# ENABLING AN END-USER DRIVEN APPROACH FOR MANAGING EVOLVING USER INTERFACES IN BUSINESS WEB APPLICATIONS
*A Web Application Architecture using Smart Business Object*

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Abstract: As web applications become the centre-stage of today's businesses, they require a more manageable and holistic approach to handle the rapidity and diversity with which changes occur in their web user interfaces. Adopting the End User Development (EUD) paradigm, we advocate an end-user driven approach to maintain evolving user interfaces of business web applications. Such an approach, demands a complementary web application architecture to enable a flexible, managed, and fine-grained control over the web user interfaces. In this paper, we proposed a web application architecture that embraces a dedicated *UI Definition Layer*, enforced by a web *UI Model*, for describing *changes* in the user interfaces of business web applications. This empowers business users to use intuitive web-based tools to effortlessly manage and create web user interfaces. The proposed architecture is realised through the Smart Business Object (SBO) technology we previously developed. We have also created a toolkit based on our proposed architecture. A tailored version of the toolkit has been utilised in an enterprise level web-based workflow application.

## 1 INTRODUCTION

The ancient Greek philosopher Heraclitus wrote that "the only constant is change". Today, the challenge in developing business web applications is the shift from implementing functionality to managing complex changes. One of the elements that often get changed is the web user interfaces (UIs). Business web applications may consist of hundreds of screens. The intensiveness and degree with which change occurs in the user interfaces of business web applications demands a more flexible approach to handle its constant evolution.

In practise, it is difficult to precisely capture all the user interface requirements during the requirement analysis phrase of a project. One factor causing this is the uncertainty and lack of understanding business users have about what they need without being able to see or use the final software artefact. Another factor is the different ways in which the developed web application is used across different departments of an organisation. For instance, the management departments in universities often use the term *AOUs (Academic Organisation Units)* to refer to what most academic staffs refer to as *schools* and *colleges*. Consequently, we often overlooked the perspectives from potential user groups of a web application, and end up with a *user-unfriendly* application with low usability. Once the web application has been deployed, business users may see new opportunities or simply find certain obsolete information in the web user interfaces that, for example, does not comply with the latest government regulations. Thus, amendments to those web user interfaces become necessary again. The conventional approach is to call the project development team to implement the changes. However, it is common that before the changes are implemented or re-implemented, requirements have changed again.

To put an end to this never-ending cycle, requires a radical change to the conventions in handling the constant evolution of the user interfaces in business web applications. The End-User Development (EUD) paradigm advocates that software should not only be *easy to use*, but also *easy to develop* (Lieberman et al., 2006). Empowering end-users and allowing trained end-users to maintain or even enhance existing appli-

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cations is a cost-effective way to support web application evolution (Wulf and Jarke, 2004). From our experience in developing web applications for enterprises, there is a growing demand from business users to maintain the user interfaces of their web applications. Thus, we believe that embracing the End-User Development paradigm and empowering business end-users to manage web user interfaces is a practical and effective approach. From the organisation's perspective, this approach translates directly into cost reduction in IT maintenance while encouraging user retention and ownership of the web application.

The distinctive advantage of such an end-user driven approach is that it enables a *hybrid*, *parallel* mode of developing web applications. With the help of contemporary model-driven development tools, professional web developers can quickly generate (and release) the intended web application with basic functionality and reasonable user interfaces. With the appropriate tools, business end-users can then constantly customise the web user interfaces until they are satisfied, while professional developers can continue to develop and finalise the remaining components of the web application. This means that both professional developers and business end-users can work on the intended web application at the same time. Therefore, an end-user driven approach to manage evolving web user interfaces can also compress the timeline required for developing business web applications.

An end-user driven approach, however, requires intuitive tools for managing web user interfaces. Accordingly, a web application architecture that supports the realisation of such tools is desirable. Such tools should empower business end-users to apply changes to the web user interfaces dynamically without affecting the web application running, in order to eliminate the need for interventions from professional developers.

In end-user driven, WYSIWYG-type web tools, such as *Click* (Rode et al., 2005), web UI changes are made on the basis of a screen (page). However, taking each screen as a unit for managing change has its shortcomings. In business web applications, it is common to have web user interfaces, such as web forms, that span across multiple screens for presenting complex business objects with a large number of attributes. Thus, in order to empower business end-users to manage complex web user interfaces in business web applications, a more manageable and sensible way of partitioning web user interfaces is required.

It is also vital for business end-users to be able to customise every UI element (controls, widgets) of their user interfaces while preserving a consistent "look and feel" across the web application. This implies that the underlying web application architecture should support a fine-grained, yet controlled approach for managing web user interfaces.

Existing web modelling approaches, such as UWE (Koch and Kraus, 2002), WebML(Ceri et al., 2000) and OO-H (Gomez et al., 2001), focus mainly on the *creation* aspect of web user interfaces with via detailed navigation modelling and presentation modelling. However, the *evolution* aspect of web user interfaces is often neglected. These techniques require extensive navigation and presentation models to be defined upfront before web user interfaces can be generated. While using conceptual models to maintain and recreate (regenerate) web user interfaces is a plausible approach for professional developers to maintain web user interfaces, it is impractical for end-users. Business end-users do not have the skill-set to understand and directly use complex conceptual modelling techniques, such as UML, to manage web user interfaces. (Atterer, 2005) found that concrete navigation modelling and presentation modelling can make the development process "work-intensive" and increases complexity even for professional developers. On the contrary, our proposal is *end-user driven* with a strong focus on the *evolution* aspect of web user interfaces. Our approach eliminates the need for extensive navigation and presentation modelling prior to the generation of web user interfaces. The underlying *UI Model* supporting our proposed architecture is concealed by intuitive form-based web tools, thus, making it completely transparent to business end-users.

Our proposed architecture is built on our previous work of the Smart Business Object (SBO) (Liang and Ginige, 2006). SBO is a framework for lightweight modelling and rich web presentation of business objects. It enables Agile Model Driven Development (AMDD) (Ambler, 2003) of business web applications. It allows business object to be modelled and generated using a lightweight, near-English syntax modelling language call SBOML (Smart Business Object Modelling Language) (Liang and Ginige, 2006). Most importantly, SBO is capable of auto-generating a rich collection of highly customisable web *UI Components*, such as web forms, tables, menus, and charts, for the modelled business objects. On the one hand, SBO is *smart* enough to automatically deduce and generate the best suitable web user interfaces for the modelling business objects with zero configurations, eliminating the need for extensible user interface modelling. On the other hand, SBO makes provision for fine-tuning the generated web user interfaces when necessary using high-level, compact data structures. Moreover, the web user interfaces generated by SBO are “self-contained”, allowing a complete web user interface to be partitioned in a sensible way for business end-users to manage. These characteristics make SBO a suitable candidate for the implementation of our proposed architecture and the realisation of an end-user driven approach to manage web user interfaces.

We will first introduce the overall architecture, the *UI Definition Layer*, as well as the required *UI Model*. We will then explain how the SBO facilitated our proposed architecture. Lastly, we will demonstrate the toolkit we have developed based on our proposed architecture, and its utilisation in an enterprise level web-based workflow application.

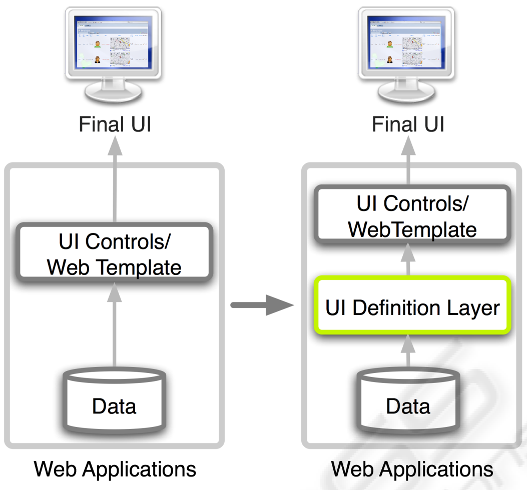


Figure 1: A Delicated UI Definition Layer.

## 2 THE PROPOSED WEB APPLICATION ARCHITECTURE

In most existing web applications, data are directly bound to disparate UI elements (controls, widgets), such as selection lists, buttons, and hypertext links, and rendered as web user interfaces using web templates or server-side/client-side scripts. While this is an efficient approach, it is also inflexible for changes, since every single change made to the web user interface requires updating the corresponding web templates or scripts directly. In order to achieve greater flexibility, we propose a web application architecture that utilises a dedicated *UI Definition Layer* for describing the *changes* in web user interfaces. Figure 1 compares existing web applications on the left with web applications using the desired *UI Definition Layer* on the right.

It is difficult for business end-user to manage disparate UI elements (controls, widgets) scattered across different screens (pages) of the web application. Therefore, we need to partition complex web user interfaces into discrete *UI Components*, such as web forms, tables, and charts, such that business end-user can easily relate them to their representations in the real world. Each *UI Component* is a logical composition of many UI elements. In this ways, web UI changes are made as per *UI Component*, as oppose to per screen.

*UI Components* must be “self-contained” and standardised. They have both rendering and event handling capabilities (to handle various user actions). The relationship between each *UI component* type and various UI elements is defined by a *UI Model*. The *UI Model* serves as the “gatekeeper” standardising the overall structure of each *UI Component*. Accordingly, the *UI Model* should be maintained by professional developers to make provision for the defining new *UI Components* or upgrading existing ones.

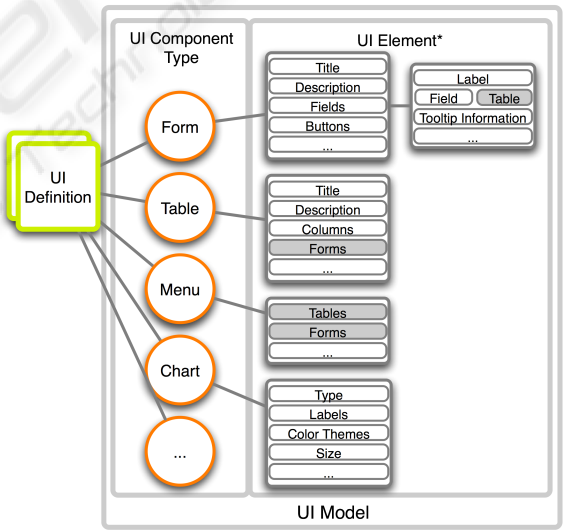


Figure 2: The UI Model (* Items shaded in grey are *UI Components*).

In order to achieve a fine-grained control over the generated web user interface, every UI elements of a *UI Component* must be customisable by end-users. Notably, *UI Components* may contain other *UI Components*. For example, a *web table* can delegate the action for updating individual records to a *web form* component. Figure 2 is an abstract view showing the structure of the *UI Model* through several commonly used *UI Components*.

In essence, the proposed *UI Definition Layer* is a set of *UI Definitions*. Each *UI Definition* is an *instance* of the *UI Model*. An example of a simple *UI Definition* implemented using XML would be:

```
<?xml version="1.0" encoding="UTF-8" ?>
<ui_def version = '0.01' type='form'>
 <form_title>Add New Employee</form_title>
 <form_description>
  Please fill in the necessary information
  about the employee
 </form_description>
 <fields>
  <field name = "address">
   <label>'Home Address'</label>
   <required>1</required>
   <comment>
    Please enter your home address here
    with Post code
   </comment>
  </field>
 </fields>
</ui_def>
```

*UI Definitions* are compact. They are designed for *customising* necessary UI elements rather than *defining* each UI elements that should exists in a web user interface. In other words, *UI Definitions* does not *define* a web user interface but only the *changes* required for that web user interface. This is a unique characteristic that differentiates our *UI Definitions*, as well as our overall approach in generating web user interfaces from existing declarative user interface definition languages such as UsiXML (Vanderdonckt, 2005) and UIML (UIML, 2007). In the previous *UI Definition* example, it does not mean that the generated web user interface (the actual web form) will consist only one field called *address*. What it does means is that while enforcing special requirements for the form's title, description, and the *address* field, display other UI elements (such as form fields if exists) using the default settings automatically. In reality, the definition of the modelled business object (e.g. an employee has first name, last name, address, phone number) plus the intrinsic characteristics of the intended *UI component* (e.g. forms have fields, pie charts are round) is sufficient to derive and render the actual web user interface with default behaviours. In this case, a *UI Definition* can be an empty placeholder reserved for future changes. We will explain this more with the introduction of the SBO's rendering APIs in Section 3.

It is also imperative for *UI Definitions* to be implemented using high-level, lightweight data structures, such that tools can be easily built on top in order to support business end-users in managing their web user interfaces.

Rendering a *UI Component*, i.e. generating the actual web user interface, is the binding of the *UI Definition* and the referenced business object (data object). Thus, the complete web user interface presented to the users is a series of rendered *UI Components* controlled by a master web template for layout. The overall process is illustrated in Figure 3.

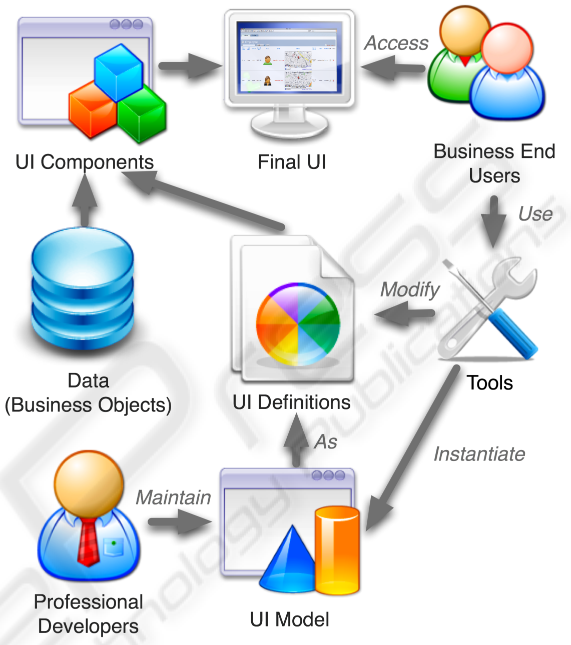
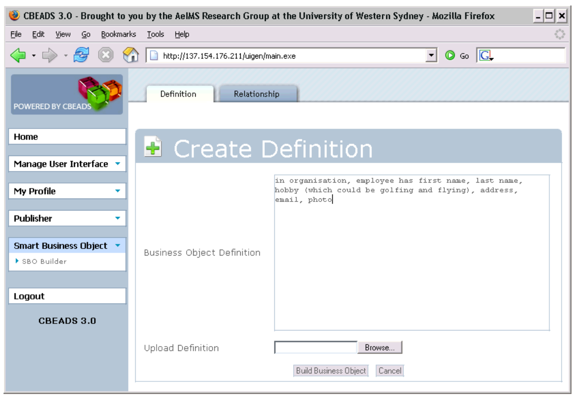


Figure 3: UI Composition Process.

## 3 THE ENABLING TECHNOLOGY


CBEADS 3.0 - Brought to you by the AeIMS Research Group at the University of Western Sydney - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://137.154.176.211/uigen/main.exe
Go
POWERED BY CBEADS
Definition
Relationship
Home
Manage User Interface
My Profile
Publisher
Smart Business Object
SBO Builder
Logout
CBEADS 3.0
Browse...
Build Business Object
Cancel

Create Definition

Business Object Definition: in organisation, employee has first name, last name, hobby (which could be golfing and flying), address, email, photo

Upload Definition

Figure 4: The SBO Builder.

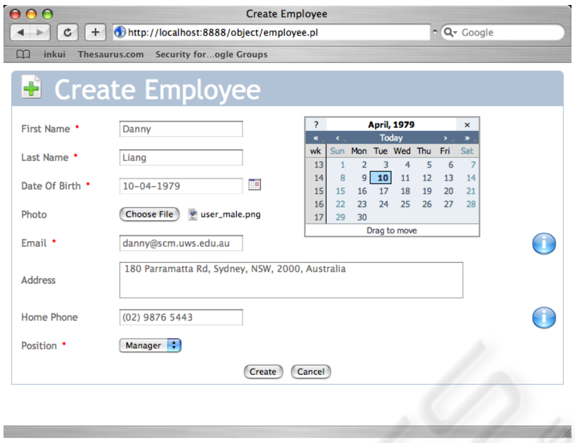
SBO is built on top of existing ORM (Object Relational Mapping) technology. SBO allows webenabled business objects to be modelled using a lightweight, near-English syntax modelling language called SBOML (Liang and Ginige, 2006). Modelling using SBOML is streamlined via the SBO Builder tool we have previously developed (Figure 4). Modelling business objects using SBOML implies the auto-generation of:

- The underlying databases (and table structures) for object persistence,
- The necessary ORM classes for manipulating the modelled business objects using Object Oriented Programming techniques, and
- A rich set of web user interfaces for presenting the modelled business objects to the web.

Writing code to render web user interfaces is a tedious and laborious task. Database schema does not provide the sufficient semantics required for presenting business objects onto the web. Thus, in order to derive the most suitable web user interfaces for the modelled business objects, SBO maintains a global schema that represent the additional aspects, such as presentation logic, validation logic, and content handling mechanism of the business objects. Such schema makes provision for, e.g.:

- Auto-generating the validation logic required for the *email* attribute during editing (often via web forms) and showing it as a *mailto* hypertext link by default in view operations
- Rendering the *photo* attribute as images on the web browser for view operations while providing the necessary uploading facility for editing by default
- Displaying the *address* attribute as a map automatically on view operations (as shown in Figure 6).

Apart from the global schema, SBO has three main components. The *Builder* component is a SBOML parser and a business object run-time loader. The *Metaobject* component maintains the customisable properties of the modelled business objects as well as the relationship among them. The main interest of this paper is its third component, called *Renderer*, which is responsible for auto-generating web user interfaces. Essentially, *Renderer* is a set of rendering APIs. As previously mentioned, *UI Definitions* are aimed for describing the necessary *changes* for the web user interface. Thus, a mechanism is indispensable for generating web user interfaces without the need for defining the complete web user interfaces and, at the same time, being able to fine-tune the generated web user interfaces if necessary. The SBO's


Create Employee
http://localhost:8888/object/employee.pl
Google
inkui
Thesaurus.com
Security for...ogle Groups
Choose File
Create
Cancel

Create Employee

| | |
|---|---|
| First Name * | Danny |
| Last Name * | Liang |
| Date Of Birth * | 10-04-1979 |
| Photo | user_male.png |
| Email * | danny@scm.uws.edu.au |
| Address | 180 Parramatta Rd, Sydney, NSW, 2000, Australia |
| Home Phone | (02) 9876 5443 |
| Position * | Manager |

April, 1979

| wk | Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|---|
| 13 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 14 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 16 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 17 | 29 | 30 | | | | | |

Drag to move

Figure 5: A Web Form for Creating New Employee.

rendering APIs are capable of fulfilling this requirement. For example, to render the web form in Figure 5 for an "employee" business object requires a single line of code by executing the `render_as_form` API:

```
organisation::employee->render_as_form();
```

SBO's rendering APIs require no declaration or configuration prior to the generation of a web user interface. As illustrated in Figure 5, we do not need to specify the existence of the required fields, their order, validation, as well as localised presentation, i.e., we also do not need to declare that

- *first name*, *last name*, etc. are mandatory fields,
- all fields should be validated accordingly,
- *photo* is an upload field,
- a calendar (date picker) is required to assist data entry for the *date of birth* field and formatted according to the users' locale

since SBO is able to automatically derive all these information from the underlying data model (the database schema), the *Metaobject* component, as well as the definitions stored in the SBO's global schema.

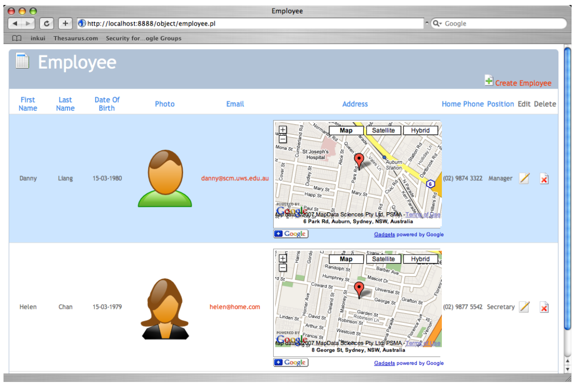
We can use the following line of code:

```
organisation::employee->render_as_table(
ajax => 1, create => 1, edit => 1, delete => 1);
```

to generate an AJAX-enabled web table with create, edit, and delete access to the "employee" business object shown in Figure 6.

Similarly, SBO's rendering APIs supports a fine-grained control over the generated user interfaces through various parameters. An example would be customising the previous "employee" web form in Figure 5 with the following requirements:

- Set the title of the form to "Add New Employee",



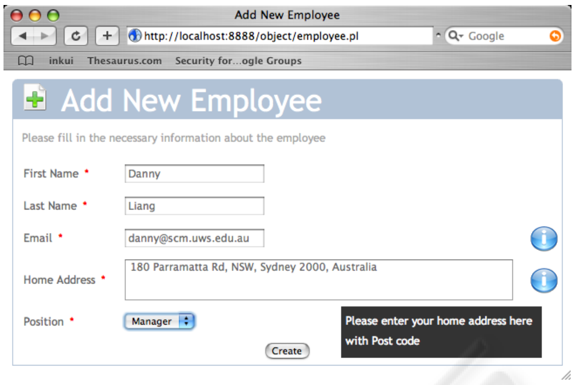
Employee

http://localhost:8888/object/employee.pl

Create Employee

| First Name | Last Name | Date Of Birth | Photo | Email | Address | Home Phone | Position | Edit | Delete |
|---|---|---|---|---|---|---|---|---|---|
| Danny | Liang | 15-03-1980 | | danny@scm.uws.edu.au | 6 Park Rd, Auburn, Sydney, NSW, Australia | (02) 9874 3322 | Manager | | |
| Helen | Chan | 15-03-1979 | | helen@home.com | 8 George St, Sydney, NSW, Australia | (02) 9877 5542 | Secretary | | |

Figure 6: A Web Table for Employees.



Add New Employee

http://localhost:8888/object/employee.pl

Add New Employee

Please fill in the necessary information about the employee

| | |
|---|---|
| First Name * | Danny |
| Last Name * | Liang |
| Email * | danny@scm.uws.edu.au |
| Home Address * | 180 Parramatta Rd, NSW, Sydney 2000, Australia |
| Position * | Manager |

Please enter your home address here with Post code

Figure 7: A Customised Web Form for Creating New Employee.

- Add a description to the form as follows: "Please fill in the necessary information about the employee",
- For the *address* attribute, change the form field's label to "Home Address", make it a mandatory field, and add a tool-tip using the following information "Please enter your home address here",
- Display only the *first name*, *last name*, *email*, *address*, and *position* fields in that order, and
- Hide the cancel button

To achieve this, all we need is to pass the following parameters (in the form of associated array) directly to the `render_as_form` API:

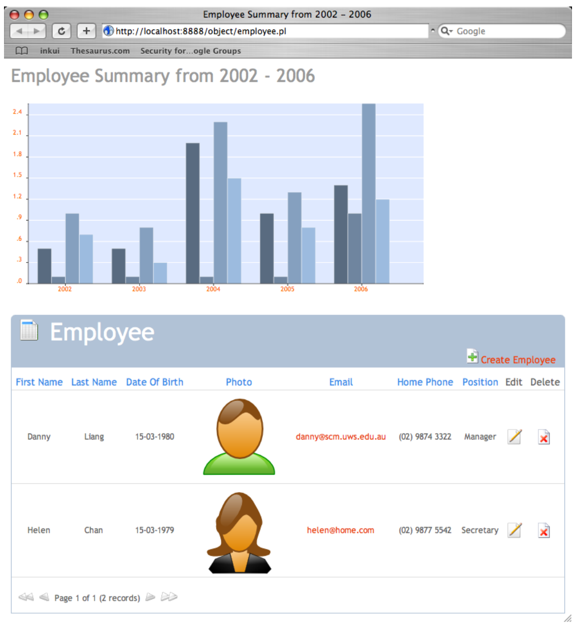
```
organisation::employee->render_as_form(
  form_title => 'Add New Employee',
  form_description => 'Please fill in the
      necessary information about the employee',
  fields => [{
      name => 'address',
      label => 'Home Address',
      required => 1,
      comment => 'Please enter your home
      address here with Post code' }],
  field_order => [
      'first_name', 'last_name',
      'email', 'address', 'position' ],
  hide_cancel => 1);
```

Once the above code segment is executed, the web form shown in Figure 7 is generated. In this way, *UI Definitions* can be easily implemented by serialising those parameters. In run-time, *UI Definitions* are retrieved, inflated (deserialised), and passed back to the corresponding SBO APIs to generate the required web user interfaces.

Notably, the rendering APIs are architected towards the MVC (Model View Controller) design pattern. The *model* is determined by the structure of the calling business object. The generated *view* of each rendering API is template-driven. Custom "Look and feels" can be achieved by specifying customised web template(s) to the corresponding rendering API. Therefore, professional developers can insure the overall "look and feel" of the web application by maintaining the web templates used by the rendering APIs.

Rendering APIs usually have one or more built-in *controllers* for handling user actions. In the previous "employee" web form, when the "create" button is clicked, the same rendering API can handle the submission (post) of the form, including uploading the binary image file. Additional coding is not required since there is a built-in controller for handling such "create" action. Custom controllers can be also specified to the rendering API to handle special actions. Consequently, each rendering API is "self-contained" due to its rendering capability and event handling capability. This "self-contained" nature of the rendering APIs makes provision for partitioning of web user interfaces as the required *UI Component* concept in our proposed architecture. Therefore, using SBO, a complete web user interface presented to the users can be considered as a composition of one or many *UI Components*, generated by rendering APIs, governed by a master web template(s) for layout. The master web template(s) also serves the purpose for retaining a global "look and feel" of the web application, as well as incorporating other static UI elements, such as simple text descriptions, outside the *UI Components*. Figure 8 is an example showing the rendering of two UI components: a bar chart and a web table, along with a simple static heading, in a master web template.

The "self-contained" nature of the rendering APIs also implies an implicit navigation model within the generated web user interfaces. For instance, in Figure 6, once an user clicks on the "Create Employee" link, the web table will hide and a form is then shown.


Employee Summary from 2002 – 2006
http://localhost:8888/object/employee.pl
Google
inkui
Thesaurus.com
Security for...ogle Groups
Employee Summary from 2002 - 2006
2.4
2.1
1.8
1.5
1.2
.9
.6
.3
.0
2002
2003
2004
2005
2006
Employee
Create Employee

| First Name | Last Name | Date Of Birth | Photo | Email | Home Phone | Position | Edit | Delete |
|---|---|---|---|---|---|---|---|---|
| Danny | Liang | 15-03-1980 | | danny@scm.uws.edu.au | (02) 9874 3322 | Manager | | |
| Helen | Chan | 15-03-1979 | | helen@home.com | (02) 9877 5542 | Secretary | | |

Page 1 of 1 (2 records)

Figure 8: A Complete Web User Interface.

There are several ways to customise or enhance the default navigation behaviours:

- Customise the parameters passed to the corresponding rendering API, such as whether to hide or show a web form on certain events
- Specify custom web templates to the corresponding rendering API to incorporate additional navigation paths or structures
- Define custom *controllers* to trigger the rendering of another web user interface, in order to sequenced user interfaces.

Due to the scope of this paper, we will not focus on the details of customising the implicit navigation model of the rendering APIs.

By harnessing the SBO framework, our proposed web application architecture is shown as Figure 9. As previously mentioned, SBO is built on top of ORM technology to achieve object persistence. The SBO layer facilitates a *Renderer* component for generating a rich portfolio of web *UI Components* for the modelled business objects. The proposed *UI Definition Layer* in this paper, is built on top of the SBO layer for flexible and fine-grained control over the web *UI Components*. A *UI Generation Tool* is utilised for business end-users to manage *User Interface Definitions* in the *UI Definition Layer*. The final user interfaces of the web applications are generated through the *UI Definition Layer* using SBO's rendering APIs. We will demonstrate the *UI Generation Tool* in the next section.

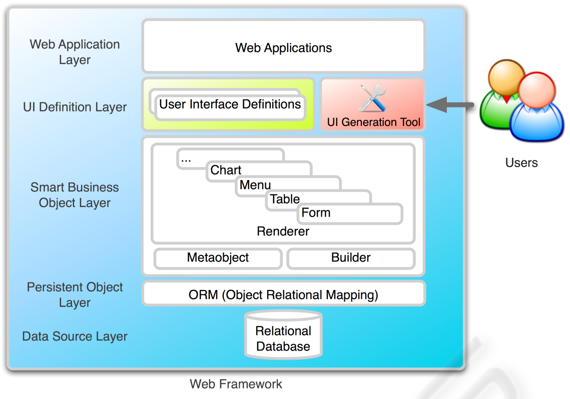
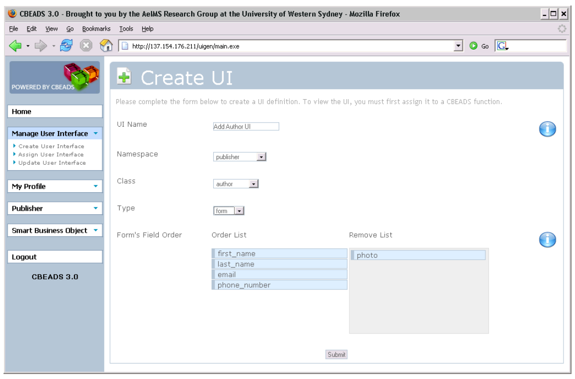


Figure 9: The Proposed Web Application Architecture.

## 4 THE UI GENERATION TOOLKIT

We have developed a *UI Generation Toolkit* to streamline the process of defining and managing *UI Definitions*. The toolkit itself is built using SBO on the CBEADS© (Ginige et al., 2005) web application framework. CBEADS© has a built-in user authentication and management module and allows web applications to be created "through the web". Once the required business objects are modelled using SBOML, we can define a new *UI Definition* by clicking on the "Create User Interface" tool. The "Create User Interface" tool shown in Figure 10 does not represent the complete list of options due to the AJAX nature of the tool where options are dynamically generated. To define a new web user interface, end-users must specify the reference business object by select the business object in the available namespaces (defining a unique key for the *UI Definition* is optional, since the tool always generated a random key). Then, end-users can select the desired user interface type, i.e. the *UI Component*, and customise various options supported by the *UI Component*. For example, we can drag-and-drop the attributes of the business objects to specify the list and the order of the form fields to be displayed (Figure 10).

Once the *UI Definition* is saved, we can assigned it to a web application in CBEADS© using the "Assign User Interface" tool. Figure 11 is a sample application generated using the *UI Definition* we have defined. Mostly importantly, we can use the "Manage User Interface" tools, shown in Figure 12, to customise existing *UI Definitions*.


CBEADS 3.0 - Brought to you by the AeIMS Research Group at the University of Western Sydney - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://137.154.176.211/uigen/main.exe
POWERED BY CBEADS
Home
Manage User Interface
Create User Interface
Assign User Interface
Update User Interface
My Profile
Publisher
Smart Business Object
Logout
CBEADS 3.0
Submit

Create UI

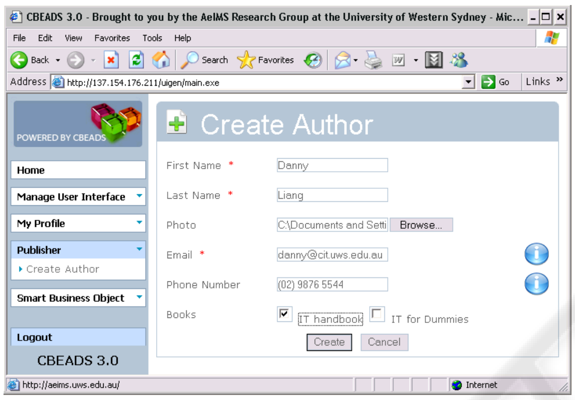
Please complete the form below to create a UI definition. To view the UI, you must first assign it to a CBEADS function.

| | |
|---|---|
| UI Name | Add Author UI |
| Namespace | publisher |
| Class | author |
| Type | form |

Form's Field Order

| Order List | Remove List |
|---|---|
| first_name | photo |
| last_name | |
| email | |
| phone_number | |

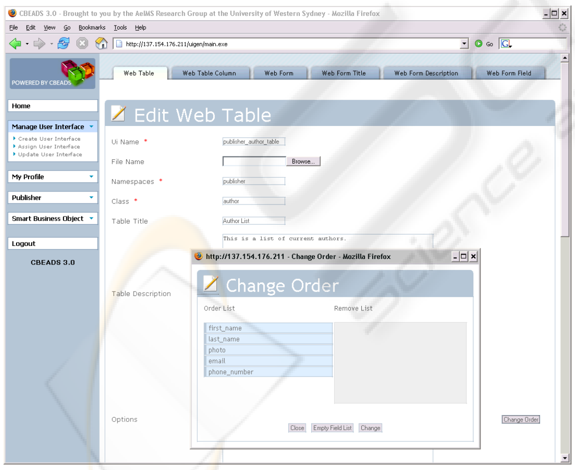
Figure 10: Creating a UI Definition.


CBEADS 3.0 - Brought to you by the AeIMS Research Group at the University of Western Sydney - Mic...
File Edit View Favorites Tools Help
Back Search Favorites
Address http://137.154.176.211/uigen/main.exe Go Links
POWERED BY CBEADS
Home
Manage User Interface
My Profile
Publisher
Create Author
Smart Business Object
Logout
CBEADS 3.0
Create Cancel
http://aeims.uws.edu.au/
Internet

Create Author

| | |
|---|---|
| First Name * | Danny |
| Last Name * | Liang |
| Photo | C:\Documents and Setti Browse... |
| Email * | danny@cit.uws.edu.au |
| Phone Number | (02) 9876 5544 |
| Books | [✓] IT handbook [ ] IT for Dummies |

Figure 11: The Generated Application.



Edit Web Table

| | |
|---|---|
| Ui Name * | publisher_author_table |
| File Name | Browse... |
| Namespaces * | publisher |
| Class * | author |
| Table Title | Author List |
| Table Description | This is a list of current authors. |
| Options | |

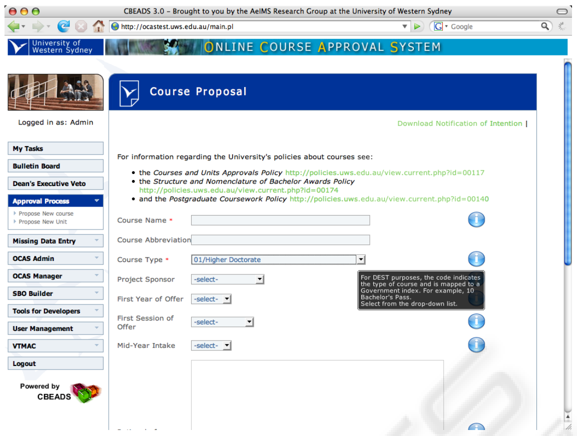
Change Order

| Order List | Remove List |
|---|---|
| first_name | |
| last_name | |
| photo | |
| email | |
| phone_number | |

Figure 12: Managing UI Definitions.

## 5 CONCLUSION AND FUTURE WORK

Web user interfaces are always evolving. To achieve an end-user driven approach to manage user interfaces in business web application, we introduced a web application architecture with a dedicated *UI Definition Layer* for describing *changes* in web user interfaces. The *UI Definition Layer* takes advantage of the SBO framework for generating highly customisable, "self-contained" web *UI Components*. We have created a toolkit to demonstrate the utilisation of our proposed architecture.



Course Proposal

For information regarding the University's policies about courses see:

- the *Courses and Units Approvals Policy* http://policies.uws.edu.au/view.current.php?id=00117
- the *Structure and Nomenclature of Bachelor Awards Policy* http://policies.uws.edu.au/view.current.php?id=00174
- and the *Postgraduate Coursework Policy* http://policies.uws.edu.au/view.current.php?id=00140

| | |
|---|---|
| Course Name * | |
| Course Abbreviation | |
| Course Type * | 01/Higher Doctorate |
| Project Sponsor | -select- |
| First Year of Offer | -select- |
| First Session of Offer | -select- |
| Mid-Year Intake | -select- |

For DEST purposes, the code indicates the type of course and is mapped to a Government index. For example, 10 Bachelor's Pass. Select from the drop-down list.

Figure 13: The OCAS Application.

A customised version of the toolkit is employed by OCAS (Online Course Approval System) (University of Western Sydney, 2006), an enterprise level web-based workflow system for automating the courses and units (subjects) approval processes in University of Western Sydney. Figure 13 is only a snapshot of the OCAS application.

Courses and units are the core business functions of a university. The sophisticated approval processes for course or unit involve almost every departments of the university. One of the main challenges in developing the OCAS application was that the web user interfaces keep evolving. This was due to many reasons, for example:

- Despite the fact that we have interviewed nearly every departments in the university, it was still impossible for us to capture all the UI requirements to satisfy all the user groups of the application.
- Some required UI specifications, such as help information required by the UIs for explaining specific jargon, does not even exist in any current form of documentation.
- The specification of the underlying business objects (some with more than 150 attributes) were also evolving. As a result, the corresponding web user interfaces need to be frequently changed accordingly.
- Some information place on the developed web user interfaces became obsolete even before the

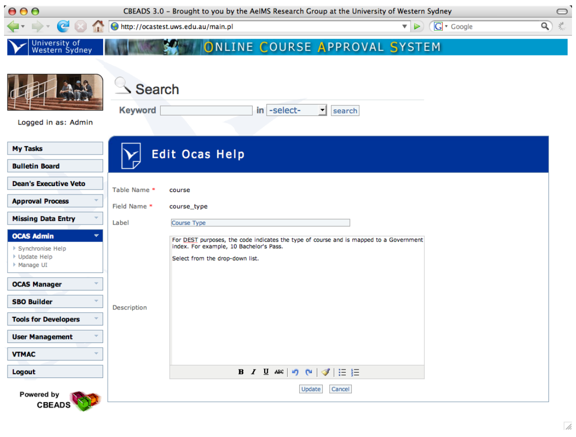


Table Name * course

Field Name * course_type

Label Course Type

Description For DEST purposes, the code indicates the type of course and is mapped to a Government index. For example, 10 Bachelor's Pass.

Select from the drop-down list.

Figure 14: Customising UIs of the OCAS Application.

implementation of OCAS application was completed.

We cannot change the fact that the web user interfaces are constantly changing. Traditional approaches were inappropriate for developing the OCAS application. Consequently, we have embraced EUD and utilised our proposed architecture to develop OCAS. We have tailored our toolkit to specialise in managing all the descriptive text, such as form descriptions, form field labels and tool-tip information, as well as table column headings, for the web user interfaces of the application (Figure 14). SBO is used to generate all the web user interfaces and entire data model for the application is modelled using SBOML. Once the basic web application is released, trained business end-users could then use the tailored toolkit to customise and finalise the web user interfaces, while the development team was implementing other core components of the application. The OCAS application was a *parallel* development between professional developers and business end-users. In such way, the project's development timeframe was greatly reduced.

Further investigation on the usage pattern of the toolkit is desirable to analyse its effectiveness from the perspective of business end-users.

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