Journal of the Korean Physical Society, Vol. 53, No. 2, August 2008, pp. 1187∼1191

e-Science for High-Energy Physics in Korea

Kihyeon Cho*

e-Science Applications Research and Development Team,
Korea Institute of Science and Technology Information, Daejeon 305-806

(Received 21 August 2007)

e-Science for high-energy physics is to study high-energy physics (HEP) "any time and anywhere" even if we are not on-site at accelerator laboratories. The components of the project include data production, data processing, and data publication that can be accessed any time and anywhere. We report our experiences on the integration and the utilization of the e-Science for high-energy physics, especially the ALICE (A large ion collider Experiment) and the CDF (collider detector at Fermilab) experiments. We discuss both the general idea and the current implementations of data processing, production, and publication.

PACS numbers: 29.85+c, 07.05.Bx
Keywords: Grid, e-Science, Data process, High-energy physics

I. INTRODUCTION

Science includes many challenging problems that require large resources, particularly knowledge from many disciplines [1]. e-Science is a new research and development paradigm for science, which is computationally intensive science carried out in highly distributed network environments [2]. e-Science uses immense data sets that require grid computing [2]. The goal of e-Science is to do any research "any time and anywhere." The main goal of HEP (high-energy physics) is to understand the basic properties of elementary particles and their interactions. HEP experiments are usually conducted at major accelerator sites where experimentalists perform detector design and construction, signal processing, data acquisition, and data analysis on a large scale [3]. The size of a collaboration is 100 $\sim$ 2000 physicists. HEP requires a particularly well-developed e-Science infrastructure due to its need for adequate computing facilities for the analysis of results and the storage of data originating from the LHC (large hadron collider) at CERN (European Organization for Nuclear Research) [2]. To perform computing at the required HEP scale, we need strong data grid support. Therefore, HEP is one of best applications for e-Science.

The goal of e-Science for high-energy physics is to study HEP "any time and anywhere" even if we are not at accelerator laboratories (on-site). The components include 1) data production, 2) data processing, and 3) data publication that can be accessed any time and anywhere even if off-site. First, data production is to get data and take shifts anywhere even if we are not on-site by using a remote operation center or a remote control room. Second, data processing is to process data by using a HEP data grid. The objective of a HEP data grid is to construct a system to manage and process HEP data and to support the user group (*i.e.*, high energy physicists) [4]. Third, data publication is for collaborations around world to analyze and publish the results by using collaborative environments.

II. E-SCIENCE FOR HIGH ENERGY PHYSICS

1. Overview

The goal of the ALICE (A large ion collider Experiment) experiment at CERN is to study the physics of strongly interacting matter at extreme energy densities where the quark-gluon plasma is expected. If computing is to be performed at the required scale of PByte, a grid is a strong requirement. For this work, we have assembled LCG (LHC Computing Grid) farms at the KISTI (Korea Institute of Science and Technology Information).

Based on the grid concept with VO (virtual organization) [5], we use this farm not only for the ALICE experiment but also for the CDF (collider detector at Fermilab) experiment. The goal of the CDF experiment at Fermilab is to discover the identities and the properties of the particles that make up the universe and to understand the interactions between those particles [6]. The CDF experiment began its Run II phase in 2001 [7]. The CDF computing model is based on the concept of the CDF analysis farm (CAF) [8]. To date, Run II has

*E-mail: cho@kisti.re.kr; Fax: +82-42-869-0789

Table 1. Components of e-Science for High-energy physics for ALICE and CDF experiments.

Component of e-Science	ALICE Experiment	CDF Experiment
Data Production	N/A	Remote Operation Center
Data Processing	ALICE Tier 2 center using LCG farm	Pacific CAF (CDF Analysis Farm) using LCG farm
Data Publication	EVO (Enabling Virtual Organization)	

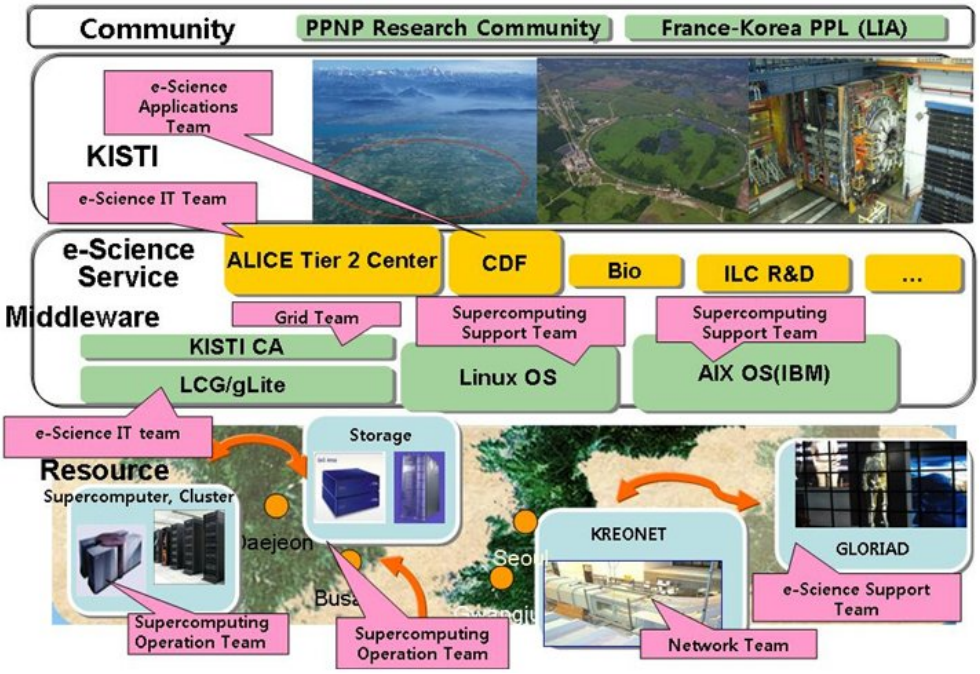

Fig. 1. Architecture of data processing for e-Science for high-energy physics.

gathered more than 2 fb^{-1} of data, equivalent to 3.0×10^9 events or a couple of PByte of data. In order to process the data, CDF is investigating shared computing resource, such as DCAF (decentralized CDF analysis farm). After DCAF in Korea [4], now we run CDF jobs at a grid farm.

Table 1 shows the components of e-Science for the ALICE and the CDF experiments. We will explain each component in the following sections.

2. Data Production

Usually, we take data on-site where accelerators are located. However, in the spirit of e-Science, we would like to take data from anywhere. A method is to use a remote operation center. An example is the remote operation center at Fermilab in the USA to operate the LHC experiment at CERN. Currently, we have constructed a remote CDF operation center at the KISTI, which will enable CDF users in Korea to take CO (consumer operator) shifts at the KISTI in Korea, not at Fermilab in USA.

3. Data Processing

Figure 1 shows the architecture of data processing for e-Science for high-energy physics. The main infrastructure of data processing for e-Science is network and computing resources. The first is network. KREONET (Korea Research Environment Open NETwork) is a national research and development network operated by the KISTI and supported by the Korea government. KREONET is connected to GLORIAD (Global Ring Network for Advanced Applications Development), which is a ring network with 10 Gbps connecting Korea to Hong-Kong and the United States. The KISTI is directly peered to CERN via a 10-Gbps network. The second is computing resources. For current and future HEP activities for large-scale data, the HEP data grid is indispensable. We need to maintain a mass storage system of hard disks and tapes in a stable state. If the HEP data are to be made transparent, CPU power should be extendable and accessible. Transparent HEP data means that the data should be analyzed even if high energy physicists as users do not know the actual source of the data [1].

The middleware resources are LCG (LHC computing

Table 2. Progress of CDF Grid.

Name	Starting date	Grid middleware	Job scheduling	Content	Site
CAF	2001	-	Condor	Cluster farm inside Fermilab	USA (Fermilab)
DCAF	2003	-	Condor	Cluster farm outside Fermilab	Korea, Japan, Taiwan, Spain (Barcelona, Cantabria), USA (Rutgers, San Diego), Canada, France,
Grid CAF	2006	LCG / OSG	Resource Broker + Condor	Grid farm	North America CAF European CAF Pacific CAF
CGCC (CDF Grid Computing Center)	2008 (plan)	LCG	Resource Broker + Condor	Big Grid farm	Korea (KISTI) France (IN2P3) Italy (CNAF)

Table 3. Comparison of Grid CAF (CDF Analysis Farm).

Grid CAF	Head node	Work node	Grid middle ware	Method	VO (Virtual Organization) Server
North America CAF	Fermilab (USA)	USSD (USA) *etc.*	OSG	Condor over Globus	CDF (Collider Detector at Fermilab) VO
European CAF	CNAF (Italy)	IN2P3 (France) *etc.*	LCG	WMS (Workload Management System)	CDF VO
Pacific CAF	AS (Taiwan)	KISTI (Korea) *etc.*	LCG, OSG	Condor over Globus	CMS (Compact Muon Solenoid) VO / ALICE (A Large Ion Collider Experiment) VO

grid). The applications are ALICE and CDF VO. We have installed and operated EGEE middleware of LCG at the KISTI site, which has been approved as an EGEE-certified site. The current LCG farm at the KISTI consists of 30 nodes (30 CPU) and 2-TByte storage.

4. Data Publication

For data publication, we host the EVO (enabling virtual organization) server system at the KISTI so that high-energy physicists in Korea may use it directly without using reflectors in USA. Therefore, the EVO server at the KISTI enables collaborations around the world to do analysis and to publish the results together easily.

III. RESULTS

For data production, we have constructed a remote control room for CO operation at the KISTI. The CDF control room at Fermilab consists of many sections. One of them is monitoring sections to check the quality of data. We call it CO, which does not affect the control of the data acquisition directly. Everything on the CDF CO desktop is available at remote sites. 'Event Display' and 'Consumer Slide' are done by 'Screen Snap Shots' through a web site. The status and logs of 'Consumer Monitors' and 'Detector Check List' are done through a web site. A 'Consumer Controller' can be sent to the remote site. Communication with shift crews at the CDF control room is done by using the EVO system.

For data processing, we have constructed the LCG farm at the KISTI for the ALICE experiment. Based on the grid concept [5], we have also constructed a CDF VO besides the ALICE VO. Moreover, a significant fraction of these resources is expected to be available to CDF during the LHC era. CDF is using several computing processing systems, such as CAF, DCAF, and a grid system. The movement to a grid at the CDF experiment is a worldwide trend for HEP experiments. Table 2 shows the progress of the CDF grid. For the LCG farm at the KISTI, we use the method of 'Condor over Globus', which is a grid-based production system. The advantage of this method is its flexibility [9]. Table 3 shows a comparison of Grid CAF. We have made a federation of LCG and OSG (open science grid) farm at AS (Academia

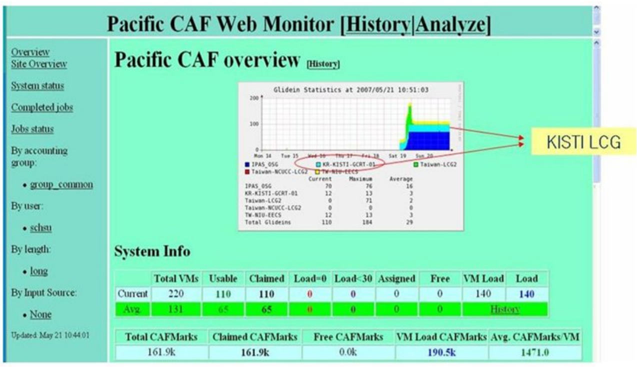

Fig. 2. Monitoring system of Pacific CAF (CDF analysis farm).

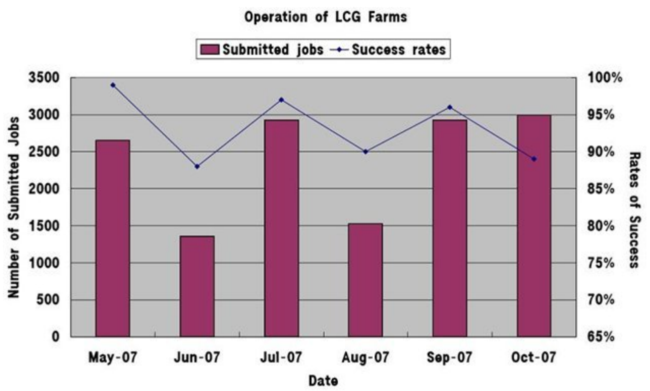

Fig. 3. Results of the operation of the LCG farm at KISTI.

Sinica) in Taiwan and the LCG farm at the KISTI. We call this federation of grid farms as ‘Pacific CAF’. The head node of ‘Pacific CAF’ is located in AS. Now the ‘Pacific CAF’ has become a federation of grid farms between one LCG farm at the KISTI (KR-KISTI-GCRT-01) in Korea and four LCG and OSG farms (IPAS_OSG, Taiwan-LCG2, Taiwan-NCUCC-LCG2, and TW-NIU-EECS) in Taiwan. Figure 2 shows the web monitoring system of ‘Pacific CAF’, including the status of work nodes at the KISTI. The KORCAF (Korea CAF) farm at Kyungpook National University in Korea and the JP-CAF (Japan CAF) farm at the University of Tsukuba in Japan will be linked to ‘Pacific CAF’. In conclusion, we have constructed an LCG farm for data processing for both the ALICE and the CDF experiments. The farm has been running since May 6, 2007. Figure 3 shows the results of operation of the LCG farm at the KISTI in 2007 by the monitoring systems [10]. The average successful job rate at the LCG farm at the KISTI is 94 % where the successful job rate is defined as the number of successful jobs divided by the total number of submitted jobs. The results show stable performance of the system.

For data publication, we have constructed the EVO servers at the KISTI. When users in Korea use the EVO servers at the KISTI, the routing time is reduced by 60 msec without the congestion of the network inside USA,

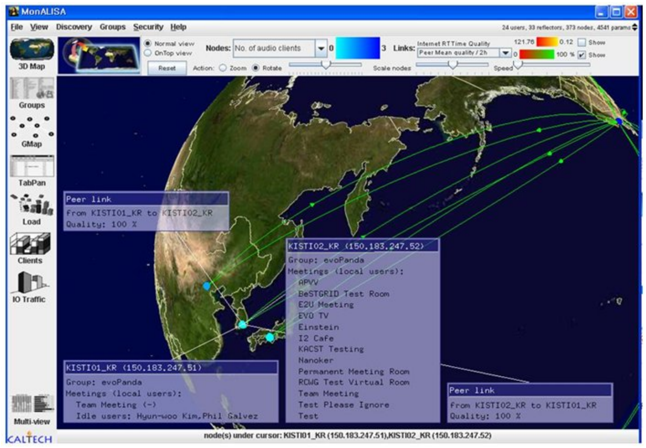

Fig. 4. Monitoring system of the EVO (enabling virtual organization).

which provides very stable research environment. Figure 4 shows the monitoring system of EVO, which is connected with the servers at the KISTI.

IV. CONCLUSION

HEP is one of the best applications of e-Science projects in Korea. The goal of e-Science for high-energy physics is to study the ALICE and the CDF experiments any time in Korea. We have shown the implementation of data production, data processing, and data publication for that purpose. For data processing, we have succeeded in installing and serving the LCG farms for both experiments based on a grid concept.

ACKNOWLEDGMENTS

We would like to thank Hyunwoo Kim, Minho Jeung, Beobkyun Kim, Jae-Hyuck Kwak, and Soonwook Hwang (Korea Institute of Science and Technology Information) for data processing at LCG (LHC Computing Grid) farm, Yuchul Yang (Kyungpook National University), Mark Neubauer, and Frank Würthwein (University of California at San Diego) for DCAF (Decentralized CDF analysis farm), and Igor Sfillioi (Fermilab) and Tsan Lung Hsieh (Academia Sinica) for Pacific CAF (CDF Analysis farm).

REFERENCES

[1] K. Cho, Comp. Phys. Comm. **177**, 247 (2007).
[2] The definition of e-Science is from wiki home page: http://en.wikipedia.org/wiki/E-Science.

[3] S. K. Park, J. Park, S. Lee, S. H. Ahn, S. J. Hong, T. J. Kim, K. S. Lee, M. Begel, T. Andeen, H. Schellman, J. Stein, S. Yacoob, E. Gallas, V. Sirotenko, J. Hauptman, G. Snow, J. Korean Phys. Soc. **49**, 2247 (2006).
[4] K. Cho, Internat. J. of Comp. Sci. and Network Sec. **7**, 49 (2007).
[5] I. Foster, C. Kesselman and S. Tuecke, Internat. J. of High-Performance Computing Appl. **15**, 200 (2001).
[6] D. Gerdes, J. Korean Phys. Soc. **45**, S268 (2004).
[7] G. P. Yeh, J. Korean Phys. Soc. **45**, S301 (2004).
[8] M. Neubauer, Nucl. Instrum. Meth. A **502**, 386 (2003).
[9] I. Sfiligoi, Comp. Phys. Comm. **177**, 235 (2007).
[10] Monitoring systems: http://pcalimonitor.cern.ch/reports/; http://gridportal.hep.ph.ic.ac.uk/rtm/.