Small County: Development of a Virtual Environment for Instruction in Geological Characterization of Petroleum Reservoirs ED51B-0526

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Abstract

We have developed an environment for interactive instruction in the geological aspects of petroleum reservoir characterization employing a virtual subsurface closely reflecting the geology of the US mid-continent, in the fictional setting of Small County, Kansas, providing geology students an opportunity to gain experience in interpreting drilling records and petrophysical logs from wells. Stochastic simulation techniques are used to generate the subsurface characteristics, including the overall geological structure, distributions of facies, porosity, and fluid saturations, and petrophysical logs. The student then explores this subsurface by siting exploratory wells and examining drilling and petrophysical log records obtained from those wells. A version of the application aimed at students in introductory geology courses implements a simpler exercise in which students search for the peak of an anticlinal structure, providing experience in the interpretation of contour maps and the improvement in information as more data points (wells) are added. We have developed the application using the open-source Eclipse Rich Client Platform, which allows for the rapid development of a platform-agnostic application with a rich graphical user interface. Building the Small County application framework on the Rich Client Platform allows it to be versatile and extensible. The core application framework includes a set of predefined methods for viewing and exploring the simulations: a bird's-eye overview of the land surface, along with tools for displaying contour maps of selected subsurface horizons, a cross-section view following a user-selected path through the subsurface, and a data log view for analyzing the properties of the subsurface at a given surface location. The framework is extended by customizing the behavior of the simulators either by setting parameters on a detailed model or by implementing new algorithms. Educational goals are met by creating exercises tailored to suit students' abilities. Exercises are built by providing plug-ins to the framework that specify the application storyboard and include custom evaluation criterion and displays.

Subsurface Simulation

The subsurface is generated using a stochastic property generator whose model parameters are defined in an exercise configuration file. First the elevations of the major intervals are simulated as a set of quadratic surfaces (with coefficients selected at random from specified ranges) plus spatially autocorrelated residuals. These surfaces are generated to exhibit reasonably realistic variability and continuity across the county. In the current version of the application, the lithologies and geophysical properties are simulated on demand when the student sites a well, rather than being simulated in advance over the entire subsurface grid. The sequence of lithologies in each interval is generated using Markov chain simulation.

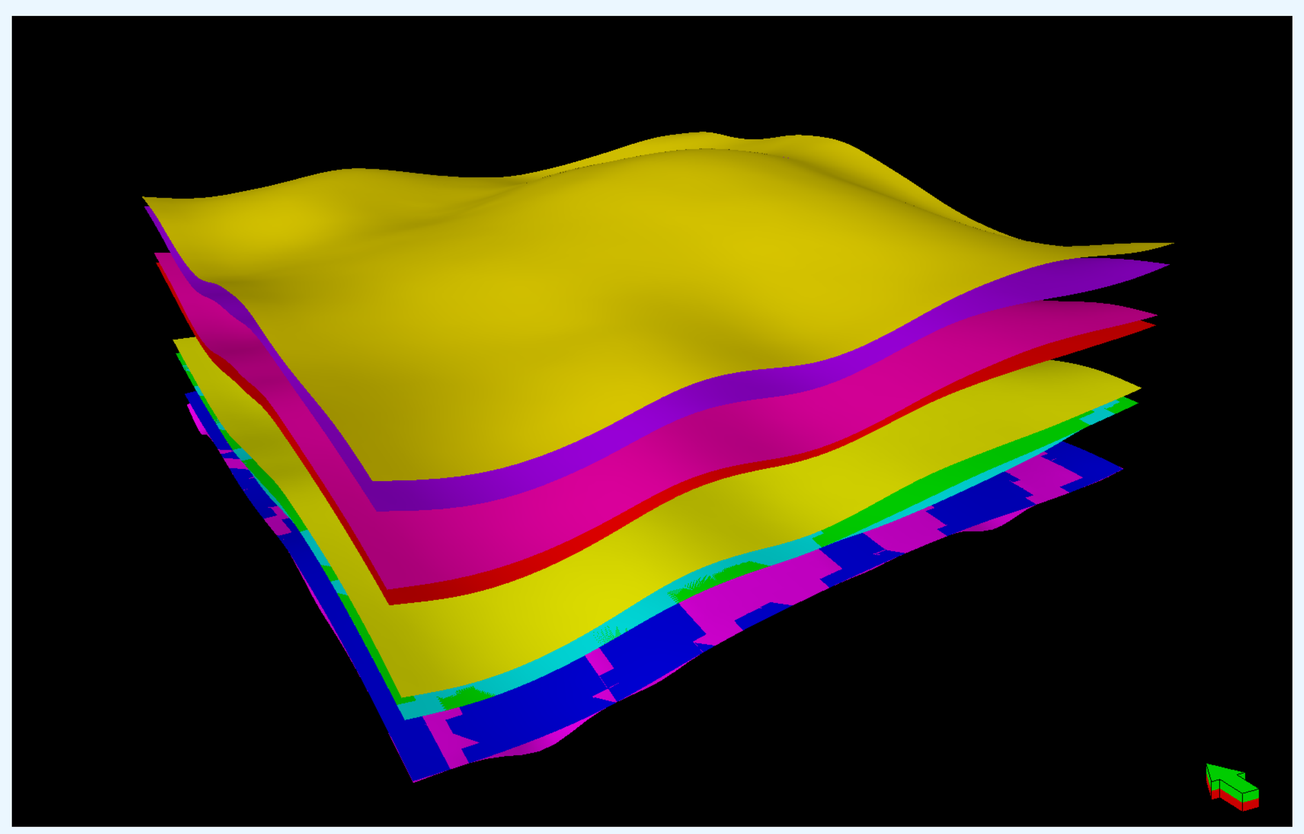

Figure 1 - One possible realization of major horizon elevations in the Small County subsurface. Elevations of the 9 horizons range from roughly 1500 feet below sea level to 1000 feet above sea level and the areal extent is 30 miles in each direction.

Advanced Undergraduate Version

The primary intention of the advanced undergraduate version of Small County is to provide students with experience in interpreting geophysical well logs, using those logs to identify interval tops, lithologies, and zones of significant oil saturation (pay) in each well they drill. The student is first presented with an overview map of the county (Figure 2). From here, the student can view contour plots of either the elevations or thicknesses of the major intervals, initially interpolated from a set of pre-existing wells. These maps are updated to reflect the information obtained from each well that the student drills. The student may also view data associated with an existing well. Clicking on a well's icon populates the Well Summary View with elevations and relative thicknesses of the intervals for the selected well's location. In addition, the student can view cross sections of the interval top elevations (Figure 3) by ctrl-clicking on a sequence of wells and then selecting the Cross Section tab.

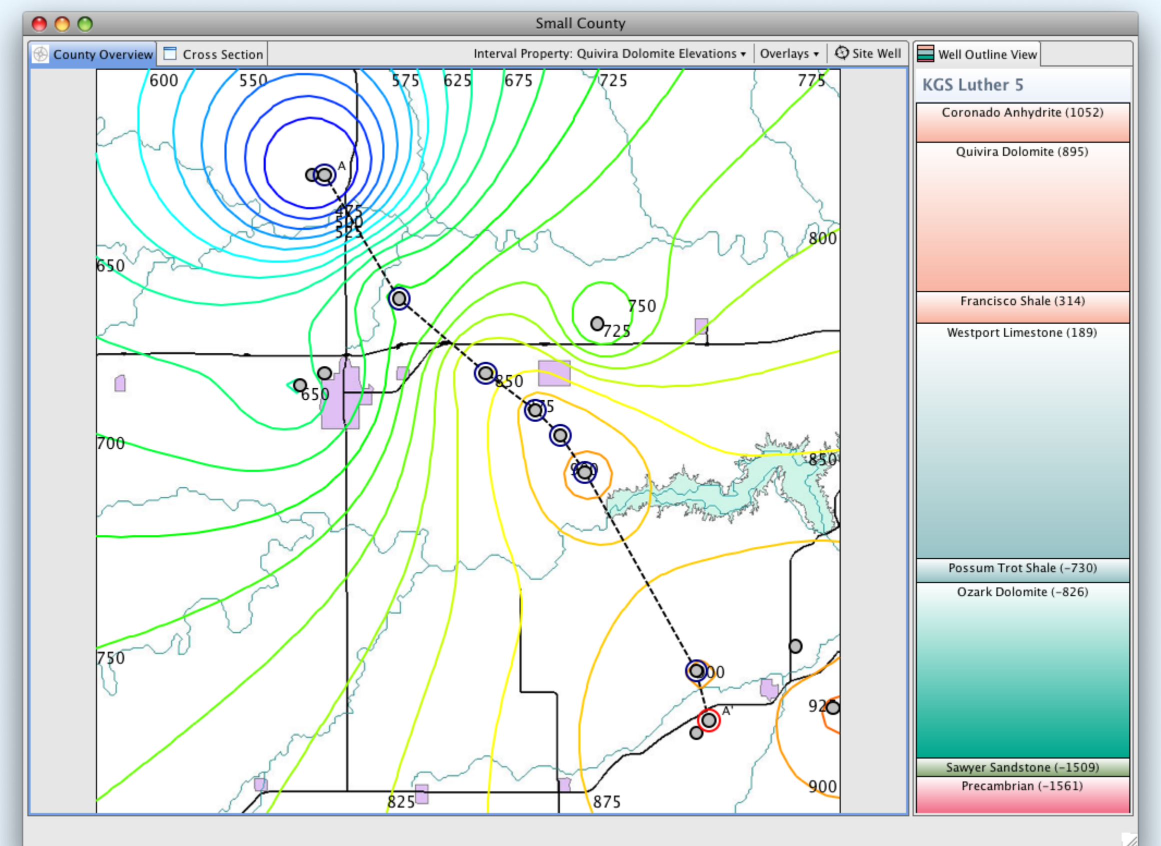

Figure 2 - County Overview wih set of wells for cross section (Figure 3) selected.

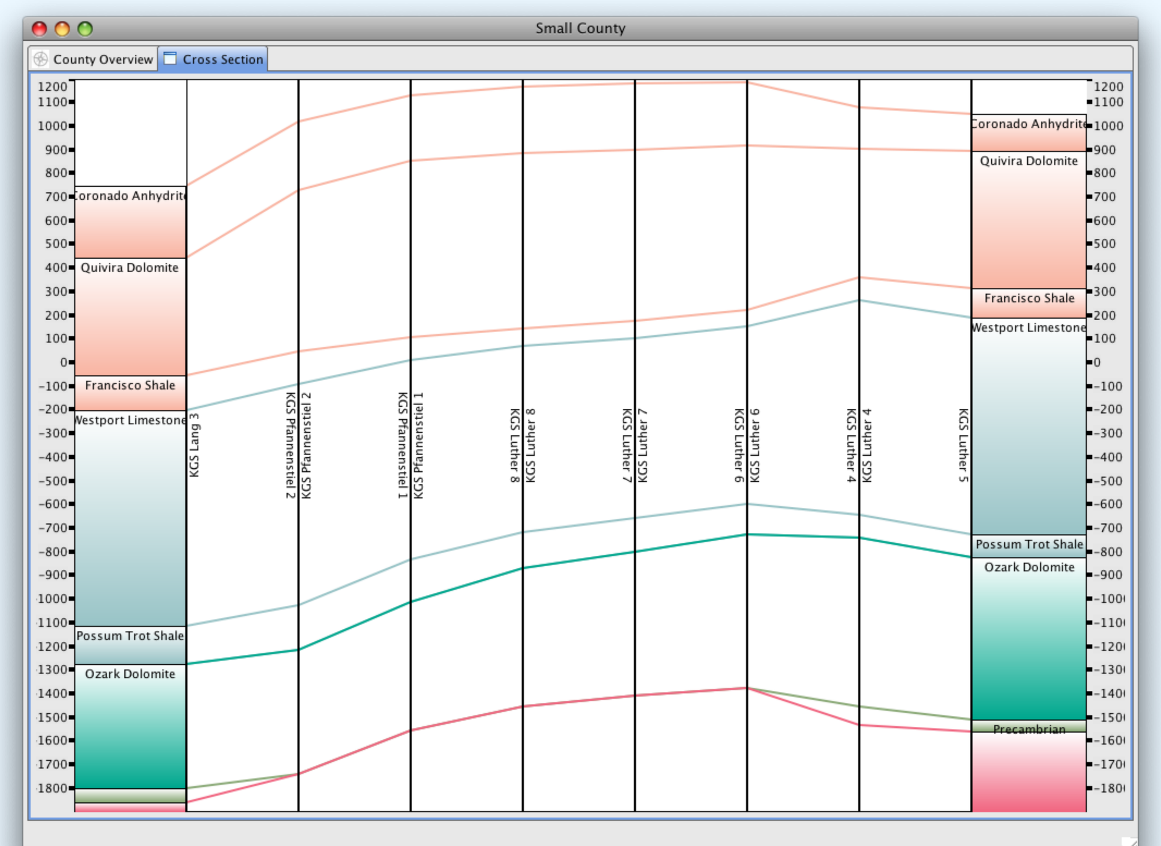

Figure 3 - Cross Section view.

Whenever the student drills a new well, the lithology sequence and the properties versus depth are simulated at the well location. When the simulation process completes, the student is presented with the Well Log View (Figure 4). Here the student's task is to interpret the presented data and determine the correct lithology at each depth as well as mark the tops of the major intervals. Additionally the student may select promising ("pay") zones to perforate for production upon completion of the well. After labeling lithologies and picking the interval tops, the student indicates that he or she has finished by selecting a toolbar button. An interpretation "score card" is presented summarizing the student's performance (Figure 5). A table depicting the difference between the actual interval tops and the student's picks is shown at the top of the window. This is followed by a summary of the picked and missed pay zones.

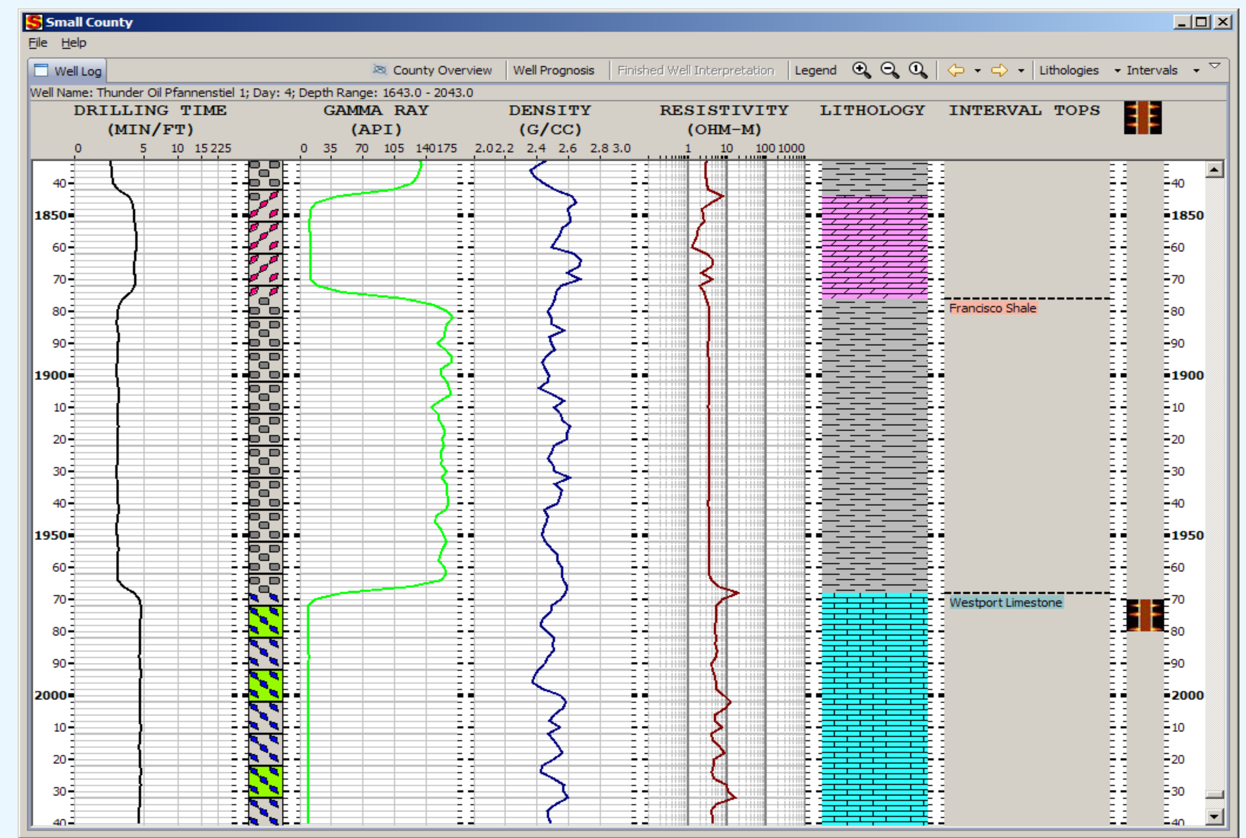

Figure 4 - Well Log view.

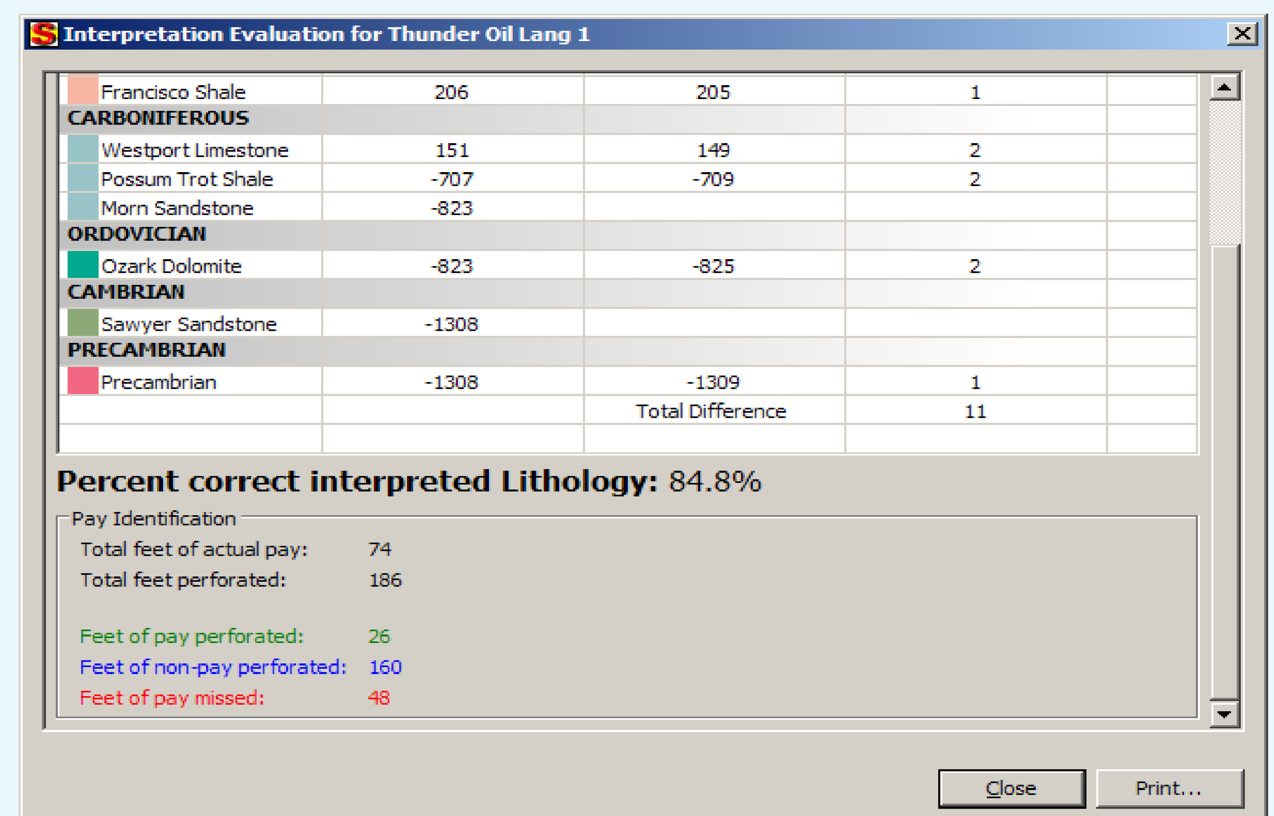

Figure 5 - Well log interpretation evaluation

Introductory Geology Version

In the introductory geology version, the student's task is to find the peak of an anticlinal structure in a single horizon, on the presumption that the best prospects for oil production would be in the vicinity of this peak. This version does not involve well log interpretation. Instead, the contour map of the horizon elevation immediately updates to reflect the "observed" elevation in any new well that the student drills. Thus, the student's task is to interpret the contour map and cross sectional displays to locate the anticline peak. After drilling five wells (in addition to ten pre-existing wells), the student is presented with a dialog box indicating how close he or she has gotten to the actual peak (Figure 6).

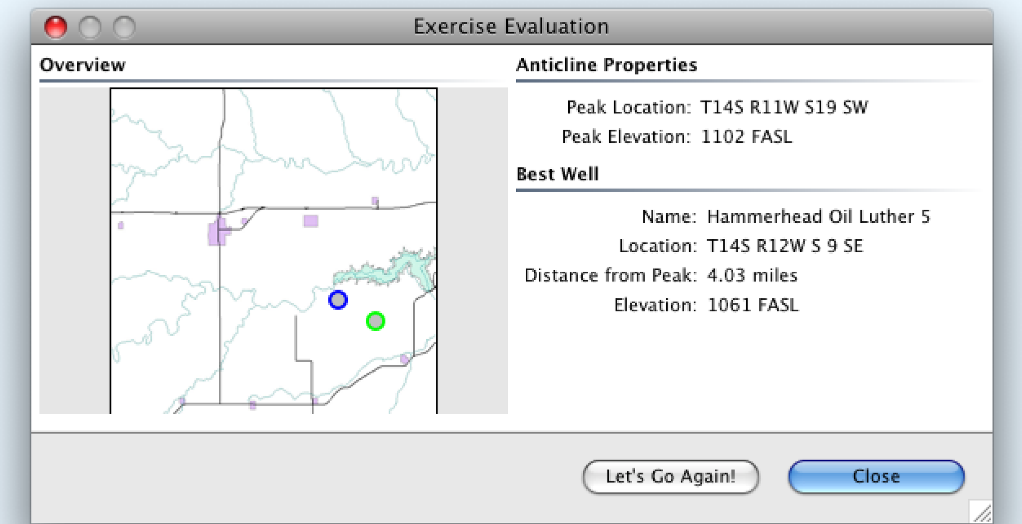

Figure 6 - Introductory Small County exercise evaluation

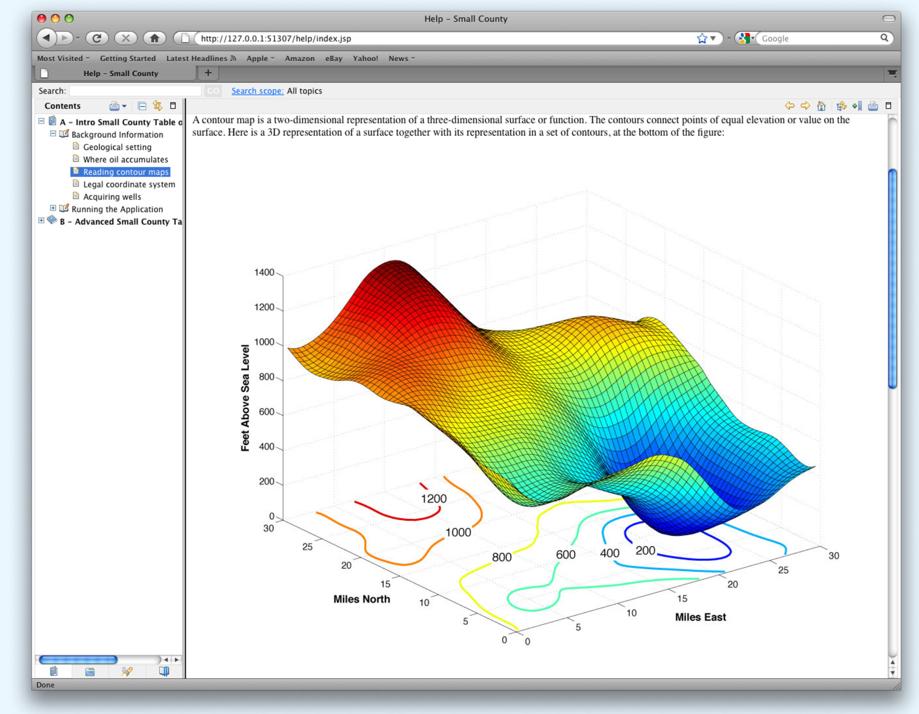

Figure 7 - An example help page

Development Platform

The Small County application is based on the Eclipse Rich Client Platform (RCP) (http://www.eclipse.org/rcp). This enables rapid development of an application that runs on multiple operating platforms (Win32, OSX, Linux/GTK) while retaining the feel of the native operating environment. The RCP provides a framework of application, UI, and modeling tools that allow the developers to focus on the applications domain without much concern for low-level implementation details. Another benefit of the RCP is that the application is based on sets of plugins. The application is therefore easily extended and its components are reusable.

Acknowledgment

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