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Distributed topology control in large-scale hybrid RF/FSO networks: SIMT GPU-based particle swarm optimization approach

Osama Awwad[1], Ala Al-Fuqaha[1,*,†], Ghassen Ben Brahim[2], Bilal Khan[3] and Ammar Rayes[4]

[1]*Computer Science Department, Western Michigan University, Kalamazoo, MI 49008 USA*
[2]*Integrated Defense Systems, Boeing Company, Huntington Beach, CA 92647 USA*
[3]*John Jay College, City University of New York, New York, NY 10019 USA*
[4]*Advanced Support Systems, Cisco Systems, San Jose, CA 95134 USA*

SUMMARY

The tremendous power of graphics processing unit (GPU) computing relative to prior CPU-only architectures presents new opportunities for efficient solutions of previously intractable large-scale optimization problems. Although most previous work in this field focused on scientific applications in the areas of medicine and physics, here we present a Compute Unified Device Architecture-based (CUDA) GPU solution to solve the topology control problem in hybrid radio frequency and free space optics wireless mesh networks by adapting and adjusting the transmission power and the beam-width of individual nodes according to QoS requirements. Our approach is based on a stochastic global optimization technique inspired by the social behavior of flocking birds — so-called 'particle swarm optimization' — and was implemented on the NVIDIA GeForce GTX 285 GPU. The implementation achieved a performance speedup factor of 392 over a CPU-only implementation. Several innovations in the memory/execution structure in our approach enabled us to surpass all prior known particle swarm optimization GPU implementations. Our results provide a promising indication of the viability of GPU-based approaches towards the solution of large-scale optimization problems such as those found in radio frequency and free space optics wireless mesh network design. Copyright © 2011 John Wiley & Sons, Ltd.

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1. INTRODUCTION

Adjusting the beam-width and the transmission power in hybrid radio frequency and free space optics (RF/FSO) mesh networks presents a competing local versus global trade-off. A node with a large beam width or high transmission power usually has more nodes in the transmission range and hence a higher degree, which reduces the average global path length, thus minimizing the end-to-end delay of multihop connections. However, a higher node degree implies higher link layer interference, which reduces local throughput because of high channel contention. On the other hand, nodes that employ a narrow beam width or low transmission power have a lower number of nodes in their transmission range, hence a lower node degree — this results in higher average global path lengths and in turn, high end-to-end delay. However, a lower node degree implies lower interference, which tends to ameliorate local throughput because channel contention decreases. As such, it appears that there is a trade-off and our objective is to construct a robust topology by minimizing the transmission power, adapting the beam width, and selecting different channels such that we meet joint throughput and end-to-end delay requirements.

*Correspondence to: Ala Al-Fuqaha, Computer Science Department, Western Michigan University, Kalamazoo, MI 49008 USA.
†E-mail: alfuqaha@cs.wmich.edu

Ammar Rayes received his Doctor of Science degree in Electrical Engineering from Washington University in St. Louis, MO, in 1994. Dr. Ammar Rayes is a Senior Manager at the Advanced Technology Support group at Cisco Systems. He has managed several solutions including Customer Advocacy Platform Architecture, wireless, broadband access, subscriber and security management, triple play over Ethernet, virtual private network, performance and traffic engineering, IOS embedded management, and simple network management protocol infrastructure and tools. Prior to joining Cisco Systems, he was a director at the Traffic Capacity Management and Planning Department at Telcordia Technologies. Dr. Rayes has authored/co-authored over 50 patents and papers on advances in numerous communications-related technologies including a book on asynchronous transfer mode switching and network design (McGraw Hill-1999). He is currently chairing the Cisco CA Patent Council and serving on the board of the International Journal of Software Architecture and Network Management Research Council.

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