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GPU Neural Mutli Objective Solver for Optical Burst Grooming

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Abstract

Transparent Optical Networks has been known as a potential solution for high speed flexible optical backbone networks since a long time ago. However, many scientific challenges remain to be overcome such as the problem of Optical Burst Grooming (OBG) with several conflicting objectives and constraints.

OBG is a fundamental problem in the engineering, control, and management of optical traffic networks, and arises in most network design applications, including optical burst routing, survivability design, and traffic scheduling. The traffic grooming problem is to coalesce several high and low speed sub bursts close in time together to form a larger burst that will be switched as one unit.

In this paper, we first formulate OBG as a Multi Objective Integer Linear Programming (MO-ILP) optimization problem. Then we propose to use a parallel and hierarchical solver based on Artificial Neural Networks (ANN) with Graphics Processing Unit (GPU) parallel implementation using Compute Unified Device Architecture (CUDA). The processing time remains fixed regardless of the input size and the number of optical constraints and conflicting objectives.

Our OBG solver benefits of the joint use of advanced ILP-MO optimization methods, ANN large-scale inherent parallelism and CUDA-GPU High-Performance Computing (HPC) architecture. Through a comprehensive simulation study, we show that, our proposed grooming approach can significantly improve the optical traffic performance, resulting in less contention and low burst lost probability.

Keywords: Transparent Optical Networks, Optical Burst Grooming, Multi Objective Optimization Integer Linear Programming, Artificial Neural Networks, Graphics Processing Unit, Compute Unified Device Architecture;

1. Introduction

The TON transmission capacity in today's optical networks has been increased significantly due to the Dense Wavelength-Division Multiplexing (DWDM) technology. In this transparent network, the requested bandwidth of a traffic stream can be much lower than the capacity of the wavelength channel [1].

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Existing optical network architectures use only all optical equipment's, Optical Add and Drop Multiplexer (OADM) and Optical Cross Connect (OXC). Unfortunately, these architectures are unable to fully utilize this bandwidth to support highly dynamic and bursty traffic. The optical fiber transmission data rate of a single wavelength channel has increased from 2.5 Gb/s in 1985 to 400 Gb/s in 2015.

Despite all its potentialities [6], there are still several challenging issues facing the design and the possible subsequent deployment of a large-scale system of these technologies. One of the most important functions of the optical equipment is Optical Burst Grooming (OBG) by multiplexing lower rate optical streams into higher rate channels or wavelengths.

Traffic Grooming in TON can be defined as the techniques used to combine low speed traffic streams onto high capacity wavelengths in order to improve the network throughput as well as to reduce the network cost. The traffic grooming problem is to coalesce several high and low speed sub bursts close in time together to form a larger burst that will be switched as one unit.

Traditional optical grooming formalism has so far proven inefficient to manage the huge amount of optical stream and solve complex decisions problems in optical networks with several conflicting objectives and constraints. This work gives a solution that meets these requirements and combines the advantages of the ANN inherent parallelism and the massif computing accelerators of GPU to solve a difficult OBG multi objective optimization problem. The proposed neural GPU OBG solver (N-GPU-OBG) is more efficient both in terms of bandwidth usage as well as in terms of processing speed.

The remaining of this paper is structured as follows: In section II we will present the related works and we will formulate our contributions and implement our N-GPU-OBG. Section II also gives a brief presentation on Artificial Neural Networks, and neurons used, with an emphasis on fully utilizing the massive parallel property and GPU architecture with cores organization. Finally, we conclude in section III and points out directions for further research.

2. Related works and contributions

2.1. OBG definition

Optical Burst Networks (OBN) contains two types of nodes as shown in Fig. 1: edge nodes that interconnect other networks and core nodes. Edge nodes receive and buffer incoming data and construct a burst data packet (BDP) that contains data (payload) to be forwarded to other edge nodes. When a BDP is ready for transmission, a Burst Header Packet (BHP) is first injected into the OBN that informs the core nodes about incoming bursts so that the necessary control and management tasks can be prepared. Variable-size optical bursts can be transported directly over DWDM without converting back to electronic form. A burst header is sent on a separate control channel shortly before the transmission of the data burst.

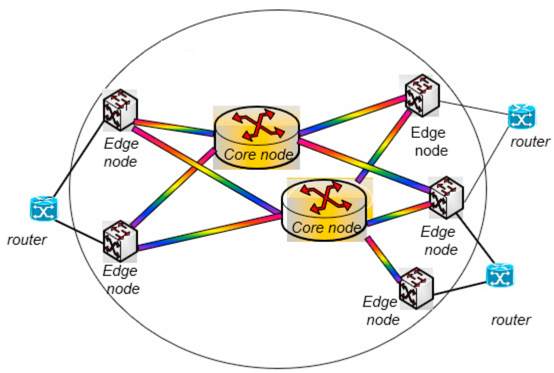

Fig. 1: Optical Burst Networks