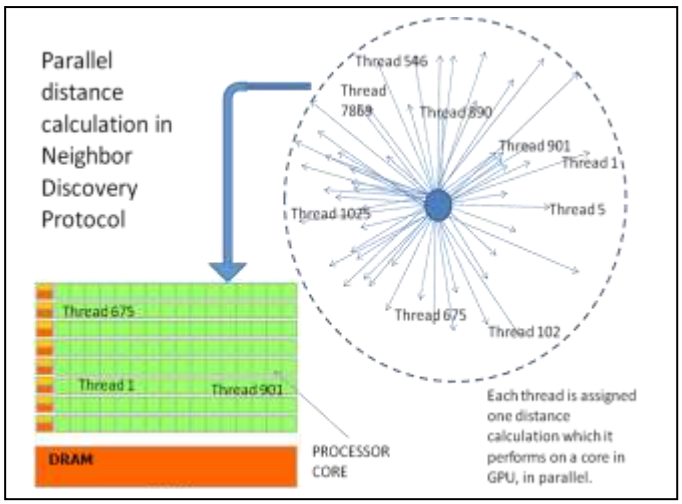


**Figure 3: Distance calculations in NDP on a CPU-GPU system will have higher parallelism opportunity**

In this version we have assigned one thread to each distance calculation, that is, each thread is responsible for completing the D calculation,

D= sqrt( (x2-x1)2+ (y2-y1)2 (1)

All thread will work in parallel and will finish the job simultaneously. In contrast to this on a CPU everything will run serially so there will be considerable delay. Therefore, we see that a parallel approach using a GPU could help us latency issues in SZRP of MANET.

The following flow chart shows our proposed methodology

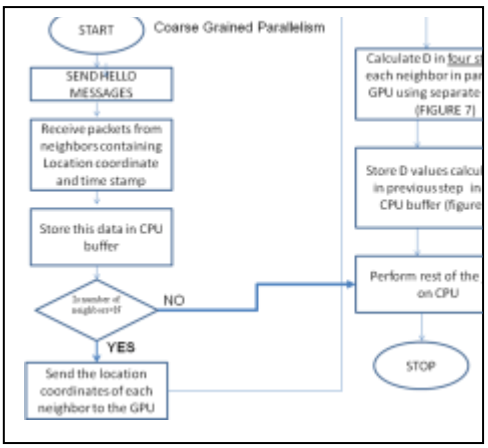


**Figure 4: Distance calculations in NDP on a CPU-GPU system will have higher parallelism opportunity**

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## V.RESULTS, CONCLUSION & SCOPE FOR FUTURE WORK

Table 1

| A | B | C | D | E |
|---|---|---|---|---|
| S.No. | No.of Nodes | CPU (Time in miliseconds) | CPU-GPU Hybrid (Coarse Grained ) (Time in miliseconds) | Speed-Up |
| 1 | 50 | 0.3 | 0.3 | 1 |
| 2 | 100 | 0.3 | 0.01 | 30 |
| 3 | 150 | 0.4 | 0.02 | 20 |
| 4 | 200 | 0.35 | 0.2 | 1.75 |
| 5 | 500 | 0.6 | 0.3 | 2 |
| 6 | 1000 | 1.9 | 0.03 | 63.33333 |
| 7 | 2000 | 1.3 | 0.09 | 14.44444 |
| 8 | 4000 | 1.5 | 0.04 | 37.5 |
| 9 | 6000 | 1.6 | 0.045 | 35.55556 |
| 10 | 8000 | 1.9 | 0.045 | 42.22222 |

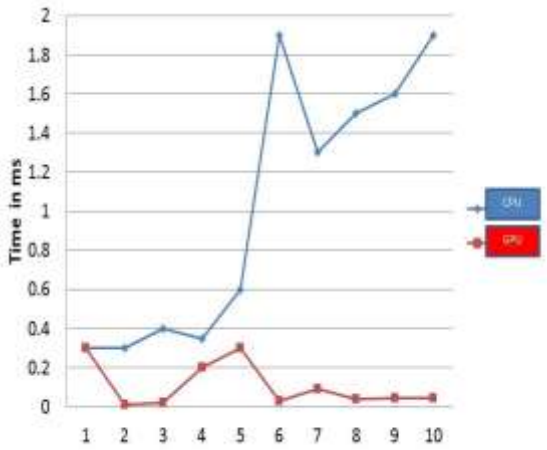


**Figure 5: Graph showing performance gain on CPU-GPU system as compared to a CPU only system. CPU= Intel Core2Duo 2GHz, GPU=NVIDIA 410m Geforce**

We observe from these graphs that a CPU-GPU system often outperforms a CPU by several folds, as high as 63 times for larger MANETS. Such large MANET is common now a day, especially due to advent of IoT devices and sensor networks. This establishes our hypothesis of using a GPU compatible algorithm for optimization of various stages in a MANET.

This work is based on using a GPU for getting performance gain in a typical MANET routing. We have demonstrated it using a real life scenario of NDP in MANET routing. Our propose method of using a CPU-GPU hybrid approach has given rise to several fold speed up as compared to a CPU only solution.

However, we argue that we can get much better performance by using several of the low level features of a GPU, and in fact of a CPU as well. Such low level features include several techniques for limiting CPU-GPU communication, and exploiting maths related computational functions provided by a GPU and CPU

manufacturer **[17]**. We have not explored those avenues. Those features can greatly benefit various computationally intensive jobs in MANET protocol.

Also we suggest doing a more mathematically rigorous analysis for establishing advantages and limitations of our proposed methods.

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