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研究課題名（和文）A machine learning based system for storing and processing big spatial-temporal data

研究課題名（英文）A machine learning based system for storing and processing big spatial-temporal data

研究代表者

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研究成果の概要（和文）：During the past two years, we have developed a software prototype for storing and processing big spatial-temporal data. This system can automatically adjust configurations according to data characteristics.

研究成果の概要（英文）：During the past two years, we have developed a software prototype for storing and processing big spatial-temporal data. This system can automatically adjust configurations according to data characteristics.

研究分野：big data system

キーワード：big data　spatial-temporal data

１．研究開始当初の背景

Due to the prevalence of location sensing technologies in recent years, there has been an explosive growth of spatial-temporal data produced by various devices, such as GPS, smartphones, and space telescopes. For example, there are more than 10 million geo-tagged tweets issued from Twitter everyday. A NASA archive of satellite earth images has more than 500 TB and is increased daily by 25GB. These spatial-temporal data has unique characteristics. First, they are inherently skewed in both space and time. For example, number of tweets submitted by people changes in different time and area. Second, data are continuously generated because the time dimension is potentially unbounded and monotonically increase.

More and more companies start to provide global services by deploying data centers (DCs) in different counties and regions. For example, Google runs its service across several geo-distributed data centers connected by a dedicated WAN. Other companies, e.g., Netflix, deploy their services at Amazon's global cloud infrastructure EC2 that spreads across 11 regions over the world. These companies conduct big data analytics across the geo-distributed computing and storage environment for risk evaluation, cost reduction, and new product creation.

MapReduce has been proposed as a programming model that parallelizes big data processing on distributed computing systems. It decomposes a job into a number of parallel map tasks, followed by reduce tasks that merge all intermediate results generated by map tasks to produce final results. MapReduce has been implemented by several open-source software platforms, e.g., Hadoop [4], which are designed to be deployed within a single data center. With this design, a widely adopted approach for geo-distributed big data analytics is to first aggregate all data to a single data center, and then conduct data processing using Hadoop with traditional single-DC configuration. This data aggregation approach would lead to poor efficiency and high cost for big data workload because a huge amount of data need to be aggregated, and the resulting data traffic would occupy excessive bandwidth of inter-DC network.

２．研究の目的

The goal of this project is to develop an intelligent software platform for storing and processing big spatial-temporal data based on MapReduce framework. All existing platforms have fixed system configuration, and cannot efficiently handle task scheduling and network traffic management.

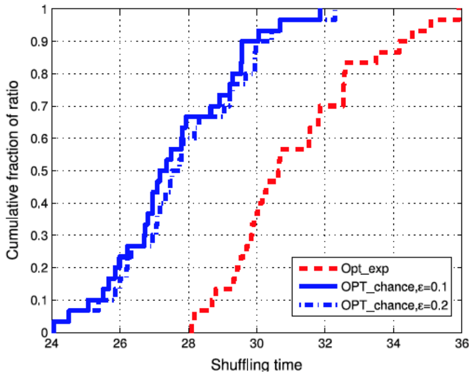
３．研究の方法

We develop a big spatial-temporal data platform with two-way interaction between data and platform using machine learning. We use Apache Spark as a base system, and develop a module called ST-controller that receives knowledge from ML-engine and uses it to optimize performance. The ML-engine collects information from data and applications, and extracts knowledge of data skew and access patterns using machine learning technology. This knowledge will be sent to ST-controller for performance optimization.

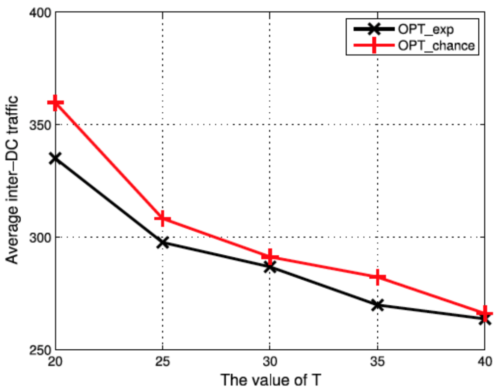
To further optimize the performance, we design a novel optimization framework by jointly considering input data movement and task placement. Input data at a data center can be loaded by map tasks located nearby if the remote data loading helps to reduce total traffic. To guarantee predictable job completion time, instead of struggling for accurate estimation of ratio of input and output data, we apply the chance-constrained optimization technique that needs little information about the distribution of output data. To solve the formulated problem, we propose an efficient algorithm by tackling the following two major challenges. First, the joint optimization of data movement and task placement makes the formulated problem nonlinear. We apply the linearization technique to equivalently replace the nonlinear constraints with linear ones. Second, the chance constraint imposed to achieve predicted job completion time cannot be directly solved by existing convex optimization technique. We propose an approximation approach by relaxing the chance constraint, such that the solution of the new formulation is also feasible to the original problem.

４．研究成果

We divide reduce tasks into six groups, and set the expected job completion time (represented by T) to 30 seconds. Therefore, the practical job completion time of both algorithms is no less than 30 seconds. As shown in Fig. 1, there are about 60 percent MapReduce jobs whose shuffling time exceeds T under the solutions of OPT_exp, which means their job completion time is also greater than T. Although fastest shuffling can finish within 28 seconds, the worst case needs 36 seconds. In contrast, OPT_chance can guarantee that the portion of jobs whose shuffling time exceeds T is always less than the threshold.



We then study the influence of expected job completion time T by changing its value from 20 to 40. The average network traffic of OPT_exp and OPT_chance is shown in Fig. 2. The traffic of both algorithms decreases as the growth of T. As the value of T becomes smaller, their optimization framework will adjust input data loading and task placement such that the maximum inter-flow time is minimized, but it would lead to larger traffic.



5．主な発表論文等
（研究代表者、研究分担者及び連携研究者には下線）

〔雑誌論文〕（計　2　件）

1. Peng Li, Song Guo, Toshiaki Miyazaki, Xiaofei Liao, Hai Jin, Albert Y. Zomaya, Kun Wang, “Traffic-aware Geo-distributed Big Data Analytics with Predictable Job Completion Time”, *IEEE Transactions on Parallel and Distributed Systems (Impact Factor: 4.181)*, vol.28, no.6, pp.1785-1796, June 1 2017.
2. Peng Li, Toshiaki Miyazaki, Kun Wang, Song Guo, and Weihua Zhuang, “Vehicle-Assist Resilient Information and Network System for Disaster Management”, *IEEE Transactions on Emerging Topics in Computing (Impact Factor: 3.826)*, vol. 5, no. 3, pp. 438-448, July-Sept. 2017.

〔学会発表〕（計　3　件）

1. Qihua Zhou, Peng Li, Kun Wang, Deze Zeng, Song Guo and Minyi Guo, “Swallow: Joint Online Scheduling and Coflow Compression in Datacenter Networks”, *The 32nd IEEE International Parallel and Distributed Processing Symposium (IPDPS)*.
2. Deze Zeng, Jie Zhang, Lin Gu, Peng Li, and Hong Yao, “Minimize Coflow Completion Time via Joint Optimization of Flow Scheduling and Processor Placement”, *IEEE Global Communications Conference (GLOBECOM)*, 2017.
3. Peng Li, Toshiaki Miyazaki, and Song Guo, “Traffic-aware Task Placement with Guaranteed Job Completion Time for Geo-distributed Big Data”, *IEEE International Conference on Communications (ICC)*, Paris, France, May 2017.

〔図書〕（計　0　件）

〔産業財産権〕

○出願状況（計　0　件）

名称：
発明者：
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種類：
番号：
出願年月日：
国内外の別：

○取得状況（計　0　件）

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〔その他〕

ホームページ等

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