

Chapter 100

Scalable Data Mining, Archiving, and Big Data Management for the Next Generation Astronomical Telescopes

Chris A. Mattmann

California Institute of Technology, USA

Andrew Hart

California Institute of Technology, USA

Luca Cinquini

California Institute of Technology, USA

Joseph Lazio

California Institute of Technology, USA

Shakeh Khudikyan

California Institute of Technology, USA

Dayton Jones

California Institute of Technology, USA

Robert Preston

California Institute of Technology, USA

Thomas Bennett

SKA South Africa Project, South Africa

Bryan Butler

*National Radio Astronomy Observatory
(NRAO), USA*

David Harland

*National Radio Astronomy Observatory
(NRAO), USA*

Brian Glendenning

*National Radio Astronomy Observatory
(NRAO), USA*

Jeff Kern

*National Radio Astronomy Observatory
(NRAO), USA*

James Robnett

*National Radio Astronomy Observatory
(NRAO), USA*

ABSTRACT

Big data as a paradigm focuses on data volume, velocity, and on the number and complexity of various data formats and metadata, a set of information that describes other data types. This is nowhere better seen than in the development of the software to support next generation astronomical instruments including the MeerKAT/KAT-7 Square Kilometre Array (SKA) precursor in South Africa, in the Low Frequency Array (LOFAR) in Europe, in two instruments led in part by the U.S. National Radio Astronomy Observatory

DOI: 10.4018/978-1-4666-9840-6.ch100

(NRAO) with its Expanded Very Large Array (EVLA) in Socorro, NM, and Atacama Large Millimeter Array (ALMA) in Chile, and in other instruments such as the Large Synoptic Survey Telescope (LSST) to be built in northern Chile. This chapter highlights the big data challenges in constructing data management systems for these astronomical instruments, specifically the challenge of integrating legacy science codes, handling data movement and triage, building flexible science data portals and user interfaces, allowing for flexible technology deployment scenarios, and in automatically and rapidly mitigating the difference in science data formats and metadata models. The authors discuss these challenges and then suggest open source solutions to them based on software from the Apache Software Foundation including Apache Object-Oriented Data Technology (OODT), Tika, and Solr. The authors have leveraged these solutions to effectively and expeditiously build many precursor and operational software systems to handle data from these astronomical instruments and to prepare for the coming data deluge from those not constructed yet. Their solutions are not specific to the astronomical domain and they are already applicable to a number of science domains including Earth, planetary, and biomedicine.

1. INTRODUCTION

The next generation of astronomical telescopes including MeerKAT/KAT-7 in South Africa (Jonas 2009), the Low Frequency Array (LOFAR) in Europe (De Vos, 2009), the Expanded Very Large Array (EVLA) in Socorro, New Mexico (Perley, 2011), the Atacama Large Millimeter Array (ALMA) in Chile (Wootten, 2003) and eventually over the next decade the cross-continental Square Kilometre Array (SKA) (Hall, 2004), and the Large Synoptic Survey Telescope (LSST) in northern Chile (Tyson, 2002) will generate unprecedented volumes of data, stretching from the near terabyte (TB) of data/day range for EVLA on the lower bounds to the 700 TB of data per second range for the SKA. These ground-based instruments will push the boundaries of *Big Data* (Lynch, 2008) (Mattmann, 2013) in several dimensions shown in Table 1. Table 1 represents the common challenges that users, educators, scientists, and other discipline users face when leveraging astronomical data, namely its size (volume, velocity); variety of formats (complexity); the geographically distributed nature of these telescopes, and the limitations in bandwidth that prevents the wide dissemination of the information throughout the world's users who desire access to it. Big data is the buzzword of the day, used to define data sets so large and complex that traditional data management systems have difficulties handling them. There are three main challenges when dealing with big data: the amount of data collected (volume), the speed at which data must be analyzed (velocity), and the array of different data formats that is collected (complexity).

Engineering the data management, data mining, and archiving systems for these world-wide science assets is a complex (computer) scientific task in its own right, especially considering most of these telescopes are under construction from different funding agencies in the U.S. and abroad, each with different priorities and with different scientific end-user communities. Furthermore, each of the telescopes and their science foci have engendered highly complex data mining challenges, including data triage techniques for identification of important or interesting signal (e.g., fast radio transients, pulsars, etc.) amongst the fire hose of noise.

Our team at the Jet Propulsion Laboratory, California Institute of Technology (JPL) has been closely coordinating and working with the science data processing and operations teams from three of the

25 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:

www.igi-global.com/chapter/scalable-data-mining-archiving-and-big-data-management-for-the-next-generation-astronomical-telescopes/150262

Related Content

Suggested Model for Business Intelligence in Higher Education

Zaidoun Alzoabi, Faek Dikoand Saiid Hanna (2013). *Data Mining: Concepts, Methodologies, Tools, and Applications* (pp. 550-566).

www.irma-international.org/chapter/suggested-model-business-intelligence-higher/73457

Hybrid Recommender System Using Emotional Fingerprints Model

Anthony Nosshi, Aziza Saad Asem and Mohammed Badr Senousy (2022). *Research Anthology on Implementing Sentiment Analysis Across Multiple Disciplines* (pp. 1076-1100).

www.irma-international.org/chapter/hybrid-recommender-system-using-emotional-fingerprints-model/308534

Feature Selection for the Promoter Recognition and Prediction Problem

George Potamias and Alexandros Kanterakis (2007). *International Journal of Data Warehousing and Mining* (pp. 60-78).

www.irma-international.org/article/feature-selection-promoter-recognition-prediction/1790

An Ensemble Approach for Prediction of Cardiovascular Disease Using Meta Classifier Boosting Algorithms

Sibo Prasad Patro, Neelamadhab Padhy and Rahul Deo Sah (2022). *International Journal of Data Warehousing and Mining* (pp. 1-29).

www.irma-international.org/article/an-ensemble-approach-for-prediction-of-cardiovascular-disease-using-meta-classifier-boosting-algorithms/316145

Space-Time Analytics for Spatial Dynamics

May Yuan and James Bothwell (2013). *Data Mining: Concepts, Methodologies, Tools, and Applications* (pp. 2117-2131).

www.irma-international.org/chapter/space-time-analytics-spatial-dynamics/73537