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GRID Computing at Belle II

Vikas Bansal

Pacific Northwest National Laboratory
902 Battelle Boulevard, 99352 - Richland, WA, USA,
for the Belle II Collaboration.

The Belle II experiment at the SuperKEKB collider in Tsukuba, Japan, will start physics data taking in 2018 and will accumulate 50 ab^{-1} of e^+e^- collision data, about 50 times larger than the data set of the earlier Belle experiment. The computing requirements of Belle II are comparable to those of a run I high-p_T LHC experiment. Computing will make full use of such grids in North America, Asia, Europe, and Australia, and high speed networking. Results of an initial MC simulation campaign with 3 ab^{-1} equivalent luminosity will be described.

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	2016	2017	2018
Disk [TB]	4000	8000	9000
Tape [TB]	1000	3000	5000
CPU [kHepSPEC06]	200	300	350

Table 1: Belle II Computing Resources Expectation

1 Introduction

The Belle II experiment is the successor of the Belle experiment [1] at the KEK laboratory in Tsukuba, Japan. The Belle experiment measured charge-parity (CP) violation in the B^0 system predicted by the theory of Kobayashi and Maskawa [2]. The successful confirmation of the prediction led to the Nobel Prize to both theorists.

The standard model of particle physics is still incomplete in describing nature and any indication of new kind of CP violation will bring us closer to the well-known puzzle of matter-antimatter asymmetry in the present universe. The KEKB accelerator delivered a total integrated luminosity of 1 ab^{-1} to Belle experiment. We aim to collect a data sample of 50 ab^{-1} with the upgraded KEKB accelerator, SuperKEKB, until the year 2025, primarily to extend searches for new kinds of CP violations.

Precision flavor physics measurements to be performed by Belle II are complementary to the direct search for new particles at the LHC. If new physics is found at the LHC, flavor physics measurements are essential to identify the kind of new physics.

2 Belle II Computing Model

The Belle II collaboration was officially founded in December 2008. Today, it has more than 600 members from over 98 institutes in 23 different countries. With collaborators located in North America, Asia, Europe, and Australia it is distributed around the world.

Beam collisions are expected to start in 2017. A data sample of about 50 times the size collected by the Belle experiment is expected to be recorded by Belle II in 10 years from now. Its data rate is predicted to be on par with the LHC [3]. Table 1 shows an estimation of the Belle II computing resources through 2018. These resources are distributed across the collaboration according to Belle II distributed computing model.

Figure 1 illustrates the Belle II computing model for the first three years of operations. PNNL along with KEK will host a compete replica of raw data and will help to distribute processed data to Europe.

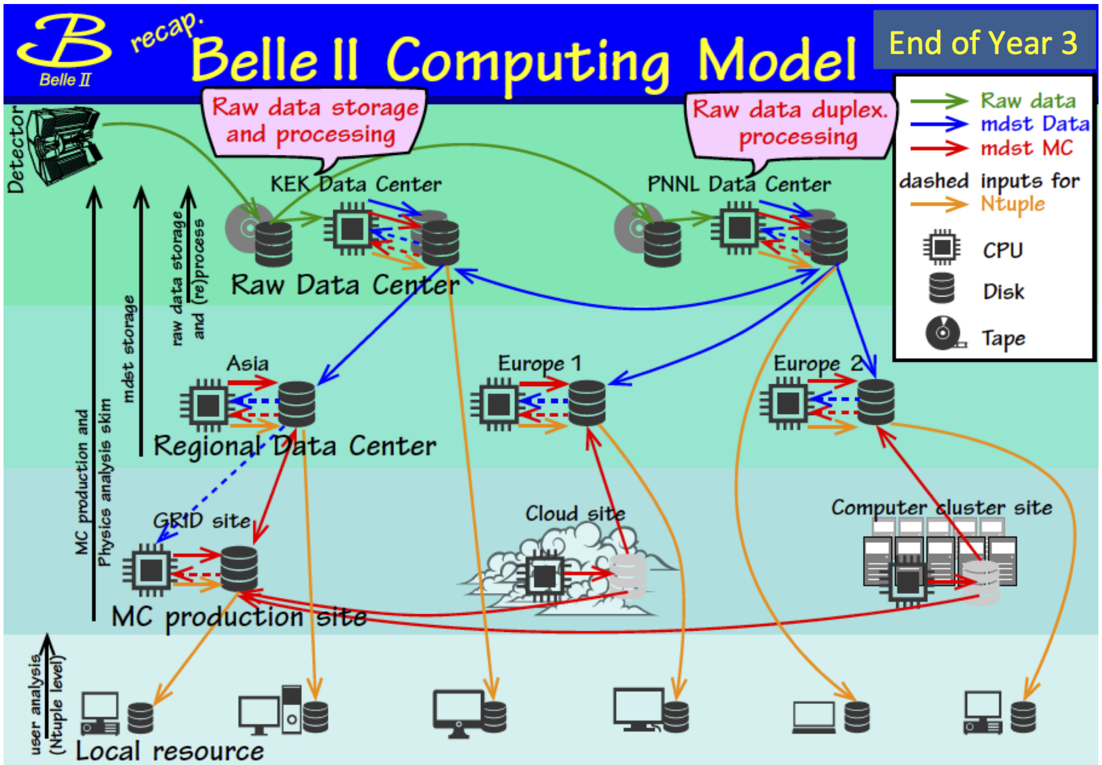

Figure 1: Belle II Computing Model for the first three years of operations.

To ensure that appropriate bandwidths are available on network routes between major sites in North America, Asia, Europe, and Australia, they are routinely tested for network traffic throughput rates as part of data challenges. Virtual LAN (VLAN) setups were established between sites to perform network data challenges both trans-atlantic and trans-pacific using FTS3 [4] service. A site-to-site matrix was deployed to monitor and capture network information for latency and network packet drop rates using MaDDash [5] and perfSONAR [6] services. Network information between sites is inserted in distributed database that guides optimal data routing path between any two endpoints.

Belle II was recently included in the LHCONE [7] Acceptable Use Policy (AUP). This will enable Belle II member sites to interconnect via the well managed infrastructure of LHC network and hence provide maximal throughput possible. A key component of the LHCONE is that all the sites are “trusted” which alleviates the need for firewalls (as it slows down data transfer rates). Also, bandwidths via public internet is limited and not feasible to support high data transfer rates.

Belle II has chosen DIRAC [8] to provide key functionality for their distributed computing model. DIRAC will orchestrate all its sub-components that can as well be distributed at many sites to achieve Belle II compuitng operations. It will also manage computing resources across all sites.

Belle II collaboration is developing various components and extensions to DIRAC, including a fabrication system that manages compute tasks over all sites, a distributed data management system, web portals for monitoring purposes, and dedicated wrappers around the Belle II reconstruction framework.

The simulation samples for the Belle II experiment have been produced in a globally distributed manner, in accordance with the distributed computing model. Figure 2 illustrates the output of the DIRAC-based production system for four MC production campaigns between 2012 and 2014. All produced data is again distributed to storage resources at various sites.

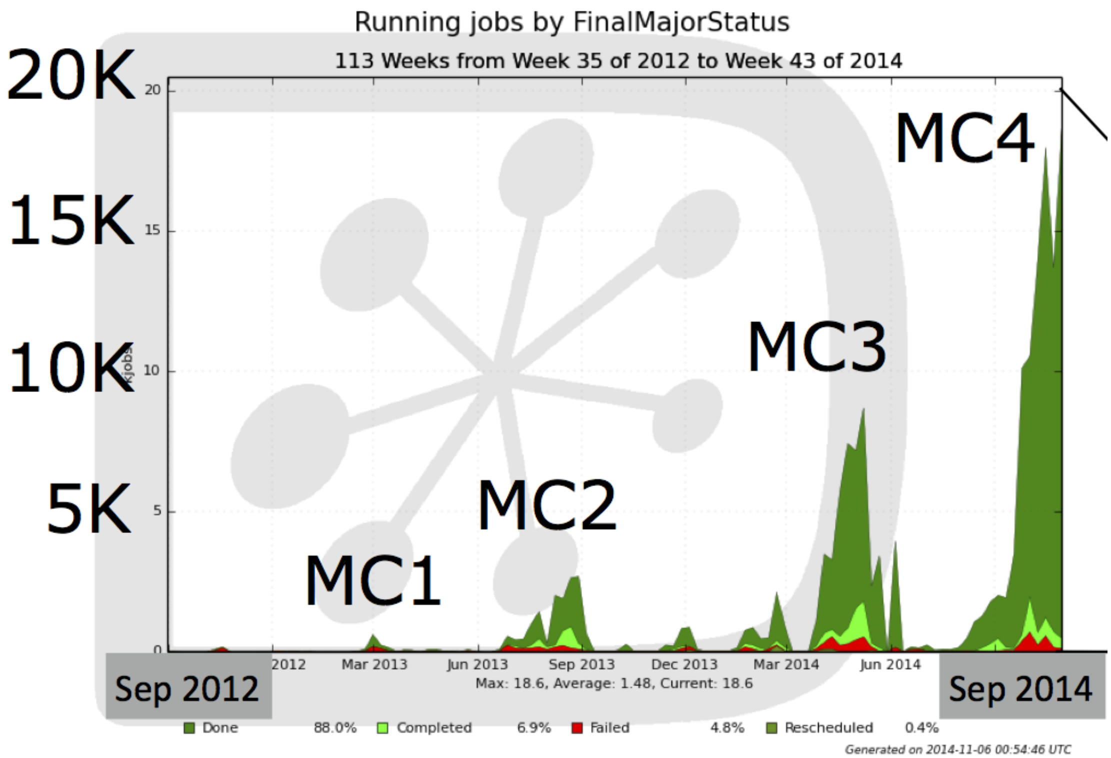

Figure 2: MC Jobs at Belle II MC production campigns between 2012 and 2014. Y-axis shows number of production jobs and X-axis spans time.

3 Conclusions

The large increase in sensitivity of Belle II over Belle comes with a significantly larger data sample. The SuperKEKB accelerator is designed to provide 50 times more data until the year 2025. This data volume is on par with the LHC and is a challenge for the computing system. The strategy involves PNNL to host a complete replica of raw data for the first three years in operation and distribute processed data to Europe. To ensure optimal network bandwidths, we routinely perform data challenges over the Belle II network which is now part of LHCONE AUP. Our computing model is facilitated by DIRAC and we have successfully tested the prototype over MC production campaigns. More details about the computing at Belle II can be found in Chapter 14 of the Belle II Technical Design Report [9].

References

[1] A. Abashian *et al.*, Nucl. Instrum. Meth. A **479**, (2002) 117.

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[5] http://software.es.net/maddash

[6] http://www.perfsonar.net/

[7] https://twiki.cern.ch/twiki/bin/view/LHCONE/LhcOneAup

[8] http://diracgrid.org/

[9] T. Abe *et al.*, arXiv:1011.0352 [physics.ins-det].