Chen, W. et al. (Eds.) (2016). Workshop Proceedings of the 24th International Conference on Computers in Education. India: Asia-Pacific Society for Computers in Education

Towards an Open and Extensible Learning Analytics Systems

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Abstract: The power of learning analytics systems comes from the ability to support diverse analytics needs that arise from a variety of learning environments at various scale. As an effective integration framework for learning analytics, the system should be versatile enough to seamlessly incorporate various analytics methods and tools as needed. Based on our previous design and implementation of a reference model for learning analytics, we describe the progress made towards an open and extensible learning analytics system to support various analytics tools and processes by explicit specification of analytics tools and flexible management of the analytics processes.

Keywords: Learning Analytics System, Open and Extensible System, Plug and Play

1. Introduction

The drastic advancement of information and communication technologies (ICTs) and learning management systems (LMS) is making learning analytics and consequential personalized learning more feasible and practical than ever before. Learning analytics, however, is still an emerging field in which sophisticated and various analytic tools need to be integrated as a unified framework to improve learning and education.

The power of learning analytics systems comes from the ability to support diverse analytics needs that arise from a variety of learning environments at various scale. As an effective integration framework for learning analytics, the system should be versatile enough to seamlessly incorporate various analytics methods and tools as needed. Based on our previous design and implementation of a reference model for learning analytics (Choi, Cho & Lee, 2014; Bae, Cho & Lee, 2015), we describe the progress made towards an open and extensible learning analytics system to support various analytics tools and processes by explicit specification of analytics tools and flexible management of the analytics processes. The reference model is built to meet the identified requirements for the learning systems to be open, extensible, distributed, interoperable, reusable, configurable, real-time, predictable, usable, secure, and traceable as shown in **Error! Reference source not found.**.

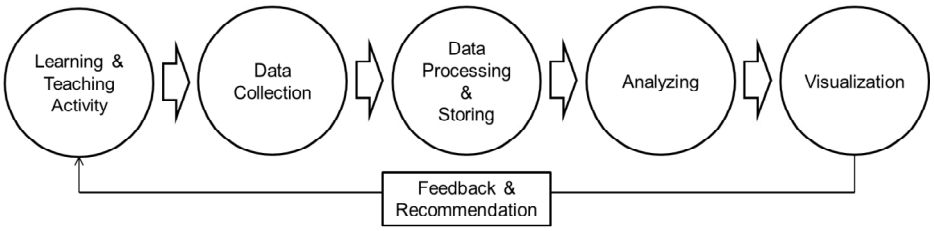

Figure 1. Workflow of Learning Analytics

The workflow shown in **Error! Reference source not found.** is adopted in the reference model of the ISO/IEC JTC1 SC36 WG8 *Information technology for learning, education, and training — Learning analytics interoperability (*ISO/IEC JTC1 SC36 WG8, 2016). The reference model describes the constituent steps as follows;

- **Learning and Teaching Activity**: the process of data modeling sources of learning activities in order to decide upon learning activity data that could be used for analytics, and the release of learning activity data for Data Collection

- **Data Collection**: the process of gathering and measuring information on variables of interest in the learning and teaching activities
- **Data Processing and Storing**: the process of preparing and storing data from diverse and heterogeneous data sources for interoperable data analysis by utilizing the standardized data model and representation.
- **Analyzing**: the process of systematic investigation of learning data by inspecting, and modeling the learning data with the goal of producing descriptive and possibly predictive knowledge
- **Visualization**: the process of creating representations of abstract data including text and schematic representations such as social diagrams and maps to allow stakeholders to see, explore, interact, and understand large amounts of information in analyzing and reasoning about data and evidence
- **Feedback and Recommendation**: the process for serving the results of a cycle of learning analysis back to the learners and their contexts so that corrective actions can be taken

Although the aforementioned requirements are applicable to the entire steps of the workflow, in this paper we focus on the requirement to be open and extensible especially for the design of analyzing step since it is the indispensable step that involves diverse and dissimilar analytics tools. In the rest of this paper, we describe our approach to explicit specification of analytics tools and flexible management of the analytics processes towards an open and extensible learning analytics system.

2. Analyzing for Learning Analytics

Analyzing is the process of systematic investigation of learning data by inspecting, and modeling the learning data with the goal of producing descriptive and possibly predictive knowledge as illustrated in **Error! Reference source not found.** *(*ISO/IEC JTC1 SC36 WG8, 2016).

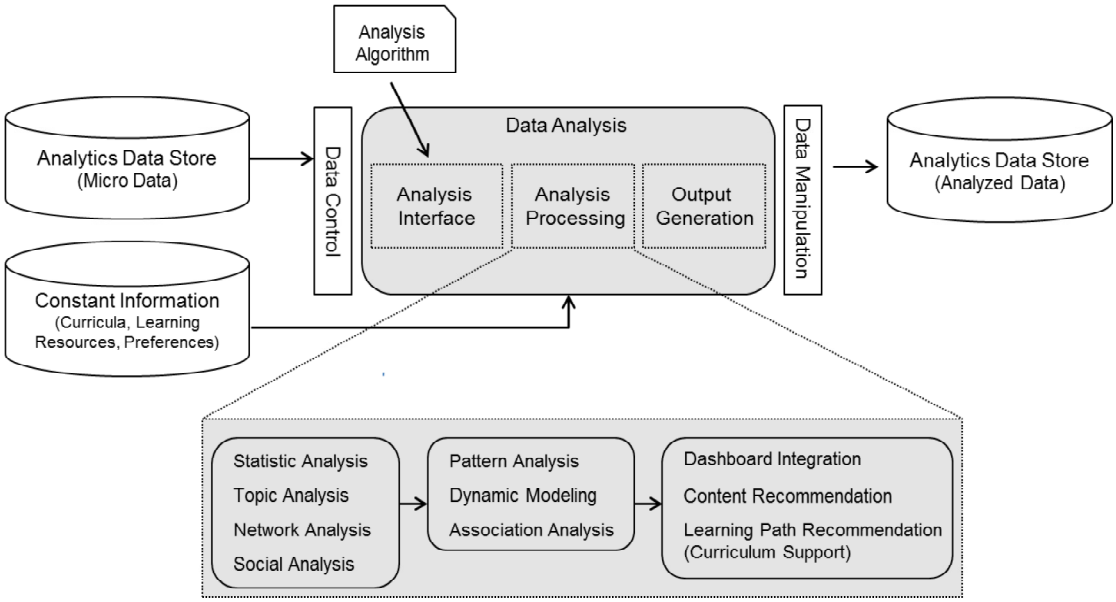

Figure 2. Analyzing for Learning Analytics

In this figure, the greyed area depicts the data analysis process for which our work to make open and extensible. Our aim is to make the analysis interfaces and tools to be interchangeably used in the learning analytics systems to allow to implement continuous learning processes in diverse learning contexts and provide on-demand adoption of the tools.

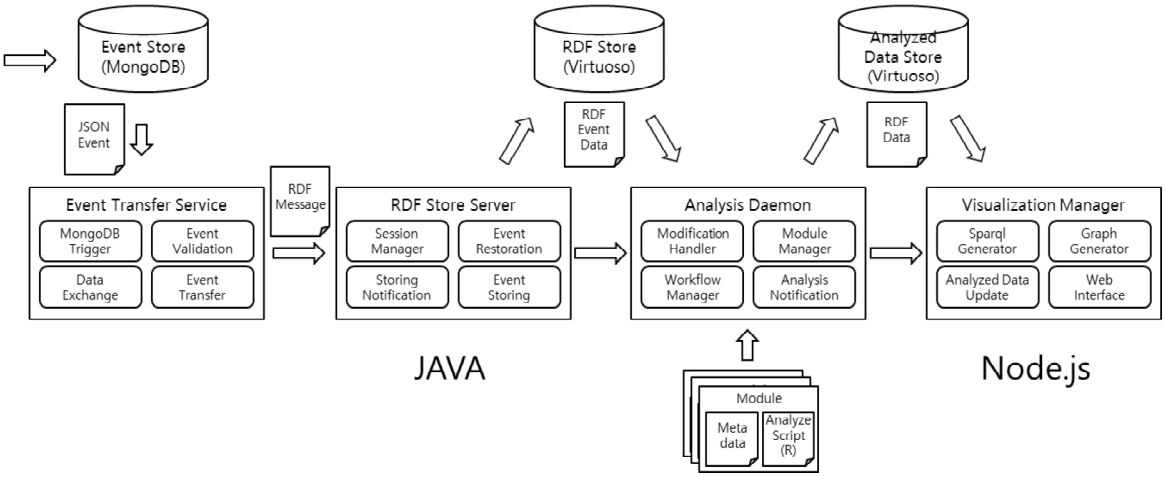

Figure 3. Overall Implementation View

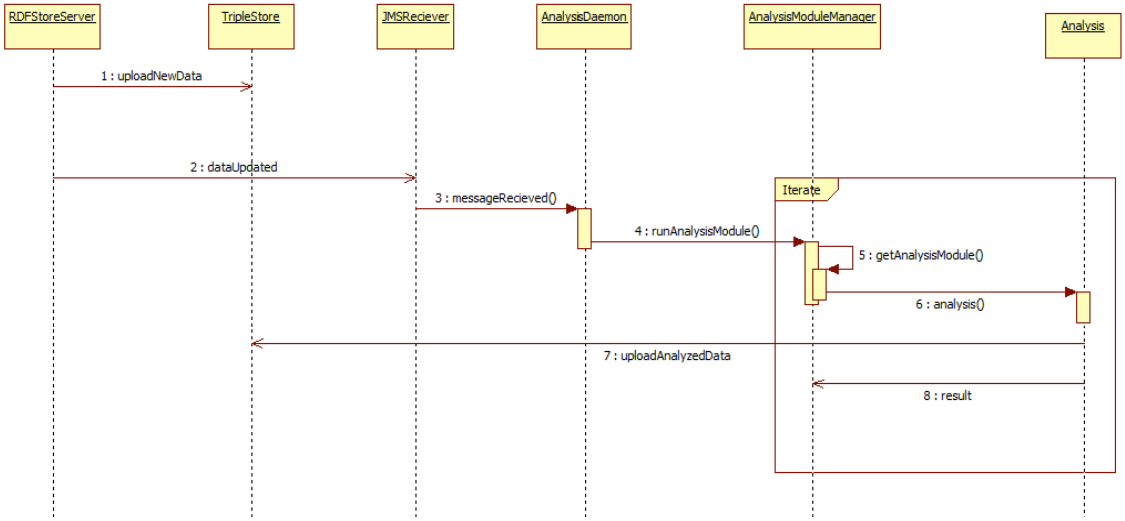

Figure 4. Sequence Diagram for the Learning Analytics System

Error! Reference source not found. shows the overall implementation view of the workflow for the learning analytics system and **Error! Reference source not found.** illustrates the sequential interactions of the components of the workflow. The following descriptions are based on this implementation view and the sequence diagram.

2.1 Analysis Interface

Analysis Interface provides a common interface to various external analysis algorithms such as predictive analytics, adaptive analytics, discourse analytics, and other assessment tools. These analysis modules firstly need to be explicitly specified for the learning analytic system to handle uniformly. We use the following minimal set of metadata as shown in **Error! Reference source not found.**.

Table 1. Metadata for Analysis Tools

Properties	Description
Developer	Description of the developer of analysis module
Location	The path to the analysis module
RequiredData	The list of data required for the analysis module
RequiredType	The associated list of types of the required data
ResultData	The list of data produced by the analysis module

ResultType	The associated list of types of the produced data
Version	The version of the module

The metadata basically describes the input and output of analysis modules and used for the module manager in the Analysis Daemon in **Error! Reference source not found.** to control the analysis module. The metadata is also utilized to search and locate appropriate analysis modules as needed.

2.2 Analysis Processing

While Analysis Interface provides a common interface to various external analysis modules, Analysis Processing manages sequencing and execution of analysis modules accordingly to the metadata of the analysis modules as shown in **Error! Reference source not found.**. Analysis Processing may start with statistical analysis, topic analysis, network analysis, social analysis and more. The results of low-level analysis then may feed into pattern learning, dynamic modeling, and association analysis before they are used by dashboard integration, content recommendation, and learning path recommendation.

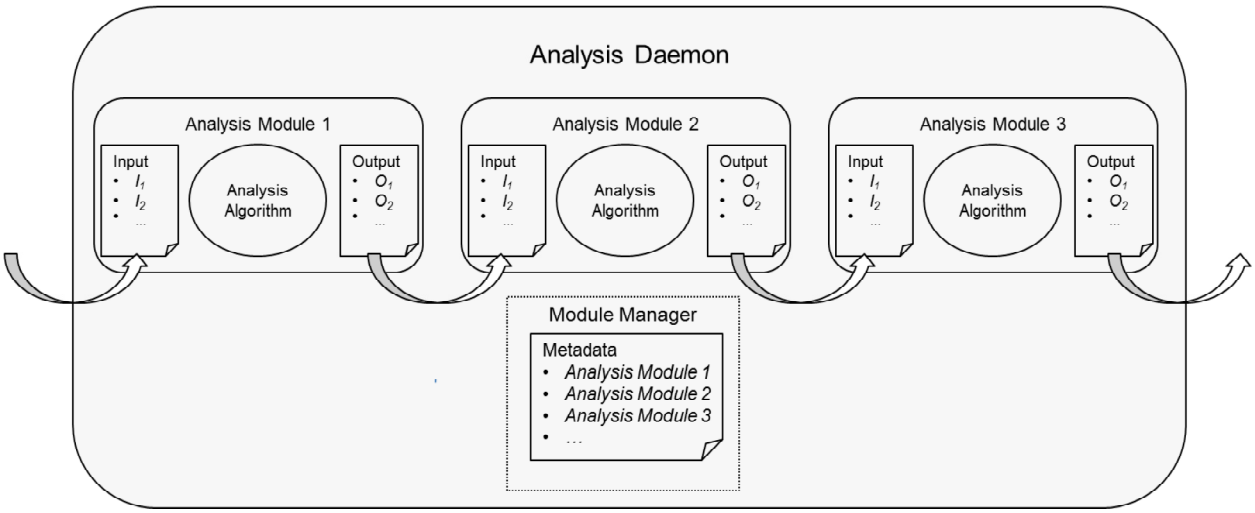

Figure 5. Analysis Processing

Metadata for the analysis modules are crucial for the Module Manager to relay data from the output of one module to the input of subsequent analysis module sequence. The activation of analysis module is spontaneously triggered by creation or changes of the corresponding data specified in the module description. Instead of statically specifying the sequence of analyzing, asynchronous and data-driven invocation of necessary modules is the key feature enabling open and extensible analyzing processes. Additionally such a data-flow feature allows parallel execution of independent analysis modules automatically.

3. Discussion and Future Work

In this paper, we presented our approach towards an open and extensible learning analytics system that is developed based on a standard reference model of ISO/IEC JTC 1 SC 36. Learning analytics systems are required to support diverse analytics necessities generated from a variety of learning environments at various scale. Our approach is to explicitly specify the metadata for analysis modules and to adopt data-driven and asynchronous invocation model analysis processing. We believe that our approach is effective in building an open and extensible integration framework for learning analytics by providing a versatile way to seamlessly incorporate various analytics methods and tools as needed. Currently, we are looking into a way to apply our approach to the whole workflow of learning analytics by leveraging our experience.

Acknowledgements

This research was supported by the ICT Standardization program of MISP (The Ministry of Science, ICT & Future Planning)

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ISO/IEC JTC1 SC36 WG8 Information technology for learning, education, and training — Learning analytics interoperability — Part 1: Reference model, ISO/IEC TR 20748-1:2016(E), To be published.