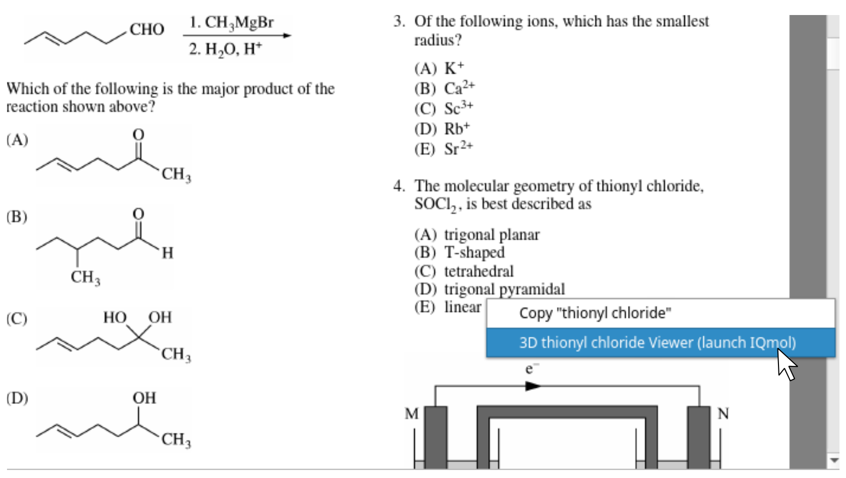
An ETS Plugin Framework for Enhanced Test Preparation

We propose an ETS Plugin Framework (**ETSPF**) whose goal is to integrate applications (for example, **PDF** viewers) for viewing documents viewers with scientific and multi-media applications by enabling these applications to share data, and also to incorporate **GUI** components specific to education and test-prep. ETS plugins would allow scientific and applications to be used as teaching tools, and also allow document viewers to present multimedia content to a degree that is not currently possible — in particular, interoperating with a diverse array of applications supporting domain-specific multimedia file formats. In effect, ETS plugins transform document viewers into specialized e-readers with with novel test-preparation features. For example, while studying for exams, students would have at their disposal interactive multimedia presentations which would offer sophisticated data visualization and **3D** graphics tools.

ETSpf for Scientific and Technical Applications

How ETSpf enables multi-application networking

ETSPF refers not to a single plugin, but a toolkit for implementing ETS plugins to be embedded in many different applications. These plugins should be sufficiently similar that students or instructors familiar with an ETS plugin in one context (chemistry, for example) would quickly understand how to use plugins present in a different context. An important **ETSPF** feature is that distinct ETS plugins would be able to communicate with each other. In particular, plugins for document viewers would send data to plugins for scientific or multimedia applications, so that students could access multimedia content linked to manuscripts, such as test-preparation materials, that they are currently reading.



Which of the following is the major product of the reaction shown above?

(A)

(B)

(C)

(D)

3. Of the following ions, which has the smallest radius?

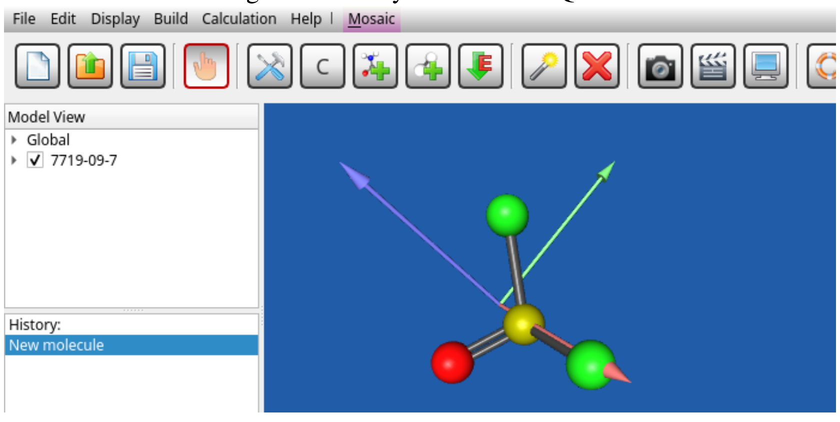
(A) K^+
(B) Ca^{2+}
(C) Sc^{3+}
(D) Rb^+
(E) Sr^{2+}

4. The molecular geometry of thionyl chloride, $SOCl_2$, is best described as

(A) trigonal planar
(B) T-shaped
(C) tetrahedral
(D) trigonal pyramidal
(E) linear

For a concrete example of advanced functionality that can be achieved by connecting two distinct **ETSPF** plugins, consider a student reading through the ETS **GRE** Chemistry practice test. This book has sample questions such as (number 4, page 11) **The molecular geometry of thionyl chloride, $SOCl_2$, is best described as** *(A) trigonal planar, (B) T-shaped, (C) tetrahedral, (D) trigonal pyramidal, or (E) linear*. To understand this question/answer, it may help students to view a **3D** model of thionyl chloride, which can be done with the aid of molecular visualization software, such as IQmol. Accordingly, this specific question in the book may be associated with Molecular Data file for $SOCl_2$ (this file is available from the "Chemical Abstracts Service" database). The relation between the specific textual location (where the practice Question 4 is presented) and the supplemental Molecular Data file would be asserted in the Semantic Document Infoset, and read by a document viewer (e.g., **XPDF**). The **XPDF** plugin would then launch IQmol and send the molecular file to the IQmol ETS plugin, with instructions to load this file into an IQmol session (see Figure 1). The end result would be that the student, with a single click (such as selecting a visualization action from a context menu on the practice question) has access to an interactive **3D** graphic representing

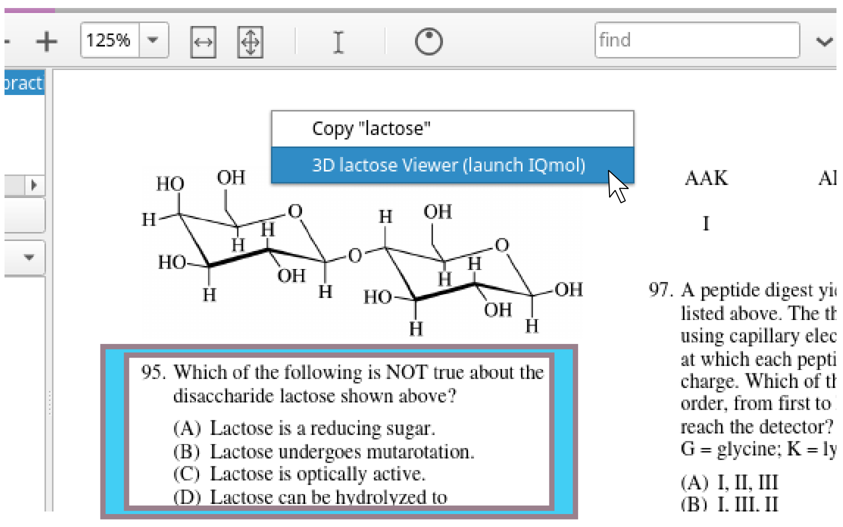
Figure 1: Thionyl Chloride in IQmol



thionyl chloride. (Of course, analogous functionality would be available for any chemical compound with multimedia files in such formats as Molecular Data, Protein Data Bank, or Chemical Markup Language).

ETSpf features for keeping track of students' previous activity.

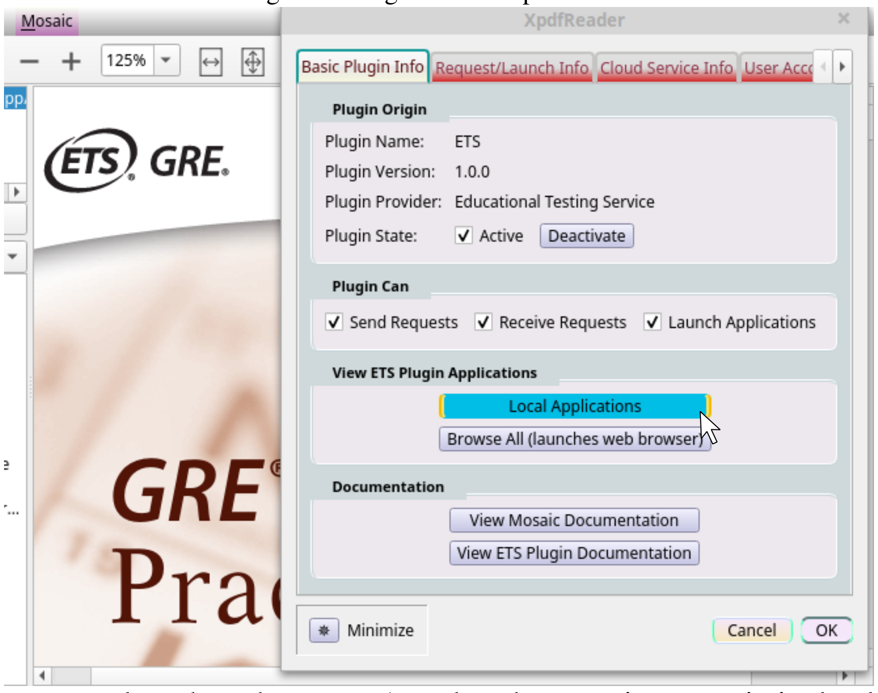
The data sent between **ETSPF** applications may be more complex than a request to open a single multimedia file. Suppose a student reading through the GRE Chemistry practice exam launches IQmol a second time — perhaps in conjunction with a later question (number 95 in the test — see figure at right) about the molecular structure of lactose. In this case, the plugin can send information not only about the present request but about the student's prior usage; in particular the fact that he or she had previously viewed the $SOCl_2$ file. The **ETSPF** plugin on the IQmol side can then load the prior file along with the new one, so the student can browse back to prior application-states if desired (see the Model View panel on Figure 3).



95. Which of the following is NOT true about the disaccharide lactose shown above?
(A) Lactose is a reducing sugar.
(B) Lactose undergoes mutarotation.
(C) Lactose is optically active.
(D) Lactose can be hydrolyzed to

97. A peptide digest yi
listed above. The th
using capillary elec
at which each pepti
charge. Which of th
order, from first to
reach the detector?
G = glycine; K = ly
(A) I, II, III
(B) I, III, II

Figure 2: Plugin Info in XpdfReader



Basic Plugin Info | Request/Launch Info | Cloud Service Info | User Acc

Plugin Origin
Plugin Name: ETS
Plugin Version: 1.0.0
Plugin Provider: Educational Testing Service
Plugin State: ✓ Active [Deactivate]

Plugin Can
✓ Send Requests ✓ Receive Requests ✓ Launch Applications

View ETS Plugin Applications
[Local Applications]
[Browse All (launches web browser)]

Documentation
[View Mosaic Documentation]
[View ETS Plugin Documentation]

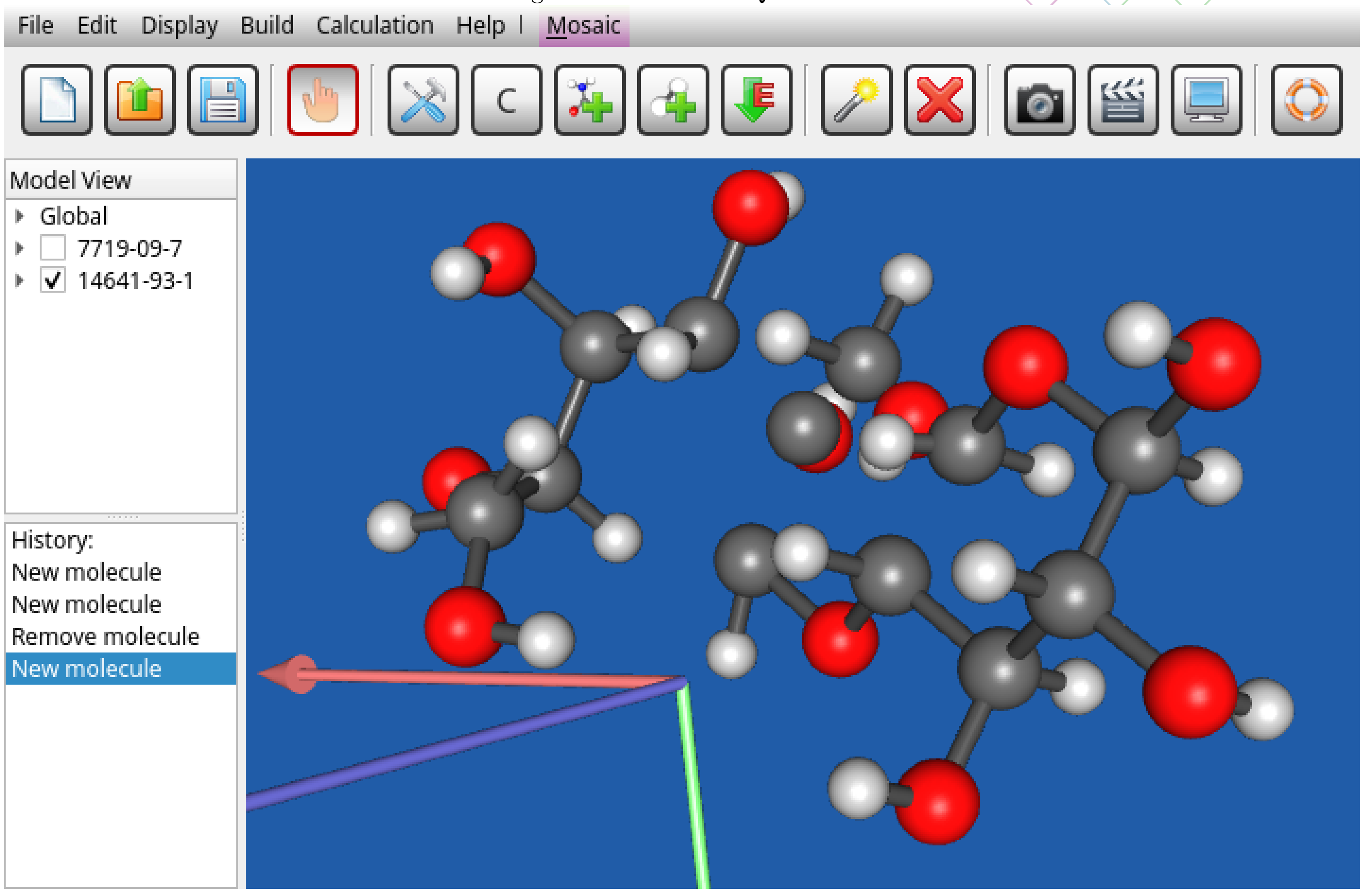
[Minimize] [Cancel] [OK]

In general, the functionality provided by each ETS plugin will depend in part on domain of the host application in which the plugin is embedded. For example, an IQmol plugin would load cheminformatic files and may activate IQmol's analytic capabilities in the domain of chemistry, whereas a plugin for applications in the domain of quantitative/statistical analysis and data visualization (such as ParaView) would open quantitative data sets with 2D or 3D views (via surfaces, scatter-plots, bar charts, etc.) and perhaps activate statistical calculations. Nevertheless, certain functionality would be shared among all ETS plugins, which would include a dialog window to show basic plugin information (see Figure 2) as well as a more detailed review of data transmitted between applications via plugins. Specifically, the "request info" tab would allow students, instructors, and plugin developers to see information about the request which prompted the current application to be launched and/or to open a specific file (see Figure 5).

ETSpf Tools for Composing Test-Preparation Materials

In general, **ETSPF** plugins for document viewers such as **XPDF** would draw information from **PDF** files (or files in other formats, e.g. **EPUB** or **HTML**) to implement pedagogic enhancements (such as integration with scientific and multimedia applications). This **ETSPF**-specific data can be placed in a separate file embedded in **PDF** or **EPUB** documents (or inserted as non-display contents in **HTML**). When a document is opened, the **ETSPF** plugin would then extract the embedded file so as to read **ETSPF**-specific data about the document — in particular, to identify **PDF** coordinates for document elements requiring special **ETSPF** actions. In the above **GRE** chemistry examples, for instance, the **ETSPF** data would permit plugins to insert context menus where text that has **ETSPF** actions is visible (for questions (4) and (95) illustrated above, the option to view the relevant compounds in IQmol).

Figure 3: Lactose in IQmol



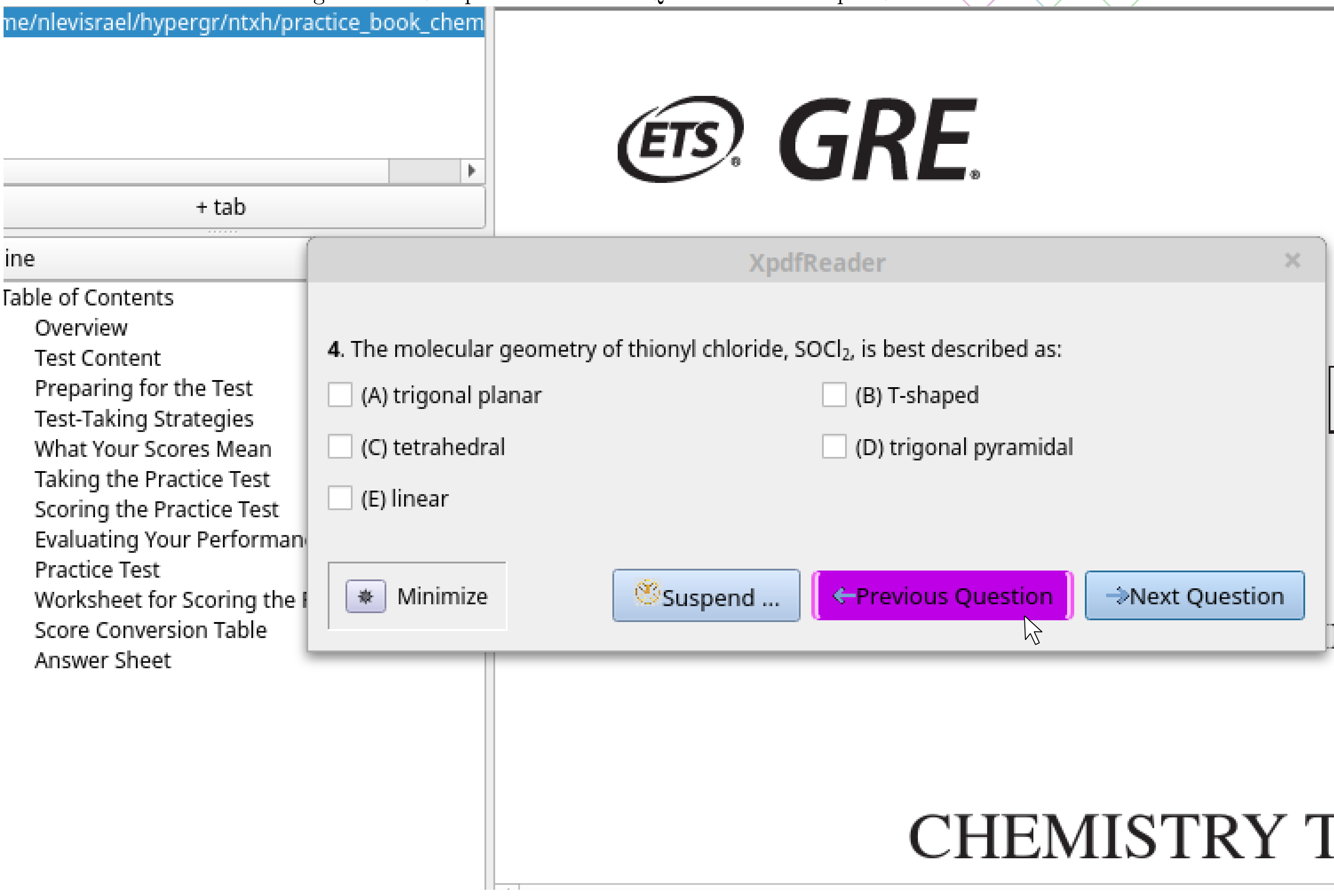
To support these capabilities, **ETSPF** would include tools to help compose publications (such as test-preparation materials) that embed what we call a "Semantic Document Infoset" (**SDI**), which divides manuscripts into textual units (sections, paragraphs, sentences, etc.) and identifies document elements such as technical terms (which may be compiled into a glossary) and figure illustrations. **ETSPF** code can then examine a publication's **SDI** to generate machine-readable structural representations of publication manuscripts, which document viewers may use to augment the underlying document with additional instructional and/or multimedia features — review questions, student instructions, glossaries, reading assignments, and so forth. The **SDI** can be used to guide **ETSPF** plugins when sharing data between applications, but also to enhance the presentation of content within the host application. For example, Figure 4 shows how an **ETSPF** plugin could provide an alternative interface for viewing practice test questions, where readers can consider each question in turn, isolated in its own window.

ETSPF implementations can include LaTeX packages which automate the creation of **SDI** data (placed as an embedded file in the generated **PDF** document). This embedded data can then be read by **ETSPF** plugins to compose multi-application networking requests, populate question/answer windows, or introduce other kinds of pedagogic content (e.g., review questions, glossaries, or class discussion suggestions). In manuscripts where questions are printed as part of the publication text (for example, the ETS **GRE** practices), the LaTeX code can store questions' **PDF** coordinates so that the document automatically scrolls while students work their way through a practice test session. Alternatively, the same techniques can be used to add review questions and answers to documents which are not expressly designed as test-prep materials, such as textbooks and research papers. In this latter case, question/answer windows may be synced to sentences or paragraphs in those publications which are relevant to the review question that the student is currently reading in a question/answer window.

HTXN Specifications

As an additional feature, **ETSPF** plugins would implement a protocol which we call **HTXN** (for "Hypergraph Text Encoding"). The goal of **HTXN** is to support the new generation of publishing technologies, where conventional document formats are increasingly being supplanted by digital, multimedia reader experiences. The traditional manuscript (the "primary" resource which is cited and downloaded) is, accordingly, often networked with a package of supplemental (or "secondary") resources. **HTXN** is designed to rigorously document these multimedia networks, enabling e-readers

Figure 4: A Sample Practice-Test Question within XpdfReader



4. The molecular geometry of thionyl chloride, $SOCl_2$, is best described as:

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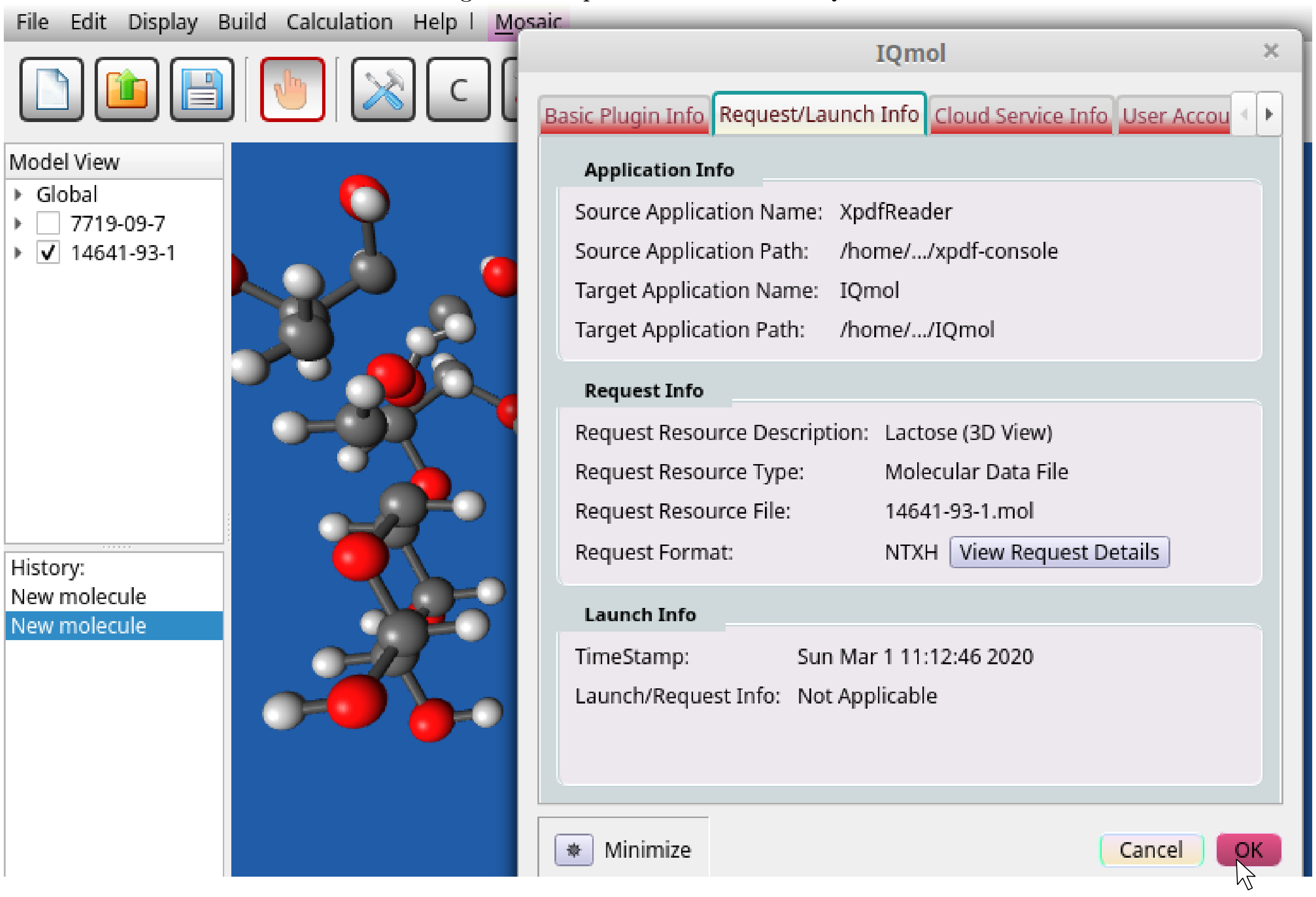
and domain-specific applications to be integrated so that users may easily access multimedia content. The **HTXN** protocol uses "standoff annotation" (i.e., character encoding and document structure are defined in isolation from one another), and can be employed to encode manuscripts in different markup formats (both LaTeX and **XML**, for instance). In the context of **ETSPF**, **HTXN** would be used to encode document information and text within the **SDI**.

Figure 5: Request Information in IQmol



Application Info

Source Application Name:	XpdfReader
Source Application Path:	/home/.../xpdf-console
Target Application Name:	IQmol
Target Application Path:	/home/.../IQmol

Request Info

Request Resource Description:	Lactose (3D View)
Request Resource Type:	Molecular Data File
Request Resource File:	14641-93-1.mol
Request Format:	NTXH

Launch Info

TimeStamp:	Sun Mar 1 11:12:46 2020
Launch/Request Info:	Not Applicable

LTS can provide a more detailed overview of **ETSPF** with additional use-cases, technical information about plugin code, and sample **HTXN**-encoded documents, on request.