A Theoretical Survey of User Interface Description Languages: Complementary Results

Josefina Guerrero-García
Juan Manuel González-Calleros
Facultad de ciencias de la Computación
Benemérita Universidad Autónoma de Puebla
Ciudad Universitaria, C.P. 72400
Puebla, México
{jguerrero, juan. gonzalez}@cs.buap.mx
Research and Development Unit, Estrategia360
Puebla, México

Jean Vanderdonckt
Université catholique de Louvain
Place des Doyens, 1 – B-1348
Louvain-la-Neuve, Belgium
jean.vanderdonckt@uclouvain.be
Jaime Muñoz-Arteaga
Sistemas de Información
Universidad Autónoma de Aguascalientes
Av. Universidad No. 940, Col. Bosques, 20100
Aguascalientes, Aguascalientes (México)
jmunozar@correo.uaa.mx

***Abstract*— This paper extends our previous work on a survey of user interface description language (UIDL). Although there is no significant progress in previous reviewed works there is significant work to be reported. We continue our in-depth analysis of the salient features that make these languages different from each other and identifying when and where they are appropriate for a specific purpose. The review is conducted based on a systematic analysis grid and some user interfaces implemented with these languages.**

***Keywords-component;* User interfaces, User Interface Description Language, Extensible Markup Language, User Interface extensible Markup Language.**

I. INTRODUCTION

The ITE2 UsiXML project aims at producing a UIDL that covers the µ7 concept defined as multi-device, multi-platform, multi-user, multi-linguality / culturality, multi-organisation, multi-context, multi-modality. In order to select and collect the most valuable aspects of existing UIDLs a deep analysis has been conducted during the last year. In the past [10] we gathered and analyzed as much literature as possible on each UIDL. Then, depending on available tools, we systematically developed 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 executable UIs, both by compilation/execution and by interpretation.

In this paper we extend this review by including recent developments in this field in our previous survey so as to keep it up to date. The remainder of this paper is structured as follows: Section 2 describes recent progress on UIDL. Section 3 defines the comparison criteria used in the comparison analysis and provides the final analysis grid. Section 4 presents the conclusion.

II. RECENT ADVANCES ON USER INTERFACE DESCRIPTION LANGUAGES

In this section we looked at our previous review [4][10] to identify if there is any advance on the UIDLs. Those languages that did not experience any progress that we are aware of are: the eXtensible Interaction Scenario Language (XISL) [13]; The eXtensible mark-up language for MultiModal interaction with Virtual Reality worlds (XMMVR) [19]; The Device Independent Authoring Language (DIAL) [31]; The delivery context [32]; The Extensible MultiModal Annotation Markup Language (EMMA) [34]; InkML [30]; VoiceXML [28]; XForms [33]; Dialog and Interface Specification Language (DISL) [24]; the Generalized Interface Markup Language (GIML) [15]; Interface Specification Meta-Language (ISML) [4]; Renderer-Independent Markup Language (RIML) [6]; Software Engineering for Embedded Systems using a Component-Oriented Approach (SeescoaXML) [17]; the Simple Unified Natural Markup Language (SunML) [22]; User Interface Markup Language (UIML) [1]; The eXtensible Interface Markup Language (XIML) [7] [8]; Web Service eXperience Language (WSXL) [2] [12]; The eXtensible user-Interface Markup Language (XICL) [9]. Yet they are still of the interest for our review as the knowledge expressed there it is useful for the future of UIDLs specification.

TeresaXML [20] is a UIDL for producing multiple final UIs for multiple computing platforms at design time. The language evolved in Time and turned into *MariaXML* [20]. This language support dynamic behaviors, events, rich internet applications, multi-target user interfaces, in particular those based on web services. In this way, it is possible to have a UI specified in MariaXML attached to a web service. MariaXML relies on the multi-layer levels of the Cameleon Reference Framework [4]. Thus it describes concepts like: Data objects manipulated by interactors, Events for abstract and concrete UI, Dialogue Model with

conditions and CTT operators for event handlers, scripts like Ajax; and dynamic set of user interface elements. All these models are supported by the software Mariae (Maria Environment) using task modeling (using ConcurTaskTrees notation) and UI modeling (MARIA language).

UserML [12] is a UIDL to model users. This approach models are semantically using an OWL ontology, called GUMO, and it is syntactically described using the UserML language. The main concept is the *situational statement* representing: user model entries, context information or low-level sensor data [12]. Figure 1 shows the metamodel including the five elements that compose a *situational statement.*

The *Mainpart* is an extension of the Resource Definition Framework (RDF) to represent information about the user using the interactive system, including aspects such as *range* of values and *auxiliary* to point to other ontologies. *The Privacy* models keeps information about the permissions to share the statement with tusers. The *Explanation* model helps to clarify conflicts or problems that the user might confront; it defines the source of the problem, the creator, collect the evidence, the degree of confidence, and the method used to identify the problem. The *Administration* model describes the role relation of the statement with the organization. The *Situation* model represents temporal (start, end, durability) and spatial (location and position) aspects of the user action. Each user model is used as information to model context-aware systems in ubiquitous environments targeting mobile, speech, virtual and graphical UIs.

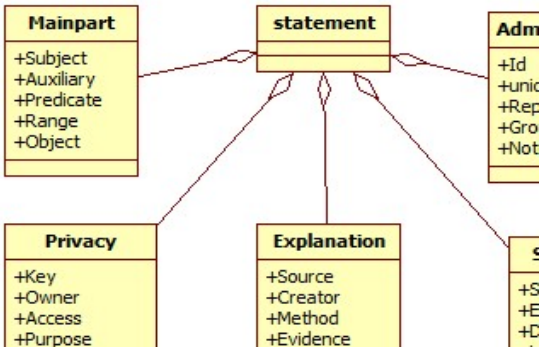

Figure 1 User Meta-Model in UserML

XooML [28] is language that describes aspects for supporting the development of software tools to collaborate and share documents. There is a XML Schema that is used by three different tools: Plantz (providing information to handle documents and other forms of information exchange), QuickCapture (capturing elements that can be related to information exchange), FreeMindX (mind-mapping). The XooML structure is minimal as it is composed of fragments that served as indivisible grouping of information, establishing a context for the comprehension of an selection amount its constituent associations. Although XooML is not a genuine UIDL it comprises aspects related to UIs that are of relevance when considering the definition of software tools supporting UIDL.

USer Interface eXtensible Markup Language (UsiXML) [27] is structured according to different levels of abstraction defined by the Cameleon reference framework [3]. The framework represents a reference for classifying UIs supporting a target platform and a context of use, and enables to structure the development life cycle into four levels of abstraction: task and concepts, abstract UI (AUI), concrete UI (CUI) and final UI (FUI). Thus, the Task and Concepts level is computational-independent, the AUI level is modality-independent (In the cockpit it can be several physical, Vocal, GUI, Tactile) and the CUI level is toolkit-independent. UsiXML relies on a transformational approach that progressively moves among levels to the FUI. The transformational methodology of UsiXML allows the modification of the development sub-steps, thus ensuring various alternatives for the existing sub-steps to be explored and/or expanded with new sub-steps. UsiXML has a unique underlying abstract formalism represented under the form of a graph-based syntax.

III. USER INTERFACE DESCRIPTION LANGUAGES COMPARISON

We kept the same protocol for the comparison as we did before, in accordance to a previous study conducted in [25], this work slightly updates and extends our previous survey [10] considering the latest results, (last rows with bold format in Table 1) along the following dimensions:

- *Specificity* indicates if the UIDL could be used in one or multi platforms or devices.
- *Publicly available*: depending on the availability of the language deep analysis can be done. This category was used to discard many languages that lack on documentation or that is confidential. The possible values are: 0 = no information available, 1 = not available, 2 = poorly available, 3 = moderately available, 4 = completely available and 5 = completely available with meta-models.
- *Type criterion* informs whether the UIDL is a research or industry work.
- *Weight of the organization* behind denotes the organization to which the UIDL belongs. Efforts from Universities are significant, particularly, those where more than one university has adopted the use of the UIDL. Those UIDL coming from the industry might have more impact and this is reflected in its level of usage.
- *Level of usage*: depending on the usage of the language we create the following categories: 0 = unknown, 1 = one person, 2 = two or more persons, 3 = one organization, 4 = two or more organizations and 5 = wide usage.

Due to its number of concepts, UsiXML has been

intentionally removed from Table 2 and it is used to illustrate the comparison protocol (Figure 2). On the left a series of developments steps compliant with the Cameleon reference framework [3], to the right the supported concepts and the transformations applied to UsiXML. Details on this comparison can be found in the model based incubator group [35] where this work has been reported. Tabla2 compares the properties of the different UIDLs according the eight criteria:

- *Component models*: this criterion gives the aspects of the UI that can be specified 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: 1) 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, 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 is specified. From this starting UI specification, corrective or factoring out decorations [25], (e.g., to add, remove, or modify any UI description) are applied so that UI specifications can be derived for the different contexts of use. 2) 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 of the different contexts of use.
- *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.
- *Supported platforms*: specify the computing platform on which the language can be rendered by execution, interpretation or both.
- *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.

IV. CONCLUSION

Eight years from now, a first review of UIDLs was conducted [23]. That work were reviewed and updated [10] accordingly to the progress of those UIDLs, while some works have continue, there were works with not reported update since then. In addition, to that review, new UIDLs that have been reported and were included in this update. The goal of this work remains to be a guide for authors to decide what UIDL to use for their projects. There is currently such a large number of UIDLs available that choosing among them can be time consuming and difficult to do, this comparison can assist UI designers in choosing a language suited to their purposes.

ACKNOWLEDGMENT

We gratefully acknowledge the support of the Repatriacion CONACYT program (www.conacyt.mx) supported by the Mexican government, the ITEA2 Call 3 UsiXML project under reference 20080026, and the PROMEP net Project under Contract UAA-CA-48.

REFERENCES

[1] Abrams, M., Phanouriou, C., Batongbacal, A.L., Williams, S. & Shuster, J. (1999), UIML: An Appliance-Independent XML User Interface Language. In A. Mendelzon, editor, *Proceedings of 8th International World-Wide Web Conference WWW'8* (Toronto, May 11-14, 1999), Amsterdam, 1999. Elsevier Science Publishers.

[2] Arsanjani, A., Chamberlain, D. and et al. (2002), (WSXL) web service experience language version, 2002. Retrieved from: http://www-106.ibm.com/developerworks/library/ws-wsxl2/.

[3] Calvary, G., Coutaz, J., Thevenin, D., Limbourg, Q., Bouillon, L., Vanderdonckt, J.: A Unifying Reference Framework for Multi-Target User Interfaces. Interacting with Computers, Vol. 15, No. 3 (June 2003) 289–308.

[4] Cantera Fonseca, J.M. (Ed.), Model-based User Interface XG Final Report, W3C Incubator Group Report, W3C, 4 May 2010. Accessible at: http://www.w3.org/2005/Incubator/model-based-ui/XGR-mbui-20100504/

[5] Crowle, S., Hole, L., ISML: An Interface Specification Meta-Language. DSV-IS 2003, Funchal, Madeira Island, Portugal. June 11-13, 2003. Lecture Notes I Computer Science 2844 Springer 2003, ISBN 3-540-20159-9.

[6] Demler, G., Wasmund, M., Grassel, G., Spriestersbach, A. & Ziegert, T. (2003), Flexible pagination and layouting for device independent authoring, *WWW2003 Emerging Applications for Wireless and Mobile access Workshop*.

[7] Eisenstein J., Vanderdonckt J., Puerta A. (2000), Adapting to Mobile Contexts with User-Interface Modeling, *Proceedings of 3rd IEEE Workshop on Mobile Computing Systems and Applications WMCSA'2000* (Monterey, 7-8 December 2000), IEEE Press, Los Alamitos, 2000, pp. 83-92.

[8] Eisenstein J., Vanderdonckt J., Puerta A. (2001), Model-Based User-Interface Development Techniques for Mobile Computing, *Proceedings of 5th ACM Int. Conf. on Intelligent User Interfaces IUI'2001* (Santa Fe, 14-17 January 2001), Lester, J. (Ed.), ACM Press, New York, 2001, pp. 69-76.

[9] Gomes de Sousa, L. & Leite, J. C. (2003), XICL: a language for the user's interfaces development and its components. *Proceedings of the Latin American conference on Human-computer interaction (Rio de Janeiro, Brazil,* August 17 - 20, 2003), ACM Press pages, New York, pp. 191-200.

[10] Guerrero-García, J., González-Calleros, J.M., Vanderdonckt, J., and Muñoz-Arteaga, J. A Theoretical Survey of User Interface Description Languages: Prelimi-nary Results. In Proc. of LA-Web/¬CLIHC'2009 (Merida, November 9-11, 2009), IEEE Computer Society Press, Los Alamitos, 2009, pp. 36-43.

[11] Helms, J., Schaefer, R., Luyten, K., Vermeulen, J., Abrams, M., Coyette, A., Vanderdonckt, J., Human-Centered Engineering with the User Interface Markup Language, in Seffah, A., Vander-donckt, J., Desmarais, M. (eds.), "Human-Centered Software Engineering", Chapter 7, HCI Series, Springer, London, 2009, pp. 141-173.

[12] Heckmann, D. Ubiquitous User Modelling, Akademische Verlagsgesellschaft Aka GmbH, Berlin, ISBN 3-89838-297-4 and ISBN 1-58603-608-4, 2006.

[13] IBM (2002), WSXL specification, April 2002, retrieved on Janury 2nd 2009.

[14] Katsurada, K., Nakamura, Y., Yamada, H., Nitta, T. (2003), XISL :A Language for Describing Multimodal Interaction Scenarios, *Proceedings of the 5th International Conference on Multimodal Interfaces ICMI'03* (Vancouver, Canada.

[15] Kost, S. (2004), Dynamically generated multi-modal application interfaces. Ph.D. Thesis, *Technical University of Dresden and Leipzig University of Applied Sciences*, Germany.

[16] Lucent (2000), Sisl: Several Interfaces, Single Logic, Lucent Technologies, Available online: http://www.bell-labs.com/user/lalita/sisl-external.html

[17] Luyten, K., Abrams, M., Vanderdonckt, J. & Limbourg, Q. (2004) Developing User Interfaces with XML: Advances on User Interface Description Languages, *Sattelite workshop of Advanced Visual Interfaces 2004*, Gallipoli, Italy.

[18] Michotte, B., Vanderdonckt, J., GrafiXML, A Multi-Target User Interface Builder based on UsiXML, Proc. of 4th International Conference on Autonomic and Autonomous Systems ICAS'2008 (Gosier, 16-21 March 2008), IEEE Computer Society Press, Los Alamitos, 2008.

[19] Olmedo,H., Escudero,D., & Cardenoso,V (2008).: A Framework for the Development of Applications Allowing Multimodal Interaction with Virtual Reality Worlds. *Communications Proceedings 16th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision'2008 WSCG'2008* (Plzen - Bory, Czech Republic, February 4-7), University of West Bohemia Press, pp. 79-86.

[20] Paternò F., Santoro C., Spano L.D., MARIA: A Universal Language for Service-Oriented Applications in Ubiquitous Environments, ACM Transactions on Computer-Human Interaction, Vol.16, N.4, November 2009, pp.19:1-19:30.

[21] Paternò, F. & Santoro, C. (2003), A Unified Method for Designing Interactive Systems Adaptable to Mobile and Stationary Platforms, *Interacting with Computers*, Elsevier, 15, pp. 349-366.

[22] Picard, E., Fierstone, J., Pinna-Dery, A-M. & M. Riveill (2003). Atelier de composition d'ihm et évaluation du modèle de composants. *Livrable l3, RNTL ASPECT*, Laboratoire I3S, mai.

[23] Puerta A.R. (1996), The Mecano Project: Comprehensive and Integrated Support for Model-Based Interface Development, *Proceedings of 2nd Int. Workshop on Computer-Aided Design of User Interfaces CADUI'96* (Namur, 5-7 June 1996), Presses Universitaires de Namur, 1996, pp. 19-35.

[24] Schaefer, R., Steffen, B., Wolfgang, M., Task Models and Diagrams for User Interface Design, *Proceedings of 5th International Workshop, TAMODIA'2006* (Hasselt, Belgium, October 2006), Lecture Notes in Computer Science, Vol. 4385, Springer Verlag Berlin, 2006, pp. 39-53.

[25] Souchon, N., Vanderdonckt, J., A Review of XML-Compliant User Interface Description Languages, Proc. of 10th Int. Conf. on Design, Specification, and Verification of Interactive Systems DSV-IS'2003 (Madeira, 4-6 June 2003), Jorge, J., Nunes, N.J., Falcao e Cunha, J. (Eds.), Lecture Notes in Computer Science, Vol. 2844, Springer-Verlag, Berlin, 2003, pp. 377-391.

[26] Thevenin, D. (2001), Adaptation En Interaction Homme-Machine : Le Cas de la Plascticité. PhD thesis, *Université Joseph Fourier*, 21 December 2001.

[27] Vanderdonckt, J. A MDA-Compliant Environment for De-veloping User Interfaces of Information Systems. In Proc. of 17th Conf. on Advanced Information Systems Engineering CAiSE'05 (Porto, 13-17 June 2005), LNCS, Vol. 3520, Springer-Verlag, Berlin, 2005, pp. 16-31.

[28] Jones, W., XooML: XML in support of many tools working on a single organization of personal information. Proceedings of the iConference 2011 (Seattle , February 8-11, 2011), ACM Press pages, New York, pp. 478-488.

[29] W3C (2004), Voice Extensible Markup Language (VoiceXML) Version 2.0, W3C recommendation, 16 March 2004, *W3C Consortium*. Available online: http://www.w3.org/TR/voicexml20.

[30] W3C (2006), W3C InkML: Digital Ink Markup Language, W3C recommendation, 24 October 2006, *W3C consortium*. Available online: http://www.w3.org/2002/mmi/ink

[31] W3C (2007a), Dial: Device Independent Authoring Language, W3C Working Draft, *W3C consortium*. Available online: http://www.w3.org/TR/dial/

[32] W3C (2007b), Content Selection Primer 1.0, W3C Working Draft, *W3C consortium*. Available online: http://www.w3.org/TR/cselection-primer/

[33] W3C (2007c), XForms 1.0 (Third Edition), W3C recommendation, 29 October 2007, *W3C consortium*. Available online: http://www.w3.org/TR/2007/REC-xforms-20071029/

[34] W3C (2008), EMMA: Extensible MultiModal Annotation markup language, W3C Proposed Recommendation, *W3C consortium*. Available online: http://www.w3.org/TR/emma.

[35] W3C Model-based User Interfaces Incubator Group http://www.w3.org/2005/Incubator/model-based-ui/wiki/Task_Meta_ModelsXML User Interface Language (XUL) 1.0.

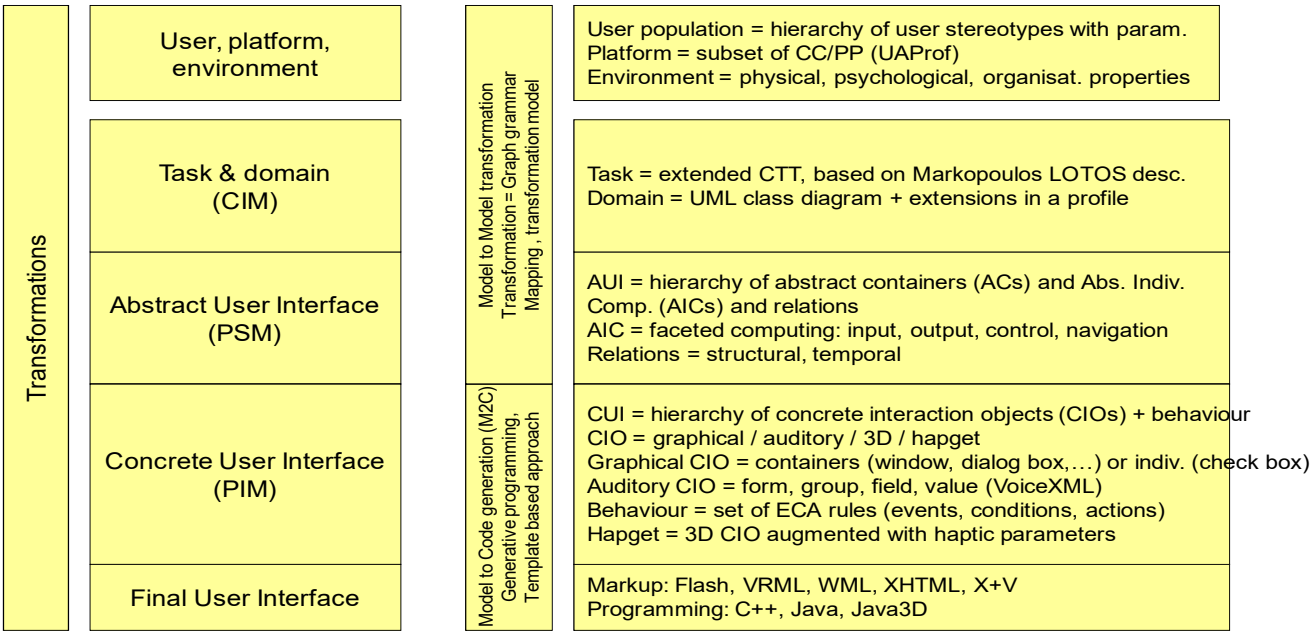

Figure 2 Comparison protocol exemplified with UsiXML.

Table 1 General features of UIDLs

UIL	Specificity	Publicly available	**Type**	Weight of the organization behind	Level of usage
DISL	Multimodal UIs for mobile devices	2	Research	Paderborn University	3
GIML	Multimodal	3	Research	Technical University of Dresden and Leipzig University of Applied Sciences	2
ISML	GUI, multiplatform, multidevice	2	Research	Bournemouth University	1
RIML	Mobile devices	0	Industry	Industry: SAP Research, IBM Germany, and Nokia Research Center along with CURE, UbiCall, and Fuijitsu Invia	3
SeescoaXML	Multiplatform, multidevice, dynamic generation UI	2	Research	Expertise Centre for Digital Media Limburgs Universitair Centrum	3
SunML	Multiplatform	4	Research	Rainbow team, Nice University	3
UIML	Multiplatform	4	Industry	Harmonia, Virginia Tech Corporate Research (OASIS)	3
WSXL	multiplatform, multidevice	4	Industry	IBM	3
XICL	Multiplatform	3	Research	Federal University of Rio Grande do Norte	3
XIML	multiplatform, multidevice	4	Research	Redwhale Software	3
XWT	**multiplatform, multidevice**	**5**	**Industry**	**Google Inc.**	**5**
UserML	**multiplatform, multidevice, multimodal**	**4**	**Research**	**University of Saarlandes**	**3**
TeresaXML	**Multiplatform, multidevice,**	**4**	**Research**	**HCI Group of ISTI-C.N.R.**	**3**
XooMl	**None**	**4**	**Research**	**University of Washington**	**2**
UsiXML	**Multiplatform**	**5**	**Research**	**UCL**	**4**

Table 2 Properties Comparison of UIDLs

UIL	Models	Methodology	Tools	Supported languages	Supported platforms	Concepts
DISL	Presentation, dialog and control	Specification of a generic, platform-independent multimodal UI	Rendering engine	VoiceXML, Java MIDP, Java Swing, Visual C++	Mobile and limited devices	Head element, interface classes (structure, style, behavior), state, generic widgets
GIML	Presentation, dialog, and domain	Specification of a generic interface description.	GITK (Generalized Interface Toolkit)	C++, Java, Perl	Not specified	Interface, dialog, widget, objects
ISML	Presentation, task, dialog, domain	Specification of a generic UI description	Under construction	Java, Microsoft foundation class, Java swing classes	Desktop PC, 3D screen	Mappings and constrains, action events, meta-objects, display parts, controller parts, interaction definition
RIML	There is no information	Specification of a generic UI description	There is no information	XHTML, XFORMS, XEvents, WML	Smart phone, pda, Mobile, Desktop Pc	Dialog, Adaptation, layout, element
SeescoaXML	Task, Presentation, dialog	Specification of a generic UI description	CCOM (BetaVersion 1.0 2002) PacoSuite MSC Editor	Java AWT, Swing, HTML, java.microedition, applet, VoxML, WML Juggler	Mobile, desktop PC, Palm III	Component, port, connector, contract, participant, blueprint, instance, scenario, pltform, user, device
SunML	Presentation, dialog, domain	Specification of a generic UI description	SunML Compiler	Java Swing, voiceXML, HTML, UIML,	Desktop Pc, pda	Element, list, link, dialog, interface, generic events, synchronization
UIML	Presentation, dialog, domain	Specification of a generic UI description	UIML.net, VoiceXML renderer, WML renderer, VB2UMIL	HTML, Java, C++, VoiceXML, QT, CORBA, and WML	desktop PC, a handheld device, tv, mobile	interconnection of the user interface to business logic, services
WSXL	Presentation,dialog, domain	Specification of a generic UI description	Not specified	HTML	PC, Mobile phone,	CUI=XForms, WSDL, Mapping=XLang Workflow=WSFL, Logic=XML event
XICL	Presentation,dialog,	Specification of a generic UI description	XICL STUDIO	HTML, ECMAScript, CSS e DOM.	desktop PC	Component, structure, script, events, properties, interface
XIML	Presentation, task, dialog, domain	Specification of a generic UI description	XIML Schema	HTML, java swing, WLM	Mobile, desktop PC, PDA	Mappings, models, sub models, elements, attributes and relations between the elements
XWT	**Presentation, context**	**Specification of a generic UI description**	**Google Web Toolkit**	**Java, JQuery**	**PC, Web Mobile**	**Context= language; location CUI = presentation (Java), layout, Mapping = Widget morphing; data binding Dialog = Java + JQuery**
UserML	**Context**	**Specification of a generic UI description**	**UbisWorld, UbisOntology Editor**	**Java + XForms**	**PC, Mobile, PDA**	**Context = User (MainPart, Privacy, Explanation, Situation, Administration), Location; CUI = Mobile, PC, PDA, XForms Mapping (Match, filter, control)**
TeresaXML	**Presentation, task, dialog, domain, context**	**Specification of a generic UI description**	**CTTE Tool for task Models Teresa, Mariae**	**Markup: Digital TV, VoiceXML, XHTML/SVG, X+V Programming: C#**	**DigitalTV, Mobile, touch-based smartphone vocal, multimodal X+V**	**AUI = Interface, Interactor, Grouping, Connection, dialog expression, composition. AUI Interactors = selection, edit, control, output Mappings, models, platform,**
XooMl	**Domain**	**Specification of generic mind-mapping document exchange**	**Plantz, QuickCapture, FreeMindX**	**None**	**None**	**Domain = Documents, fragments Mapping= association Attributes**