



A Wiki-based System for Schema and Data Evolution

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Approach inspired by wiki-based sites, in which users may structure the data they provide in complex ways and manage it in a collaborative way.

Our application scenario deals with:

- a vast number of documents containing information about items;
- documents' information is not completely unstructured;
- each document may (possibly in a loose way) adhere to one of a relatively small number of schemas (thereon called templates).

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- Italian society 7pixel¹ own many price comparison websites (ShopyDoo, TrovaPrezzi, InfoPrix. . .)
- It holds the large majority of the market share in Italy has a very significant presence in other european countries (e.g. Spain, France, Germany, Netherlands) and non-european as well (e.g. Brazil).
- Some www.shopydoo.it numbers:
 - more than 2.000.000 of unique user per month
 - 4.000.000 of offers
 - 1.500 merchants
 - more than 9.000 datasheets

¹www.7pixel.it

The background

- each item for sale may belong to one datasheet
- datasheets for the same category should share the same structure to let users easily compare them
- sometimes this is not true, sometimes they are wrong, often users suggest corrections

In our project

- Every document describes the technical details of a single product;
- there is one template for product category;
- our dataset contains 9605 documents and 72 templates (about 65 MB of XML files)

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Motivating example

Wikipedia



Windows 3.1x

Part of the [Microsoft Windows](#) family



Screenshot of Windows 3.11

Developer

Microsoft

Releases

Release date 6 April 1992([info](#))[\[?\]](#)

Current version 3.11 (December 31, 1993; 17 years ago)([info](#))[\[?\]](#)

Source model [Closed source](#)

License [MS-EULA](#)

Preceded by [Windows 3.0](#)

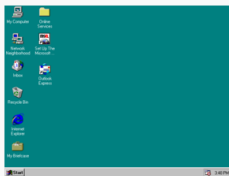
Succeeded by [Windows 95](#)

Support status

Unsupported as of 31 December 2001

Windows 95

Part of the [Microsoft Windows](#) family



Screenshot of Windows 95

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Releases

Release date 24 August 1995([info](#))[\[?\]](#)

Current version 4.0 (Build 950 C: OEM Service Release 2.5) (November 26, 1997; 13 years ago)([info](#))[\[?\]](#)

Source model [Closed source](#)

License [Microsoft EULA](#)

Kernel type [Monolithic](#)

Platform support [IA-32](#)

Preceded by [Windows 3.1x](#)

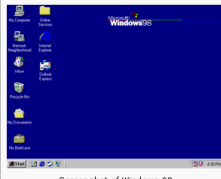
Succeeded by [Windows 98](#)

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Unsupported as of 31 December 2001^[1]

Windows 98

Part of the [Microsoft Windows](#) family



Screenshot of Windows 98

Developer

Microsoft

Releases

Release date **RTM:** 15 May 1998

Retail: 25 June 1998([info](#))[\[?\]](#)

Current version **First edition:** 4.1 (Build 2000: Service Pack 1) (26 May 1999; 12 years ago)

Second Edition: 4.1 (Build 2222 A) (5 May 1999; 12 years ago)([info](#))[\[?\]](#)

Source model [Closed source](#)

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Kernel type [Monolithic kernel](#)

Preceded by [Windows 95](#)

Succeeded by [Windows Me](#)

Support status

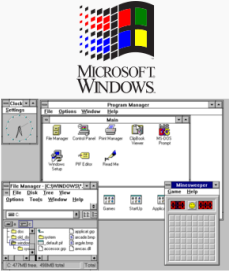
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Motivating example

Wikipedia



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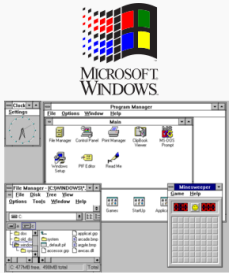
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Motivating example

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Motivating example


Wikipedia



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MICROSOFT
WINDOWS



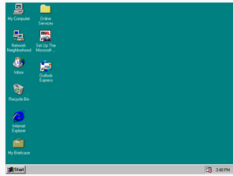
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Motivating example

Wikipedia



Lancia Y (840)



Production	1996-2003
Assembly	Melfi, Potenza, Italy
Body style	3-door hatchback
Engine	1.1L <i>Fire I4</i> petrol 1.2L <i>Fire I4</i> petrol 1.4L <i>Pratola Serra I4</i> petrol
Transmission	5-speed manual ECVT
Wheelbase	2,380 mm (94 in)
Length	3,723 mm (146.6 in) 3,740 mm (147 in) (facelift 2000)
Width	1,690 mm (67 in)
Height	1,435 mm (56.5 in)
Related	Fiat Punto (176) Fiat Barchetta Fiat Palio
Designer	Enrico Fumia

Fiat Seicento



Manufacturer	Fiat
Also called	Fiat 600 (2005-2010)
Production	1998-2010 (1,328,839 made)
Assembly	Tychy, Poland ^[1]
Predecessor	Fiat Cinquecento
Successor	Fiat Nuova 500 Fiat Nuova Panda
Class	City car
Body style	3-door hatchback 3-door panel van
Layout	FF layout
Engine	0.9L straight-4 <i>OHV</i> 40 PS (29 kW; 39 hp) 1.1L straight-4 <i>Fire</i> 54 PS (40 kW; 53 hp) Electric engine 41 PS (30 kW; 40 hp)
Wheelbase	2,200 mm (86.6 in)
Length	3,337 mm (131.4 in)
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Curb weight	730-750 kg (1,600-1,700 lb)

Motivating example

Wikipedia



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Motivating example

Wikipedia



JPEG	
Magic number	ff d8
Standard(s)	ISO/IEC 10918, ITU-T T.81, ITU-T T.83, ITU-T T.84, ITU-T T.86

Portable Document Format



Adobe PDF icon

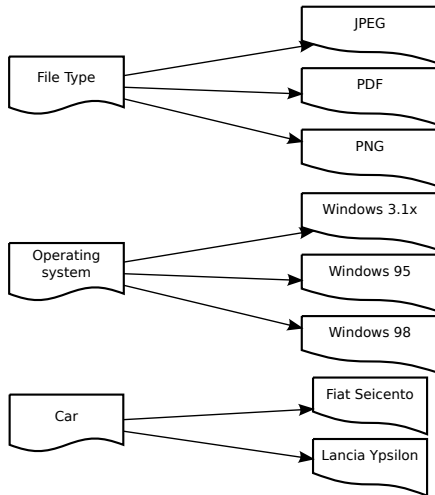
Filename extension	.pdf
Internet media type	application/pdf application/x-pdf application/x-bzpdf application/x-gzpdf
Type code	'PDF' (including a single space)
Uniform Type Identifier	com.adobe.pdf
Magic number	%PDF
Developed by	Adobe Systems
Initial release	1993
Latest release	1.7
Standard(s)	ISO 32000-1:2008 ^[1]
Website	Adobe PDF Reference Archives

Portable Network Graphics



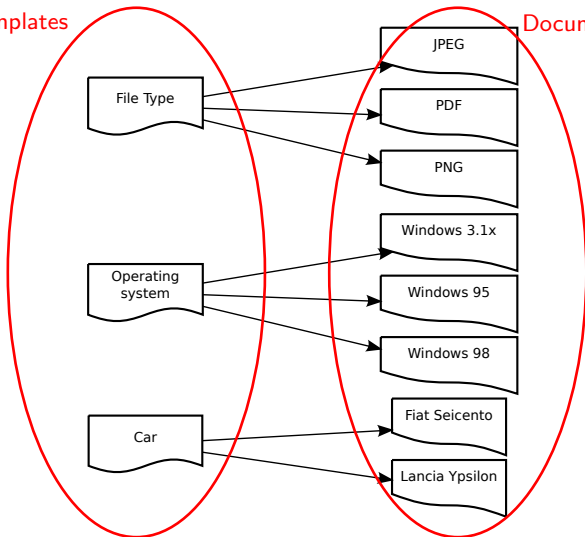
A PNG image with an 8-bit transparency channel (top). The same image is overlaid onto a checkered background (bottom), typically used in [graphics software](#) to indicate transparency.

Filename extension	.png
Internet media type	image/png
Type code	PNGf PNG
Uniform Type Identifier	public.png
Magic number	89 50 4e 47 0d 0a 1a 0a
Developed by	PNG Development Group (donated to W3C)
Initial release	October 1, 1996
Type of format	lossless bitmap image format
Extended to	APNG, JNG and MNG
Standard(s)	ISO/IEC 15948 ^[1] IETF RFC 2083
Open format?	Yes



Templates

Documents



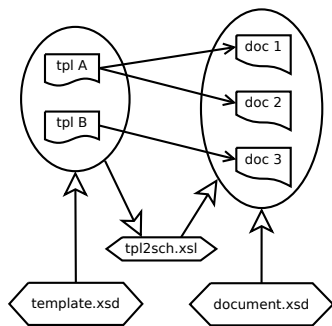
Idea

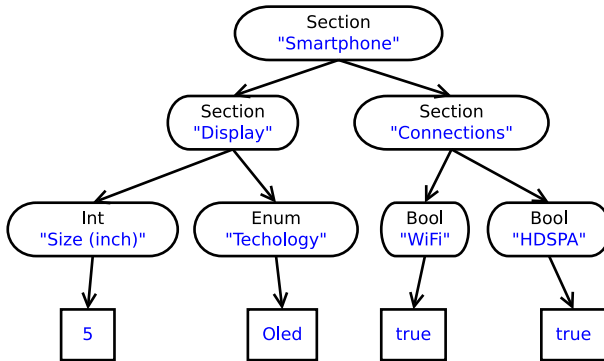
The problem domains



- check documents and template validity;
- check document validity with respect to its template;
- propagate template edits;
- find not valid documents;

- documents and templates are XML files;
- XSDs checks whether documents and templates are valid;
- an XSLT transforms templates in Schematron documents that check documents' validity with respect to the template;
- a lightweight XQuery Update-like language is used to update documents and templates



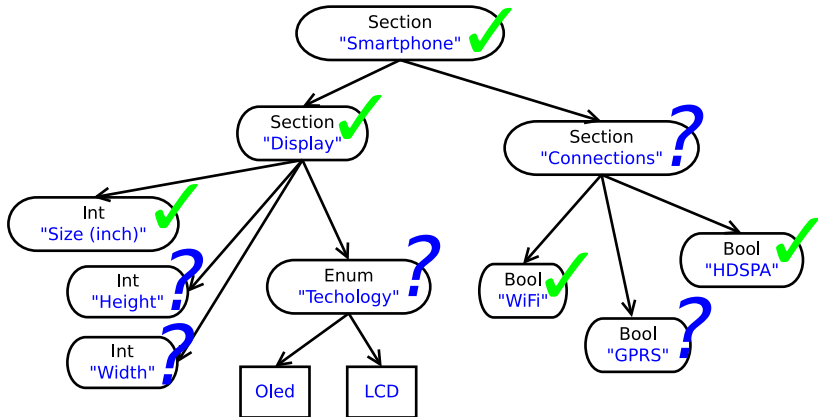


internal nodes (elements) which are tuples with a name, a type and a set of children nodes;

external nodes (data) which contains only a string value;

Our framework

Template



Every element node contain a *mandatory* attribute which define if the node is mandatory or optional in the document.

A document is *valid with respect to a template* if and only if:

- ① it is valid;
- ② all document's elements are also present in the template with the same name and the same type;
- ③ all template's elements with mandatory set has a corresponding element in the document;
- ④ the children of *enum*, *values* and *section* elements of the document are also children of the corresponding template's elements.

Our framework

Document update



Document update

```
xup ← TranslateToXQueryUpdate(up);  
doc ← XQueryProcessor(doc, xup);
```

ValidateXSD(doc)

```
tpl ← FindAssociatedTemplate(doc);  
sch ← TranslateTemplateToSchematron(tpl);
```

Accept update

ValidateSCH(doc, sch)

Reject update

Our framework

Document update



Document update

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xup ← TranslateToXQueryUpdate(up);  
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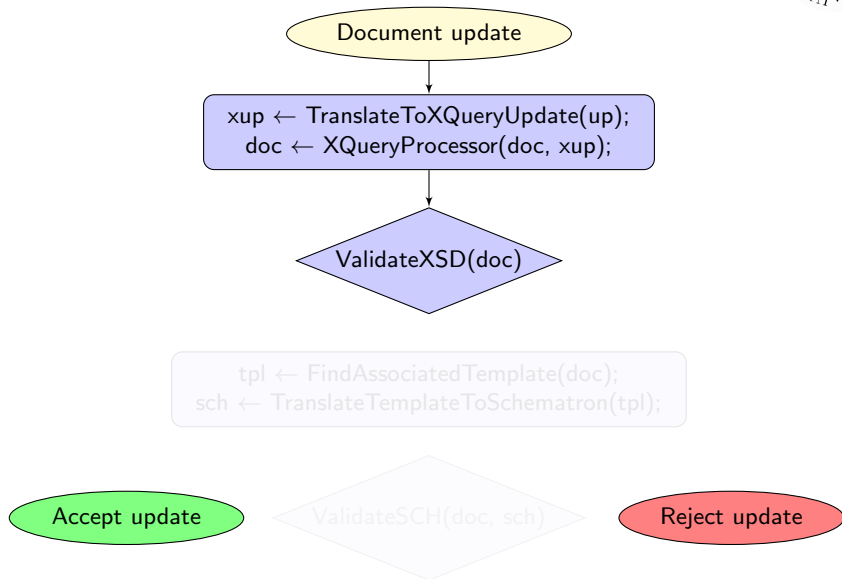
Accept update

ValidateSCH(doc, sch)

Reject update

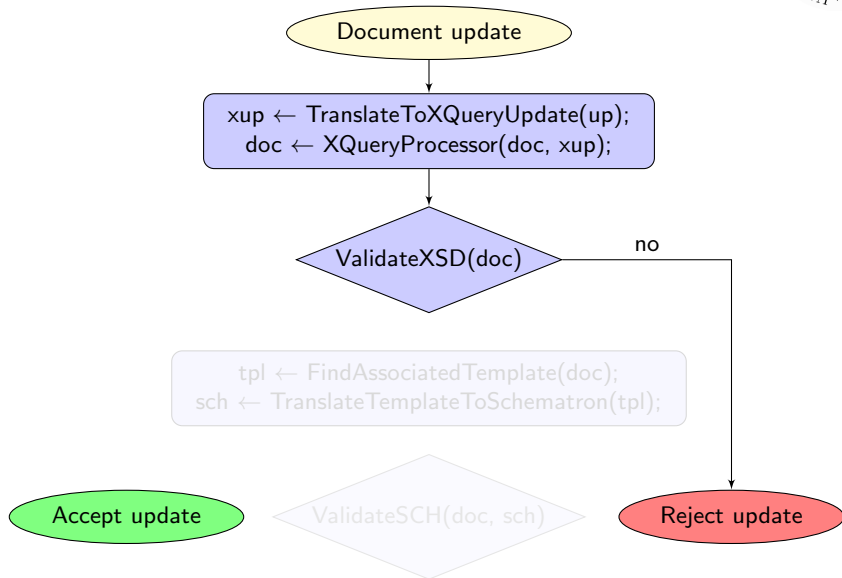
Our framework

Document update



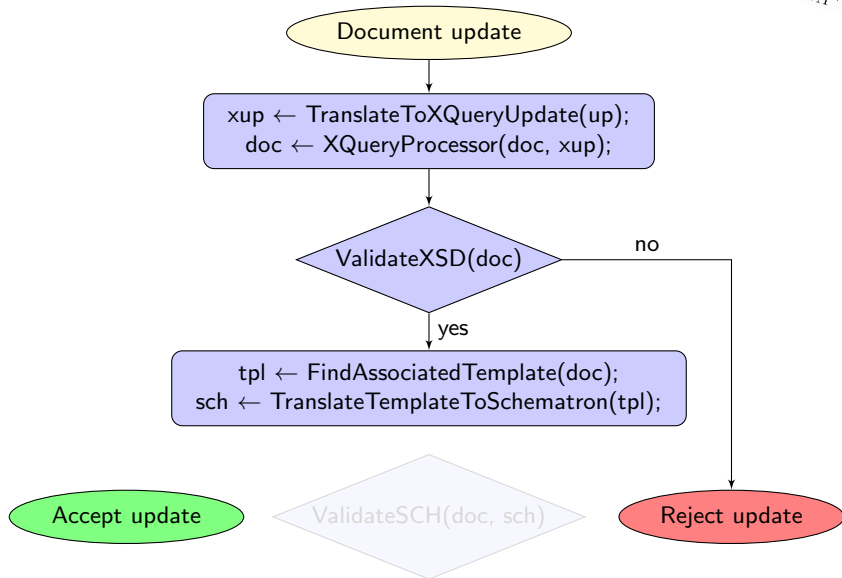
Our framework

Document update



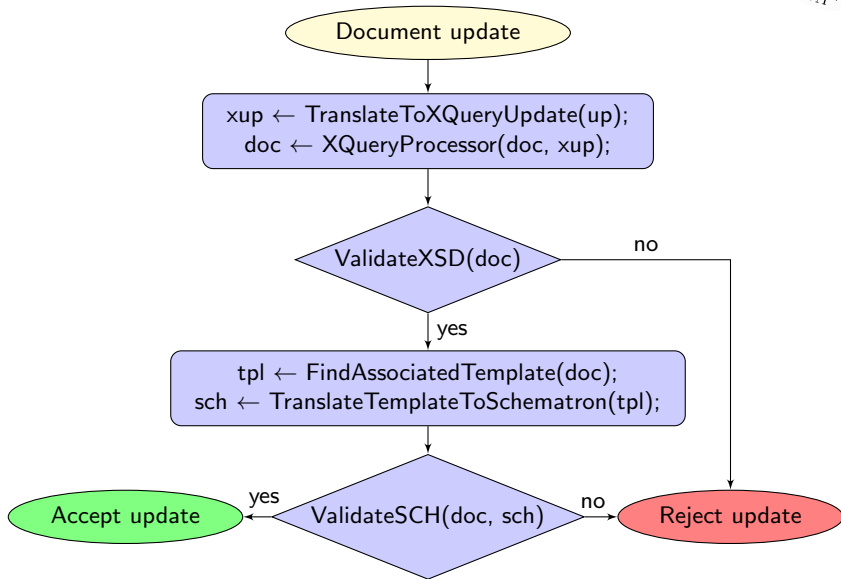
Our framework

Document update



Our framework

Document update



Our framework

Template update language



Operation	Documents unchanged	Documents still valid
Insert an element	✓	✓/✗/?
Insert an element with value	✗	✓
Insert data	✓	✓
Change a type	✗	✓/?
Rename an element	✗	✓
Change the mandatory	✓	✓/?
Delete a node	✗	✓
Replace data	✗	✓

Our framework

Template update



Template update

```
xup ← ToTemplateXQueryUpdate(up);  
tpl ← XQueryProcessor(tpl, xup);
```

StatusOfDocuments(tpl,up)

ValidateXSD(tpl)

```
foreach doc in GetAssociatedDocuments(tpl) do  
  SetValidity(doc, false);  
done
```

```
sch ← TranslateTemplateToSchematron(tpl);  
xup ← TranslateToDocumentXQueryUpdate(up);  
foreach doc in GetAssociatedDocuments(tpl) do  
  doc ← XQueryProcessor(doc, xup);  
  if not ValidateWRHW3CSchema(doc) then  
    SetValidity(doc, false)  
  else  
    SetValidity(doc, ValidateWithSchematron(doc, sch))  
  end  
done
```

Accept update

Reject update

Our framework

Template update



Template update

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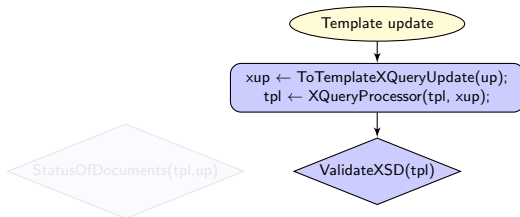
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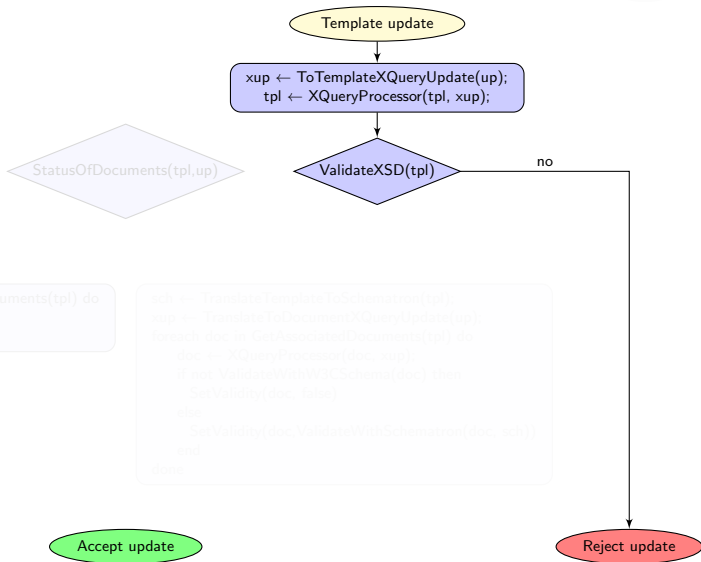
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Accept update

Reject update

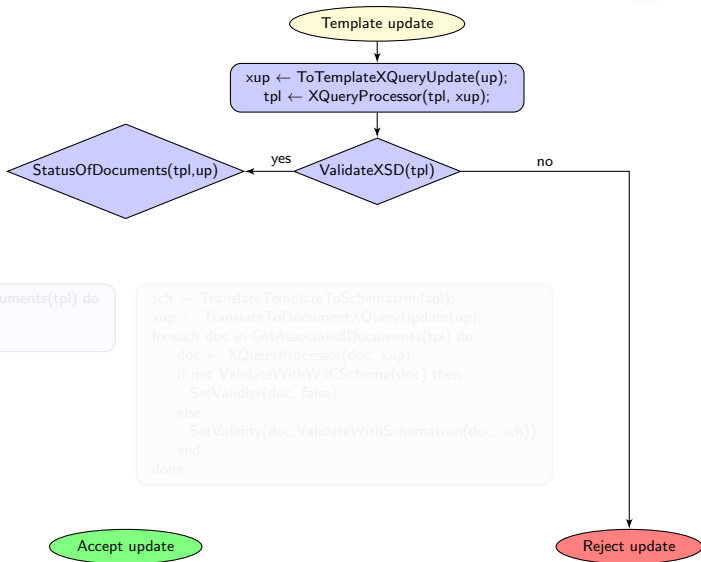
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Template update



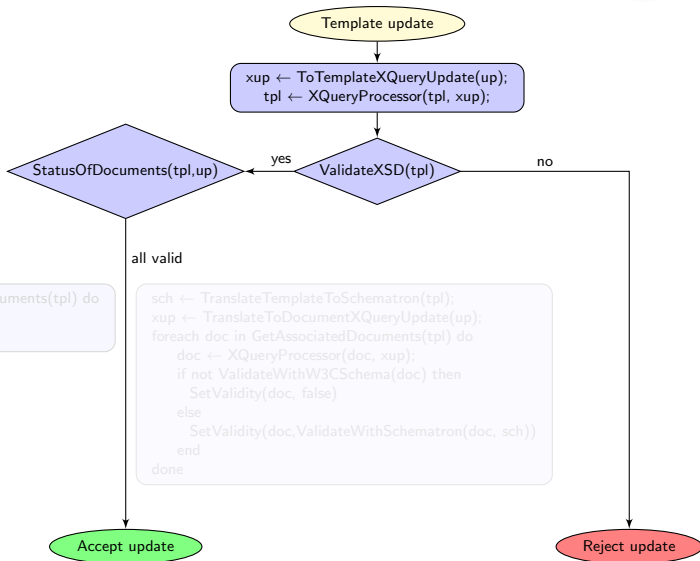
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Template update



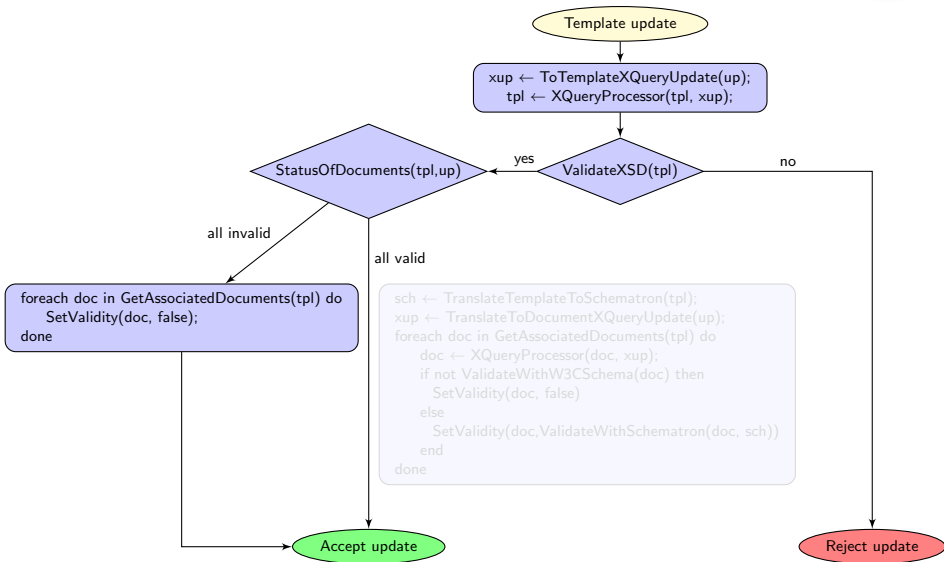
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Template update



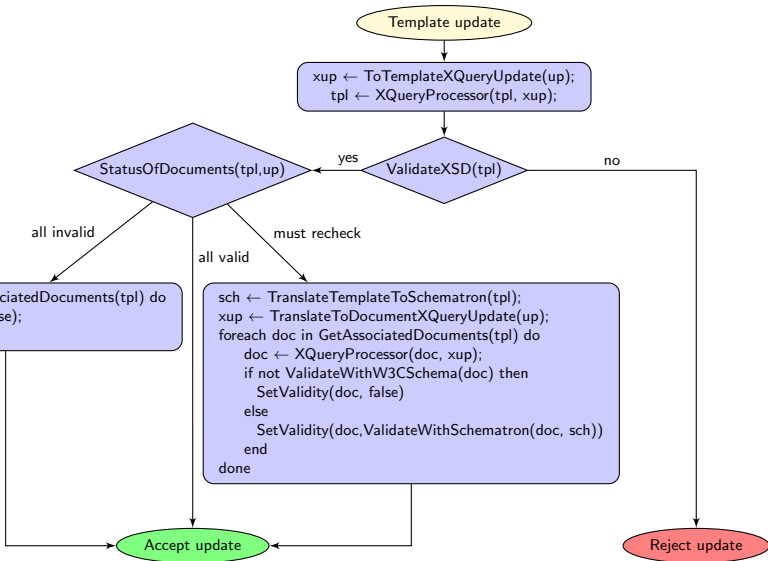
Our framework

Template update



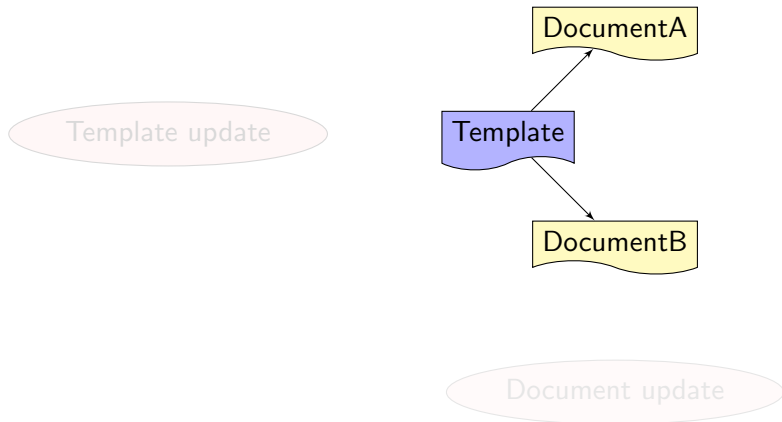
Our framework

Template update



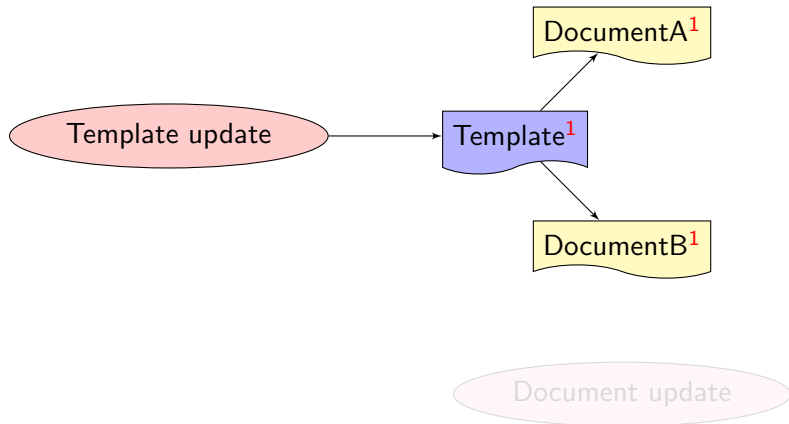
Our framework

Revision control support



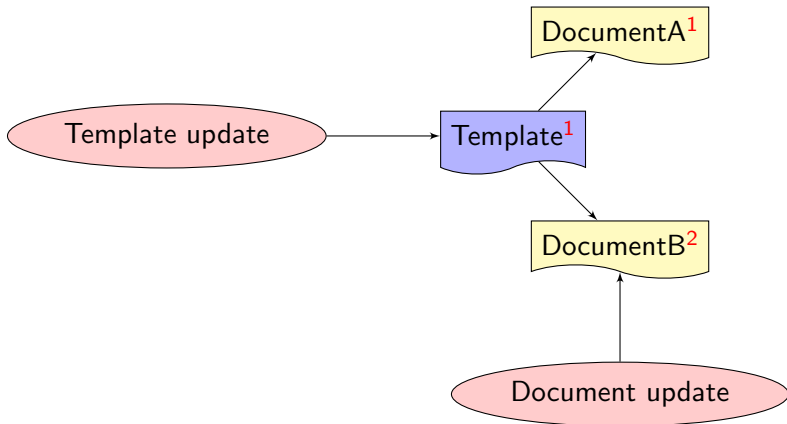
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Revision control support



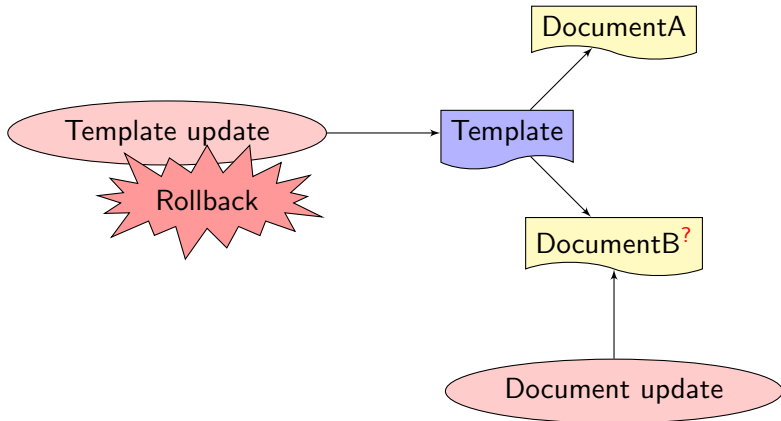
Our framework

Revision control support



Our framework

Revision control support



Idea

Find a trade-off between two opposite approaches

- ① **conservative**: restore the state before the template update, losing the document update;
- ② restore all the schema modifications but not the document content;
- ③ restore only the document's part affected by the template update;
- ④ **speculative**: keep the last revision of the document even if it is not valid;

Idea

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- ④ **speculative**: keep the last revision of the document even if it is not valid;



Level 1: restore the state before the template update, losing the document update

- ① As a deliberate act of vandalism a user deletes or rename large part of a template;
- ② Every document can only try to limit the damages, but can not improve the document quality;



Level 2: restore all the schema modifications but not the document content

- 1 consider a car radio template;
- 2 someone rename the *Audio* section in *Speaker system*;
- 3 the semantic of the section is not changed, so every document update is legit.
- 4 but all the other templates which describe consumer electronics stuffs contain an *Audio* section;
- 5 it is better revert this update to uniform the template structures;



Level 3: restore only the document's part affected by the template update

- 1 consider a *Notebook* template which contains a *Memory* and a *HD* sections;
- 2 an unskilled user rename the *Memory* section in *Disk sizes*;
- 3 The semantic of the section is changed;



Level 4: keep the last revision of the document even if it is not valid

- 1 someone add a new data *Autofocus* under the multi-values *Extra features* in a camera template;
- 2 a useful information, but it is redundant since there is an optional boolean field *Auto focus* in the section *Lens system* yet.

The prototype

Current status



A web interface allowing users to:

- easily find documents and templates by (possibly) partial matches;
- read a rendered version of templates and documents;
- edit templates and documents in an interactive way;
- search for invalid documents after a template update.

The prototype

Example



The image displays three browser windows illustrating a prototype for a calculator template and two valid calculator documents.

Top Window: Calculators-20088
URL: `wikitest:8080/Template/Show/Calcul`
Title: **Calculators-20088**
Content: A table with a header **Calculators-20088** and a sub-header **Features**. The table lists features with checkboxes for edit and delete, and a plus sign for adding new features.

Calculators-20088	
Features	
Battery	<input type="checkbox"/> <input checked="" type="checkbox"/>
Electric current	<input type="checkbox"/> <input checked="" type="checkbox"/>
Model	<input type="checkbox"/> <input checked="" type="checkbox"/>
Printing functionality	<input type="checkbox"/> <input checked="" type="checkbox"/>
Solar energy	<input type="checkbox"/> <input checked="" type="checkbox"/>
Tilted display	<input type="checkbox"/> <input checked="" type="checkbox"/>

submit

Bottom Left Window: citizen-fc600-en
URL: `wikitest:8080/Document/...`
Title: **citizen-fc600-en**
Content: A valid calculator document for the 'citizen-fc600-en' model.

Valid

[edit](#)
[template](#)

Calculators-20088	
Features	
Model	FC600
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes

Bottom Right Window: palsonik-k1216-en
URL: `wikitest:8080/Document/Show/palsonik-k121`
Title: **palsonik-k1216-en**
Content: A valid calculator document for the 'palsonik-k1216-en' model.

Valid

[edit](#)
[template](#)

Calculators-20088	
Features	
Model	K1216
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes

The calculator template and two valid calculator document

The prototype

Example



The screenshot shows a Firefox browser window with the URL `wikitest:8080/Template/Show/Calcul`. The main content area displays the title **Calculators-20088**. A modal dialog box titled **Add** is open, containing the following fields:

- name:** Scientific
- Bool:** Bool (dropdown menu)
- mandatory:**

Buttons for **Ok** and **Cancel** are visible at the bottom of the dialog. Below the dialog, two browser windows are visible. The left window shows the page `wikitest:8080/Document/S` with the title **citizen-fc600-en** and a **Valid** status. The right window shows `wikitest:8080/Document/Show/palsonik-k121` with the title **k1216-en**. Both windows contain a table of features for their respective calculator models.

Calculators-20088	
Features	
Model	FC600
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes

Calculators-20088	
Features	
Model	K1216
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes

Add a mandatory element

The prototype

Example



Calculators-20088

Calculators-20088		
Features		
Battery	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Electric current	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Model	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Printing functionality	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Solar energy	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Tilted display	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Scientific	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

submit

citizen-fc600-en

Invalid

[edit](#)
[template](#)

Calculators-20088		
Features		
Model	FC600	
Printing functionality	false	false
Tilted display	false	false
Electric current	false	false
Battery	yes	yes
Solar energy	yes	yes

palsonik-k1216-en

Invalid

[edit](#)
[template](#)

Calculators-20088		
Features		
Model	K1216	
Printing functionality	false	false
Tilted display	false	false
Electric current	false	false
Battery	yes	yes
Solar energy	yes	yes

Invalidate the documents

The prototype

Example



The image displays three overlapping browser windows illustrating a web application prototype. The top window, titled "Calculators-20088", shows a list of features: "Calculators-20088", "Features", "Battery", and "Electric current". The bottom-left window, titled "citizen-fc600-en", shows a modal dialog box titled "Add" with the text "true" and "Ok" and "Cancel" buttons. The bottom-right window, titled "palsonik-k1216-en", shows a list of features: "Calculators-20088", "Features", "Battery", "Electric current", "Model", "Printing functionality", "Scientific", "Solar energy", and "Tilted display".

We can add the missing element

The prototype

Example



The image displays three overlapping browser windows from Firefox, each showing a Wikitext document. The top window, titled 'Calculators-20088', shows a table with the following features:

Calculators-20088	
Features	
Battery	yes
Electric current	yes

The bottom-left window, titled 'citizen-fc600-en', shows a document with the title 'Calculators-20088' and a table of features:

Calculators-20088	
Features	
Model	FC600
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	true

The bottom-right window, titled 'palsonik-k1216-en', shows a document with the title 'Calculators-20088' and a table of features:

Calculators-20088	
Features	
Model	K1216
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	false

All three windows show a 'Valid' status and links for 'edit' and 'template'.

Documents are now valid again

The prototype

Example



The screenshot illustrates a web browser window displaying a prototype for 'Calculators-20088'. A dialog box titled 'Add' is open, showing a form with the following fields:

- name:
- Display type
- Enum (dropdown menu)
- mandatory

Buttons for 'Ok' and 'Cancel' are visible at the bottom of the dialog. A 'submit' button is also present at the bottom left of the dialog.

The background shows two browser windows. The left window, titled 'citizen-fc600-en', displays a 'Valid' status and a 'Features' table for 'Calculators-20088'. The right window, titled 'k1216-en', displays a 'Features' table for 'Calculators-20088'.

Calculators-20088	
Features	
Model	FC600
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	true

Calculators-20088	
Features	
Model	K1216
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	false

We add a not mandatory single choice element ...

The prototype

Example



Calculators-20088

Features	
Model	FC600
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	true

Calculators-20088

Features	
Model	K1216
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	false

... and its valid values

The prototype

Example



The image displays three browser windows illustrating a prototype system. The top window shows a 'Calculators-20088' page with a 'Features' section containing a list of features with checkboxes. The bottom-left window shows a 'citizen-fc600-en' page with a 'Valid' status and a table of features. The bottom-right window shows a 'palsonik-k1216-en' page with a 'Valid' status and a table of features.

Calculators-20088 Features

- Battery
- Electric current
- Model
- Printing functionality
- Solar energy
- Tilted display
- Scientific
- Display type
- segment
- dot matrix

citizen-fc600-en

Valid

[edit](#)
[template](#)

Calculators-20088	
Features	
Model	FC600
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	true

palsonik-k1216-en

Valid

[edit](#)
[template](#)

Calculators-20088	
Features	
Model	K1216
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	false

Documents are still valid

The prototype

Example



The screenshot shows a web browser window with the URL `wikitest:8080/template/Show/Calcul`. The main content area displays a form titled "Calculators-2008S" with a "Features" section. The features are listed as follows:

Feature	Status
Battery	<input checked="" type="checkbox"/>
Electric current	<input checked="" type="checkbox"/>
Model	<input checked="" type="checkbox"/>
Printing functionality	<input checked="" type="checkbox"/>
Solar energy	<input checked="" type="checkbox"/>
Tilted display	<input checked="" type="checkbox"/>
Scientific	<input checked="" type="checkbox"/>
Display type	<input type="checkbox"/>
segment	<input type="checkbox"/>
dot matrix	<input type="checkbox"/>

Below the form, there is a "submit" button. To the left, another browser window shows the rendered document titled "citizen-fc600-en" with a "Valid" status and a "submit" button. To the right, a third browser window shows the document in edit mode, with the "Features" section and a "submit" button. The "submit" button in this window is labeled "submit 1 operations".

We can add the optional element to a document.

The prototype

Example



citizen-fc600-en

Valid

[edit](#)
[template](#)

Calculators-20088	
Features	
Model	FC600
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	true

submit

palsonik-k1216-en

Valid

[edit](#)
[template](#)

Calculators-20088	
Features	
Model	K1216
Printing functionality	false
Tilted display	false
Electric current	false
Battery	yes
Solar energy	yes
Scientific	false
Display type	segment

And all is still valid

- ① introduce a recommender system in order to rank wiki pages and stimulate users to improve their content;
- ② extend the recommender system to evaluate users' work;
- ③ introduce a policy mechanism that allow wiki administrators to define users' access control, for example
 - only a user who edit more than 100 document can edit a template;
 - only a user that has got an high rate can delete a template;
- ④ study and develop a more powerful update language;