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A Fine-grained Parallel Approach for Optimizing Secure Zone Routing protocol

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Abstract*: Today we have huge amount of data in general and related to wireless comm. in particular, thanks to advancement in communication technologies. This data can be used to get various insights about user preferences and also for call monitoring. We plan to explore commodity graphics cards, which have Graphical Processing Unit (GPU), for this purpose. Since the GPU has huge computational power, it motivates us to use it in our research. Specifically we explored the possibility to use GPUs for optimization of SZRP or Secure Zone Routing Protocol. In this direction we present our fine-grained approach for optimization of SZRP.

Keywords: GPU; SZRP; MANET; ZRP; Ad-hoc; Wireless

I. INTRODUCTION

The graphics card that we use in our PC for gaming and visual enhancement has a Graphics Processing Unit (GPU) and some dedicated off-chip DRAM. GPUs in general have a highly parallel architecture and in particular some of NVIDIA's GPUs have 240 cores per processor (compare this with modern CPUs: 2, 4 or 8-cores) [2]. With such a parallel architecture, GPUs provide excellent computational platform, not only for graphical applications but any application where we have significant data parallelism. For example one can accelerate virus scanning by off loading the virus-matching task on the GPU.

The GPUs thus are not limited to its use as a graphics engine but as parallel computing architecture capable of performing floating point operations at the rate of 10^{12} bytes/s. Technocrats have realized the potential of GPUs for highly computational tasks, and have been working in general purpose computation on GPUs (GPGPU) for a long time.

GPGPU or GPU computing is the use of a GPU (graphics processing unit) to do general purpose scientific and engineering computing. The model for GPU computing is to use a CPU and GPU together in a heterogeneous computing model. The sequential part of the application runs on the CPU and the computationally-intensive part runs on the GPU. From the user's perspective, the application just runs faster because it is using the high-performance of the GPU to boost performance [3]. The application developer has to modify their application to take the compute-intensive kernels and map them to the GPU. The rest of the application remains on the CPU. Mapping a function to the GPU involves rewriting the function to expose the parallelism in the function and adding "C" keywords to move data to and from the GPU. GPU computing is enabled by the massively parallel architecture of NVIDIA's CUDA architecture. The CUDA architecture consists of 100s of processor cores that operate together to crunch through the data set in the application.

The Tesla 10-series GPU is the second generation CUDA architecture with features optimized for scientific applications such as IEEE standard double precision floating point hardware support, local data caches in the form of shared memory dispersed throughout the GPU, coalesced memory accesses and so on. But GPUs have some inherent limitations as well. For example many applications are not fully parallel and only a limited fraction is parallelizable **[4]**. It is thus obvious that in such cases performance may in fact degrade.

One more issue with GPU is that we need to copy data to and from GPU. The memory copying operation is very costly as compared to computations. Thus this might degrade the overall system performance instead of improving it **[4].** Our focus is on applying our understanding of GPU Computing or GPGPU for optimization of SZRP [6], a common protocol for improving security in MANET [3-5]. Following sections give some details on MANET and some challenges in the same. The subsequent sections gives detail on our approach and present our initial findings.

II. WHAT IS MANET ?

We present below some interesting features of the MANET:

A. A mobile ad hoc network (MANET)
B. Also known as wireless ad hoc network or ad hoc wireless network,
C. A continuously self-configuring, infrastructure-less network of mobile devices connected wirelessly.

D. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router.

E. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic.

F. Such networks may operate by themselves or may be connected to the larger Internet. They may contain one or multiple and different transceivers between nodes. This results in a highly dynamic, autonomous topology.

III. CHALLNEGES IN MANET ?

A. We Present Below Some of the Challenges One Has To Faces In The Manet

1) Though MANET has several advantages, it lacks proper mechanism for security

2) The communication in MANET relies completely on radio transmissions, which is susceptible to eavesdropping by an unauthorized node.

3) This makes it mandatory to deploy an end-to end encryption to prevent eavesdropping.

4) 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.

5) 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.

6) MANETs behavior is highly dynamic, where non-participation and exits are highly unpredictable. In such dynamic environment, any static security mechanism is insufficient.

7) A dynamic security approach, where security related parameters are adjusted on-demand is a must have in such situation.

8) The routing protocol used in MANET, called “Zone Routing Protocol” has no security enabling feature and thus it is its biggest limitations. That was the reason SZRP was introduced.

9) Further, in MANET many nodes are non-participating. In such cases any communication with among the nodes results in wastage of CPU-resource, bandwidth and battery power. Such resources are already limited in MANET devices.

Manet’s 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 **[5]** has no security enabling feature and thus it is its biggest limitations. That is why SZRP [6] is proposed which adds a security layer to make communication in a MANET secure.

IV. NEIGHBOUR DISCOVERY PROTOCOL

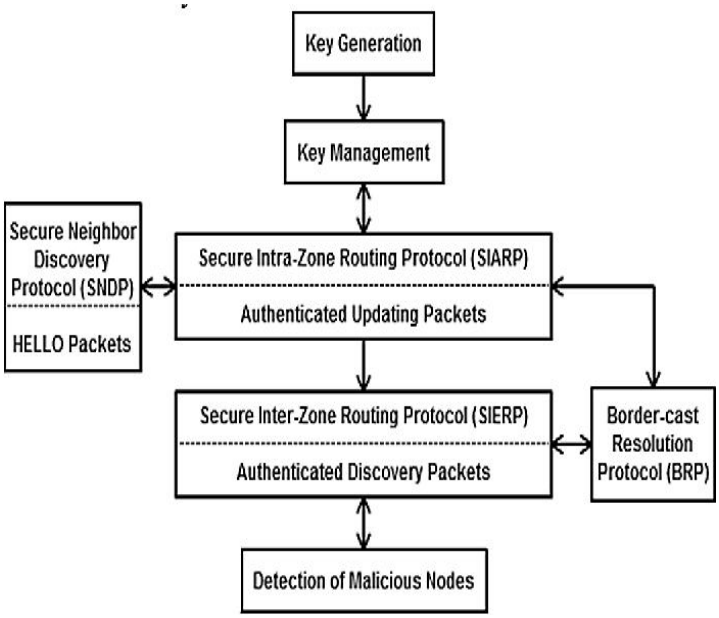

Figure 1: Security in SZRP

The approach for SZRP has been discussed in [6] and the basic scheme is shown in the above figure. As can be seen here we plan to exploit parallelism as much as possible. One of the areas where we plan to apply GPU is for Neighbor Discovery Protocol (NDP). As the mobile users are further growing NDP complexity is expected to grow exponentially [7].

The basic idea of our approach in using a GPU for NDP is discussed now. In NDP one of the most computationally expensive jobs is the calculation of the distances based on T (time) and L (Location). These measurements are done independently corresponding to each node by a querying node. Also because the computational load is huge, we estimate an Arithmetic Intensity (no. Of calculations per communication) is very high. The following figure [1] shows how we solve NDP distance calculation on a GPU.

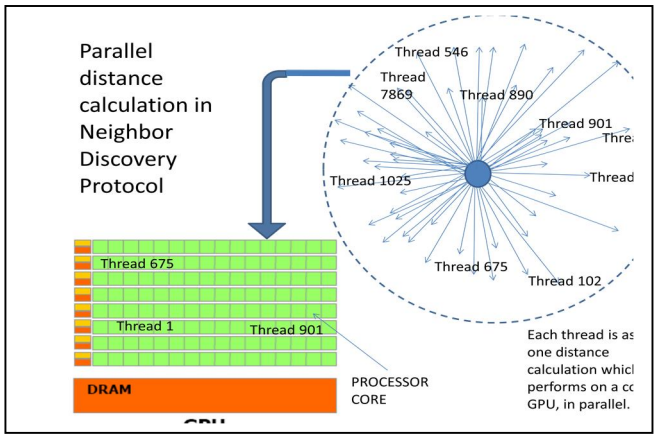

Figure 2: Distance calculations in NDP on a CPU-GPU system will have higher parallelism opportunity

The authors in [1] have assigned in this version, 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.

V. WHAT IS OUR FINE-GRAINED APPROACH?

The above approach for NDP is a coarse grained approach. We present our ideas for Fine-grained (FG) approach. In a FG approach instead of a single thread calculating the eqn (1) above, we launch more threads to calculate partial distances.

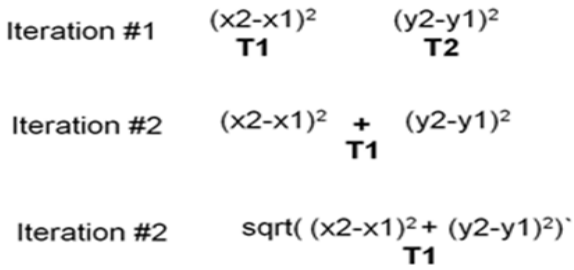

Figure 3: Fine Grained Approach for NDP

We see that in effect we are exploiting more parallelism, i.e. even in individual iterations we are doing this calculation in parallel in contrast to coarse grained approach proposed by the author in [1].

VI. RESULTS, CONCLUSION & SCOPE FOR FUTURE WORK

We present here our findings so far. A basic CUDA kernel (GPU function) has been tested on a CUDA-Compatible Graphics card as shown below:

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Add MANET node strength (CUDA KERNEL)

```
__global__ void add_Manet_Nodes(float
*ad,float *bd,float *Resultant_Strength,int  N)
{
     Resultant_Strength [threadIdx.y * N +
threadIdx.x] = ad[threadIdx.y  * N + threadIdx.x]
+ bd[threadIdx.y  * N + threadIdx.x];
}
```

This kernel sums up two matrices

The above kernel is ported to GPU and results accuracy was tested. The capability of our GPU is shown below:

Figure 4: deviceQuery output

This is the result of a program called DeviceQuery that ships with NVIDIA CUDA SDK. Although we were able to verify the accuracy of the CUDA kernel, but regarding performance gain, we developed some theoretical understanding. As per this understanding Matrix Addition (above kernel) is not a good candidate for a GPU implementation as the Arithmetic Intensity is low. Verification of this is part of our on-going research. In this paper we highlighted some of the benefits of using a GPU in various areas in wireless communication. Specifically we explored the possibility of using the same in a NDP in MANET. The end goal is to optimize the Routing Protocol, i.e. SZRP. While the earlier attempts were made using coarse-grained parallelism, in this work we proposed a Fine-grained approach because we expect more performance gain using this approach.

Our implementation in future will take into account various low level features of a GPU, including our proposed Fine-grained parallelism. A number of other areas in SZRP will also be explored.

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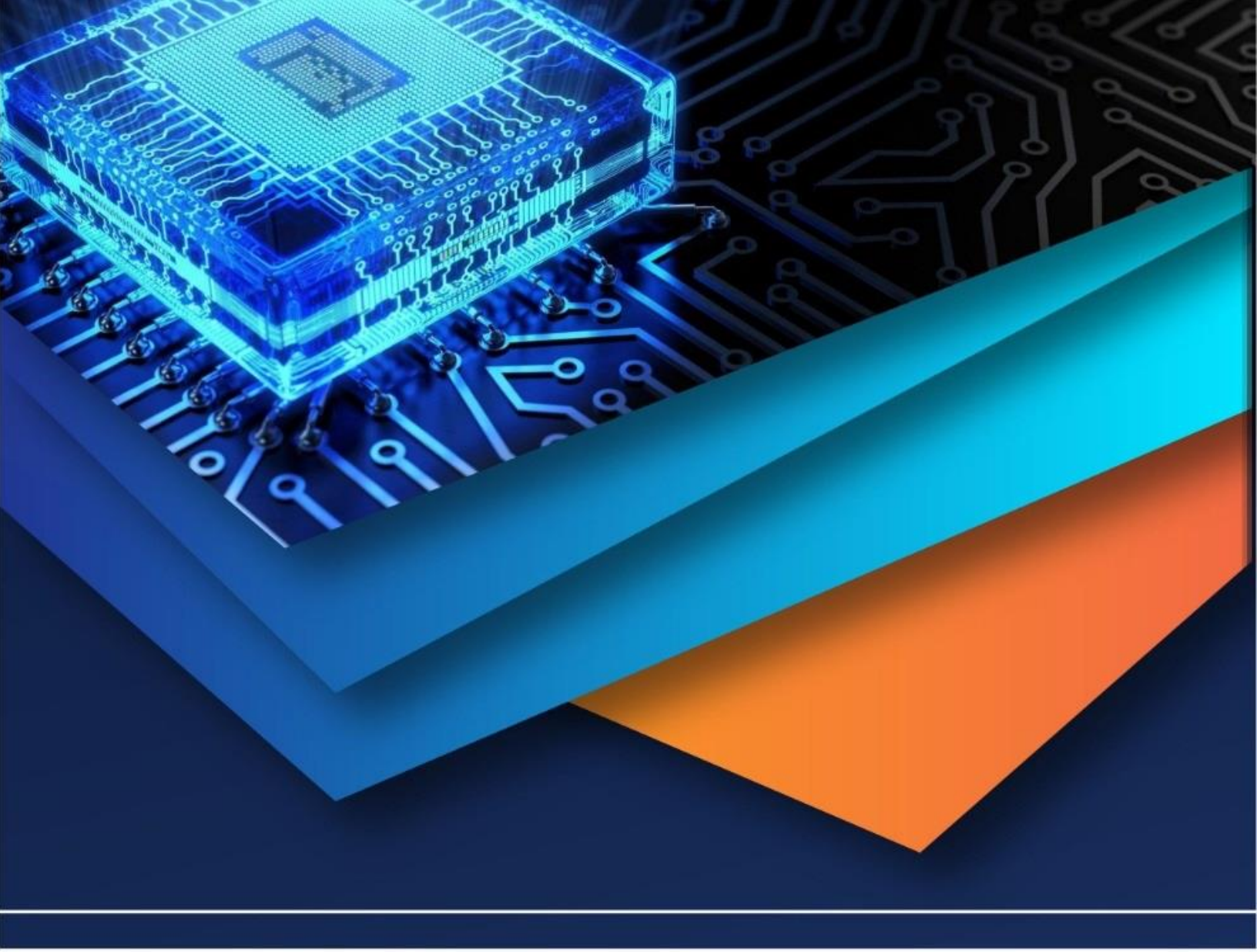

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