A Review of XML-Compliant User Interface Description Languages

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Abstract. A review of XML-compliant user interface description languages is produced that compares a significant selection of various languages addressing different goals, such as multi-platform user interfaces, device-independence, content delivery, and user interfaces virtually defined. There has been a long history and tradition to attempt to capture the essence of user interfaces at various levels of abstraction for different purposes. The return of this question today gains more attraction, along with the dissemination of XML markup languages, and gives birth to many proposals for a new user interface description language. Consequently, there is a need to conduct an in-depth analysis of features that make all these proposals discriminant and appropriate for any specific purpose. The review is extensively conducted on a significant subset of such languages based on an analysis grid and user interfaces that we tried to implement across these languages.

1 Introduction

For years, Human-Computer Interaction (HCI) witnessed a perennial race for the ultimate User Interface (UI) Description Language that would ideally capture the essence of what a UI could be or should be. A UI Description Language (UDIL) consists of a high-level computer language for describing characteristics of interest of a UI with respect to the rest of an interactive application. Such a language involves defining a syntax (i.e. how these characteristics can be expressed in terms of the language) and semantics (i.e., what do these characteristics mean in the real world). It can be considered as a common way to specify a UI independently of any target language (e.g., programming or markup) that would serve to implement this UI.

The issue of UIDL was first raised when it was required to develop a UI like a module of an interactive application rather than merely a series of lines codes. Then, this issue was reinforced when the desire appears to model a UI by a set of specifications so as to communicate these specifications and to share them across stakeholders. Or to (semi-)automatically generate the code of the UI, as desired in model-based approaches for developing UIs. When a UI was required to be run simultaneously on different computing platforms, this need took shape in
some language that would be exchanged from one platform to another without any change to avoid any extraneous development effort.

For some years, the race progressively slept. The wide availability of markup languages and the capability of introducing any language based on XML meta-language, along with the multiplicity of today's available platforms (e.g., mobile phone, smart phone, pocket PC, handheld PC, tablet PC, laptop, traditional PC, and even wall screens) have awaken this race and have exacerbated it to a point where today more than a dozen of UIDLs exist that focus on some of the desired characteristics. To shed light on this proliferation of UIDLs, we conducted a systematic comparison based on an analysis grid. For this purpose, we gathered and read as much literature as possible on each UIDL. Then, depending on available tools, we systematically develop a multi-platform or multi-context UI for a simple dictionary so as to identify the capabilities of the UIDL and the ability of this UIDL to be supported by editing, critiquing, analysis tools, and, of course, tools for producing runnable UIs, both by compilation/execution and by interpretation.

The remainder of this paper is structured as follows: section 2 reports on some related work that have been considered as significant milestones in the race for THE UIDL. Section 3 respectively describes each UIDL that has been retained as significant in the comparison and identifies the main goals pursued by each UIDL. Section 4 similarly describes alternate UIDLs that have been considered for the comparison, but which are more restricted in scope or goals. Section 5 defines the comparison criteria to be used in the comparison analysis and provides the final analysis grids. Section 7 concludes the paper by keeping only salient features of high interest for each considered UIDL.

2 Related work

Historically, many approaches have emerged to solve the problem of the portability (without any extraneous development effort) of UIs on multiple platforms. Some approaches can be identified in the race for the ultimate UIDL [3]:

1. **Binary emulation**: An application can run on different platforms without having to be recompiled, thanks to a software emulator that executes the Intel instruction set, the operating and the windowing systems. **Wabi** (Windows Application Binary Interface), from SunSelect uses this approach.

2. **Virtual toolkits**: Virtual toolkits have been introduced to reduce the effort of development: the developer writes a unique code using a virtual Application Programming Interface (API) that will be executed on all the platforms for which the API exists. In other words, this approach provides a software layer between the application and the environment that makes the translation from one API to another. Two kinds of virtual toolkits exist:
   - **by actualisation** (layered toolkits): the toolkit binds the virtual Abstract Interaction Object (AIO) [23] to the real CIO of the platform by actualizing them. For instance, X Virtual Terminal (Xvt) [24] gives C,
C++ interface for the presentation in OSF/Motif, Open Look, Macintosh, Ms-Windows et IBM OS/2. This advantage lies in the large range of virtual primitives, but its usage is limited by the presence of an massive run-time library. Indeed, the toolkit supports only those features already supported by both the source and the target platforms.

- by re-implementation (emulation toolkits): the toolkit re-implements each virtual AIO for each platform. For instance, Galaxy [9] offers a library of ClOs having the same layout on each platform. The advantage lies in the native look and feel but each virtual primitive needs to be re-implemented in terms of real primitives.

Although these tools certainly contain some abstractions that are expressed in a platform-neutral format, it does not accommodate with many platform constraints.

3. Ported APIs: The tools based on this approach support native APIs (usually Windows) on other environments. It concentrates only on the source and the destination platforms of the application and so, it supports a high percentage of the source functionality on the destination platform. Windows Interface Source Environment (WISE) from Microsoft is an example of such a tool.

4. Tools generating adaptive UIs: Tools that generate a user interface which can be adapted at runtime depending on the context of use. One example is the BOSS-system [20] which is a component of the FUSE-architecture. Indeed, the user interface generated by BOSS is very flexible, e.g. the layout style of the UI can changed at runtime. BOSS maintains a hierarchical internal representation of the UI, that can be modified at any time by re-structuring rules, and consequently reflected by a UI refresh.

5. Multi-context tools at the logical level: Those tools generate at design time a concrete UI for a specific context, from an abstract description of the UI. The abstract description is written in a specific language that differs from one tool to another. Among those tools is Liquid UI [2]. Most languages of the two next sections belong to this approach, but only XML-compliant languages will be considered here.

3 Significant Contributions

In this section, the main contributions of XML-compliant languages for the definition of UIs are analyzed, based on the available information.

3.1 UIML

The User Interface Markup Language [2] is a meta-language that allows designers to describe the user interface (UI) in generic terms, and to use a style description to map the UI to various operating systems, languages and devices. UIML was created by Virginia Tech's Center for Human Computer Interaction, Harmonia

A UIML document contains three different parts: a UI description, a peers section that defines mappings from the UIML document to external entities (target platform’s rendering and application logic), and finally a template section that allows the reuse of already written elements. In UIML, a UI is described as a set of interface elements with which the end-user interacts. For each part, a presentation style is given (e.g. position, font style, color), along with its content (text, images etc.) and possible user input events and resulting actions.

The interface description is then rendered according to the specification of the presentation component, and communicates with the application logic via the logic definitions. The renderer either interprets UIML on the client device (similar to the way a web browser renders an HTML file) or compiles it to another language (like WML, HTML). One big shortcoming of UIML is that, as it just offers a single language to define the different types of user interfaces, it does not allow the creation of user interfaces for the different languages or for different devices from a single description: there is still a need to design separate UIs for each device.

UIML and the related products are still under development. UIML version 3.0 was released last year, and conferences are organized each year.

3.2 AUIML

In 1998, IBM undertook an Advanced Technology project to develop a Device Independent Markup Language in XML. This project (previously called DRUID) ended up with a XML vocabulary called Abstract User Interface Markup Language (AUIML) [13].

AUIML allows defining the intent (or purpose) of an interaction with a user instead of focusing on the appearance. This means that the designers have to concentrate only on the semantics of the interactions. Indeed, AUIML is intended to be independent of any client platform, any implementation language, and any UI implementation technology [5]. A single intent should run on many devices. A UI is described in terms of manipulated elements (a data model that structures the information required to support a particular interaction), of interaction elements (a presentation model that specifies the look of the UI - choice, group, table, tree) and of actions which allow to describe a micro-dialogue to manage events between the interface and the data.

Besides the specification of the appearance of the UI, the presentation model allows flexibility in the degree of specificity of what is expected of the renderer: the designer can either decide to precisely control what is to be displayed or only specify the interaction style, leaving the decision to the renderer. As AUIML is mostly developed for internal use at IBM, most information is confidential. So far, no editor tool is available and little is done in publicity.
3.3 XIML

The eXtensible Interface Markup Language (XIML), the follower of MIMIC [18], provides a way to describe a user interface without worrying about its implementation. It was initially developed by the research laboratories of RedWhale Software Corp. It is now supported by the XIML forum (http://www.ximl.org), an industrial organization dedicated to the research, the dissemination, the adoption, and the standardization of XIML. The goal of XIML is to describe the UI abstracts aspects (e.g., tasks, domain and user) and concrete aspects (i.e., presentation and dialogue) throughout the development life cycle. Mappings from abstract to concrete aspects are similarly supported [8].

XIML is a hierarchically organised set of interface elements that are distributed into one or more interface components [17]. Theoretically, the language does not limit the number and types of components that can be defined and there is also no limit on the number and types of elements within each component. In a more practical sense, however, XIML predefines five basic interface components, namely: (1) the task component that captures the business process and/or user tasks that the interface supports; (2) the domain component which is a set of all the objects and classes used; (3) the user component that captures the characteristics of the (group of) users that can use the application; (4) the dialog component that determines the UI interaction, and (5) the presentation component[17].

Besides the interface components, a XIML description is composed of attributes and relations. An attribute is a feature or a property that has a value and belongs to a component. A predefined set of attributes already exists. A relation links one or several components together, within a same model component or across several ones.

The definition of the language is on the way to be finished. A tool is proposed to manage the different conception levels and the generation of user interfaces. Although a XIML specification is intended to lead to both an interpretation at runtime and a code generation at design time, no information is given about a tool that may be used at runtime.

Furthermore, a tool converts any MOBI-D [19] model specification into an XIML specification and another one reverse engineers HTML pages into XIML (Vaquita) [7].

3.4 Seescoa XML

Seescoa (Software Engineering for Embedded Systems using a Component Oriented Approach ) is a project that started in October 1999 and has to be finished in September 2003, involving a research consortium of four Belgian university partners. The main objective of Seescoa project is to adapt the software engineering technologies to the needs of embedded software [12].

The Seescoa project proposes an architecture for runtime serialization of Java user interfaces into a XML description. This XML description provides an abstraction of the user interface, which is described as a hierarchy of Abstract
Interaction Objects (AIO) [23]. Once a user interface has been serialized, and a
XML description produced, the description has to move to another device, where
it can be "deserialised" into a user interface for the target device. This deserial-
isation involves mapping the platform independent AIO onto platform specific
CIO. Indeed, while parsing the XML document that contains an abstraction of
the user interface, the renderer of the target platform is free to choose other
ways to present the same functionality in the user interface. For every system a
XSLT is defined which maps the AIO of the abstract user interface description
to CIO on the bases of the constraints of each platforms[11].

The XML description of the UI is an interface components (AIO) decomposi-
tion. It describes the "look and feel" of the UI. Besides the presentation tags (up
to now, six different interactors available), the action tag specifies the action to
be fired if the interactor is manipulated. Seescoa XML is still under development
and there is no stable version of the language up to now. A shortcoming of this
language is that it has only a conversation mechanism for Java User Interface.

3.5 Teresa XML

Teresa XML is the XML-compliant language that was developed inside the
Teresa project, which is intended to be a transformation-based environment de-
signed and developed at the HCI Group of ISTI-CNR (http://giov.cnrr.cnr.it).
It provides an environment that support the design and generate a concrete user
interface for a specific type of platform [10]. The Teresa project take place inside
an European project (Cameleon IST).

The Teresa XML language is composed of two parts: (i) a XML-description
of the CTT notation [16] which was the first XML language for task models; (ii)
a language for describing user interfaces. This last part will be more deeply inves-
tigated. Teresa XML for describing UIs specifies how the various AIO composing
the UI are organized, along with the specification of the UI dialog.

Indeed, a UI is a set of one or more presentation element(s). Each presentation
element is characterized by a structure, that describes the static organization of
the UI (the AIOs[23]) and 0 or more connections, thus giving information about
the relationships among the various presentations elements of the user interface
(it identifies the presentation element whose activation triggers the transition to
another presentation element). Each structure element can be either an elementary AIO or a composition of them. Each AIO can be either an interaction AIO
or an application AIO depending on whether or not an interaction between the
user and the application is involved [14]. Teresa XML is used in a tool (TERESA)
that support the generation of task models, abstract UIss, and running UIss.

3.6 WSXL

The Web Services Experience Language (WSXL), released by IBM, is a Web
services centric component model for interactive Web applications. It is intended
for applications providing a user experience across the Internet [4]. The two goals
of WSXL are firstly to be able to build web applications to a wide variety of
channels and secondly to create web applications from other ones. WSX is built on widely accepted established and emerging open standards, and is designed to be independent of execution platform, browser, and presentation markup languages.

WSX uses base components to allow easy migration and adaptation of web applications. An Adaptation Description may be associated with a WSX base component. It describes how the markup generated by the component may be adapted to new channels. WSX enables applications to be built out of separate presentation, data, and control components; this helps developers to separate design issues and facilitates the reassembly of multiple alternative versions of the components in order to meet the requirements of separate channels, users, and tasks as outlined in the introductory requirements section above.

The WSX presentation component implements portTypes used to describe and maintain DOM-accessible instances of presentation in WSX applications. The namespaces for elements used in presentation components are not fixed by WSX, though commonly useful ”widget” sets may be available such as those defined in the XFORMS UI draft. WSX presentation components may generate output markup in any target XML language and should indicate which languages may be requested. WSX is currently not yet developed for mobile user interfaces. WSX is just designed to be the next piece of the set of web services.

4 Other Contributions

4.1 XUL

The Extensible User Interface Language (XUL) is a Mozilla’s XML-based language for describing window layout. The goal of XUL is to build cross platform applications, making applications easily portable to all of the operating systems on which Mozilla runs [1].

XUL provides a clear separation among the client application definition and programmatic logic, presentation ("skins" consisting of CSS and images), and language-specific text labels. As a result, the "look and feel" of XUL applications can be altered independently of the application definition and logic.

A UI is described as a set of structured interface elements (windows, menubar, scrollbar, button ...), along with a predefined list of attributes. Scripts are added in order to allow interaction with the user. Furthermore, to build cross platform web applications, some bindings can be made between XUL and other technologies introduced by Mozilla: (i) the eXtensible Binding Language (XBL) which is a markup language that defines new elements (methods, content, properties) for XUL widgets; (ii) Overlays that are XUL files used to describe extra content for the UI; (iii) XPCOM/ XPConnect that permits the integration of new libraries and (iii) XPIInstall that provides a way to package XUL application. XUL has its focus on window-based graphical user interfaces. This focus is also a limit. XUL is not applicable to interfaces of small mobile devices. Furthermore, there are no abstractions of interaction functionality available.
4.2 XISL

The Extensible Interaction Sheets Language (XISL) is a multi-modal interaction description language. It is designed for describing interaction using multi-modal inputs and outputs [6].

An interaction is described in terms of users operations (e.g. click, speech input) for a XML element and actions (e.g. screen update, speech output) based on the operations. Only interactions are described in a XISL document. As XISL is a multi-modal description language, it is designed to control and support parallel and sequential inputs/outputs as well as alternative input. The XISL execution system consists of three modules: a front-end module (a UI that has audio capabilities, e.g. a microphone or a speaker), a dialog manager module (it interprets XISL documents, manages dialog flows, and controls inputs and outputs), and a document server module (a general web server).

The main advantage of XISL is that it remodels VoiceXML to meet multi-modal interaction requirements.

4.3 AAIML

The Alternate User Interface Access standard (AAIML) is being developed by the V2 technical committee of the National Committee for Information Technology Standards (NCTIS).

To overcome the problem of accessibility to UIs for disable persons, the concept of "Universal Remote Console" (URC) has been introduced. It allows people with disabilities to remotely control a variety of electronic devices (target device/service), such as copy machines or elevators, from their personal remote control device [25]. Because all those electronic devices are manufactured by different companies, a standard must be found, that allows the personal remote control device (typically a mobile device) to control them.

When a target device or service is accessed, it transmits an abstract user interface to the remote console which, in turn, provides the particular input and output mechanisms that are appropriate for the user. V2 is currently working on the definition of a XML-based language to convey an abstract UI description from the target device or service to the URC. This language would be structured as a set of abstract interactors for input and output operations. On the URC, this abstract description would be mapped to a concrete description, available on the platform.

4.4 TADEUS-XML

TADEUS-XML was developed for the purpose of the model-based approach of the same name [15]. In a TADEUS-XML description, a UI is made up of two parts: a model component (abstract interaction model), that describes the feature of the UI on a high level of abstraction, and a presentation component.

The XML-based interaction model is a hierarchically structured set of User Interface Objects (UIO). Each UIO has different attributes specifying their behavior. Besides this model, a XML-Based Device Definition is available, that
transforms the former model into a device dependent abstract model, which is still on an abstract level but integrates some constraints specific to the target platforms (mapping of the UIO to concrete UIO). Finally, a XSL-based model description is derived, based on the knowledge of the availability of UIOs for specification representation and a running interface is generated. TADEUS-XML is on development stage. The tool supporting the mapping and design process is not yet developed.

5 General Comparison

In the two previous sections, a description of the different UIDLs for UI description was given. The purpose of this section is to make a general comparison of all the previously cited languages together in a general overview. Table 1 compares the general properties of the different UIDLs according the six following criteria:

- **Component models**: This criteria specifies the the aspects of the UI that can be taken into account in the description of the UIs. The task model is a description of the task to be accomplished by the user, the domain model is a description of the objects the user manipulates, accesses or visualizes through the UIs, the presentation model contains the static representation of the UI and the dialog model holds the conversational aspect of the UI.

- **Methodology**: Different approaches to specify and model UIs exist:
  * Specification of a UI description for each of the different contexts of use. As a starting point, a UI specification for the context of use considered as representative of most case could be taken, or the one valid for the context of use considered as the least constrained or finally the one valid for the context of use considered as the most comprehensive. From this starting UI specification, corrective or factoring out decorations [22] (e.g., to add, remove, or modify any UI description) are applied so that different UI specifications can be derived.
  * Specification of a generic (or abstract) UI description valid for all the different contexts of use. This generic UI description is then refined to meet the requirements for different contexts of use. This point gives the approaches that are supported by the different UIDLs.

- **Tools**: Some of the languages are supported by a tool that helps designer and renders the specification to a specific language and/or platform.

- **Supported languages**: Specify the programming languages to which the XML-based language can be translated.

- **Platforms**: Specify the computing platform on which the language can be rendered by execution or interpretation or both.

- **Target**: A context of use [21] is made up of three different models: the user model, the environment model (that represent different configuration of the physical conditions in which the application is used) and finally the platform model (represents any property of the platform). This criteria is aimed at indicating which model variation the markup language was designed for (i.e., mono/multi-platform, mono/multi-user or mono/multi-environment).
Table 2 compares UIDLs according to the five following criteria:

- **Abstraction level**: each UIDL may exhibit the capability to express a runnable UI (instance level), one or many models involved in the development of this UI (model level), how these models are built (meta-model level), and what are the fundamental concepts on which this operation is based (meta-meta-model level).

- **Amount of tags**: to reach the above level of abstraction, each UIDL manipulates a certain amount of tags, which is also highly depending on the coverage of the concepts.

- **Expressivity of the language**: this criteria denotes not only the capability of the UIDL to express concepts of the real world, but also the easiness and the usability of manipulating them with the UIDL. If, for a same expressible concept, a first UIDL needs 5 lines of specification and another one, only 2, the latter will be said to be more concise.

- **Openness of the language**: this criteria informs the designer whether a UIDL sees its concepts or tags fixed or user-modifiable. A UIDL can have a fixed amount of tags while keeping the capability to introduce new concepts that have not been specified in the canonical definition.

- **Coverage of concepts**: depending on the level of abstraction, each UIDL may introduce some specific vs. generic concepts (e.g., a given presentation model vs. any model, each custom-defined), their properties (e.g., to what extent can a concrete presentation be specified), and their relations.

6 Acknowledgements

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7 Conclusion

The previous investigation and comparison of the most significant UIDLs, if not all, reveal that there might be a plethora of UIDLs, from which it may seem hard to pick up one. We believe that this choice is more dictated by the goals to be pursued if one decides to adopt one of these UIDLs rather than only the different criteria that have been compared.

For instance, XUL is an official Mozilla initiative which received considerable attention from the international audience. However, XUL is mainly intended to support different viewing capabilities that are required to be supported by different computing platforms. Per se, it does address some requirements for supporting multiple platforms, but it is not intended to be a genuine and complete UIDL, as it is probably the less expressive one.
On the other end of the expressiveness continuum is located XIML, which demonstrates the highest expressivity possible since it is located at the metamodel level (the only one in the comparison). Therefore, XIML is particularly appropriate to specify UIs for multiple platforms, multiple contexts of use, even for custom situations that have not been thought before, as it is an open language. But its tool support is less advanced at the time of writing this paper than tools provided by UIML. UIML seems to be one of the most restrictive UIDLs, but the one which is the most supported by software. The real attractiveness of a UIDL heavily depends from this: it is meaningless to possess a refined specification of a UI that cannot be rendered or only partially.

Thus, we believe that XIML should be more appreciated for its interoperability qualities for exchanging UI descriptions between stakeholders (e.g., from one software to another), while UIML should be more accepted for true generation. AAUIML is dedicated to accessibility issues and should probably be used only in these circumstances. AUML is today more part of the internal processes of IBM than in a complete suite of tools, although IBM WebSphere became a truly operational software with wide scope in mind. Like UIML, AUML only supports some predefined features of the presentation and the dialog models. It does not support other models that are manipulated in context-sensitivity. Moreover, it is impossible to expand the language. IBM today focuses more on the development of Web services, through the WSUI and the WSXL languages.

In this study, we did not consider Xforms (see http://www.w3.org/MarkUp/Forms/), which is a W3C initiative to express forms-based UIs at a level that is more abstract than supposed-to-be physical HTML descriptions. In some way, this initiative addresses the question of multiple computing platforms. Although Xforms is promoted by the W3C, thus giving it the widest potential audience abroad, no true implementation already exists yet neither in existing Web browser nor in web appliances, but it is promised to appear like that. Xforms is basically aimed at expressing forms-based UIs with presentation and some dialog aspects, but does not necessarily support other UI modalities (e.g., vocal UIs).

Finally, we did not consider the legal issues of using one of these languages in a tool to be used or developed. XML is protected by copyright by the XIML Consortium. Any software that is XIML compliant can consequently be distributed only if the future user of this software already possesses a XIML license. Although this license can be freely obtained from the XIML consortium, this registration process may be interpreted as a burden and a potential reduction of the audience. The vast majority of the other UIDLs are totally free of use.
References

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<th>Models</th>
<th>Methodology</th>
<th>Tools</th>
<th>Supported languages</th>
<th>Supported Platforms</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>UIML</td>
<td>Presentation and dialog</td>
<td>Liquid UI: rendering engine, code generator and editor</td>
<td>Java, HTML, WML, VoiceXML, C++, PalmOS</td>
<td>Handheld and desktop PC; Smart, standard and mobile phone; vocal UI</td>
<td>Multi-platform</td>
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<tr>
<td>AUIML</td>
<td>Presentation and dialog.</td>
<td>Rendering engine</td>
<td>HTML, DHTML, Java Swing, PalmOS, WML</td>
<td>Handheld and desktop PC</td>
<td>Multi-platform (available interactors, displays)</td>
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<tr>
<td>XIML</td>
<td>Any model.</td>
<td>Rendering engine, code editor</td>
<td>HTML, WML, Java</td>
<td>Handheld and desktop PC; mobile phone; Java Terminal</td>
<td>In theory, multi-platform, -user and -environment; in practice, multi-platform</td>
</tr>
<tr>
<td>Seescoa XML</td>
<td>Presentation and dialog</td>
<td>Rendering engine</td>
<td>Java Swing and AWT, HTML</td>
<td>Handheld and desktop PC</td>
<td>Multi-platform</td>
</tr>
<tr>
<td>Teresa XML</td>
<td>Presentation and dialog: Task, domain and platform</td>
<td>TERESA</td>
<td>XHTML, Voice XML</td>
<td>Handheld and desktop PC, mobile phone</td>
<td>Multi-platform</td>
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<tr>
<td>WSXl</td>
<td>Presentation, dialog and data.</td>
<td>WSXl SDK</td>
<td>Markup languages: HTML, XUL, UIML, ...</td>
<td>Desktop PC</td>
<td>Mono-platform, -user, -environment</td>
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<td>Presentation and dialog.</td>
<td>Rendering engine, Gecko, XPCOM/ XPCConnect, XPIInstall, Mozilla</td>
<td>XUL</td>
<td>Desktop PC (Web application using Mozilla)</td>
<td>Multi-platform</td>
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<td>Dialog.</td>
<td>XISL Interpreter</td>
<td>XML-based languages</td>
<td>Mobile phone, Desktop PC, digital TV with multi-modal capabilities</td>
<td>Multi-platform</td>
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<tr>
<td>AAIML</td>
<td>Presentation and dialog.</td>
<td>Not yet defined</td>
<td>Not yet defined</td>
<td>Simulation on Handheld PC, Smart TV</td>
<td>Multi-user on multiple platforms</td>
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<td>TADEUS XML</td>
<td>Presentation (based on a user, a task and an object models)</td>
<td>TADEUS, XML converter to be developed</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Multi-platform</td>
</tr>
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Table 1. Comparison of UIDLs general properties.
<table>
<thead>
<tr>
<th>Language</th>
<th>Level</th>
<th>Tags</th>
<th>Expressivity</th>
<th>Openness</th>
<th>Concepts</th>
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</thead>
<tbody>
<tr>
<td>UIML</td>
<td>Model level</td>
<td>36 tags</td>
<td>Moderate</td>
<td>No</td>
<td>Interface, structure, style, content, behavior, part, peers, logic, presentation</td>
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<tr>
<td>AUIML</td>
<td>Model level</td>
<td>No clear information available, at least 55 tags</td>
<td>Moderate</td>
<td>No</td>
<td>Date-group, group, actions</td>
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<td>XIML</td>
<td>Meta-model level</td>
<td>33 tags</td>
<td>High: everything can be expressed, as the language is open</td>
<td>Yes</td>
<td>Component models, model element, relation_definition, feature_definition, attribute_definition</td>
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<tr>
<td>Seescoa XML</td>
<td>Model level</td>
<td>On the way to be completed, no stable DTD available</td>
<td>Low</td>
<td>No</td>
<td>Group, interactor, action</td>
</tr>
<tr>
<td>Teresa XML</td>
<td>Model level</td>
<td>32 tags for the UI description</td>
<td>High</td>
<td>No</td>
<td>Presentation, structure, AIO, interaction_AIO, application_AIO, AIO_composition and connection</td>
</tr>
<tr>
<td>WSXL</td>
<td>Instance and model level</td>
<td>No limit, XFORMS</td>
<td>Low: web-application, only graphical UI</td>
<td>No</td>
<td>Window, box, hbox, vbox</td>
</tr>
<tr>
<td>XUL</td>
<td>Instance and model level</td>
<td>At least 60 tags</td>
<td>Low: limited to windows-based graphical UI</td>
<td>No</td>
<td>Window, box, hbox, vbox</td>
</tr>
<tr>
<td>XISL</td>
<td>Model level</td>
<td>53 tags</td>
<td>High: multimodal UI on multiple platforms. Input Modalities supported: DTMF, speech, pointing, keyboard. Output Modalities: window, speech, video, audio, agent.</td>
<td>Yes</td>
<td>Dialog, exchange, operation, action, input, output</td>
</tr>
<tr>
<td>AAIML</td>
<td>Model level</td>
<td>Not yet defined</td>
<td>Moderate</td>
<td>Not specified</td>
<td>Not yet defined</td>
</tr>
<tr>
<td>TADEUS XML</td>
<td>Model level</td>
<td>Not specified</td>
<td>Low</td>
<td>No</td>
<td>Uio, input, output, trigger</td>
</tr>
</tbody>
</table>