ModelDoc: Auto-generated, Auto-regenerated Wiki-Based Database Documentation

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ABSTRACT
Software developers often find databases difficult to work with because they are not documented properly. When documentation does exist, it is often inaccurate, out-of-date, and/or unclear. In this paper, we present ModelDoc – an extension on MediaWiki – as a new approach to documenting databases and, potentially, other aspects of an application. ModelDoc will auto-generate documentation from a live data source, and it then continually auto-regenerates that documentation as the data source changes. The documentation is consistent and kept up-to-date, but also exists along the standard wiki functionality, allowing collaboration throughout the evolution of the database.

Categories and Subject Descriptors
H.4 [**Information Systems Applications**]: Miscellaneous; D.2.7 [**Software Engineering**]: Distribution, Maintenance, and Enhancement

General Terms
wiki, database, database schema evolution, documentation, auto-generated documentation

1. INTRODUCTION
The problem of software documentation is well-known but rarely explored. Documentation is often missing, or when it does exist, it is out-of-date, incomplete, and/or simply inaccurate. There are countless reasons for this lack of documentation–an absence of technical writers on a team, a perception that documentation is optional and only to be done during "free time", the intractability of documenting a large legacy system, etc. – but they can usually be summed up as: documentation is not easy to write and maintain. Even when documentation is created initially, as the project changes it falls out of date, making it harder to change the project further, often leading to project stagnation or failure [12] [15].

Collaborative documentation is also increasingly important. Contemporary software projects are almost never individual endeavors. Projects often have large teams of developers working on them, and these developers have different perspectives and sets of knowledge. Further, teams are increasingly inter-disciplinary. The project that inspired ModelDoc was made up of developers, mechanical, electrical, and structural engineers, so it cannot be properly understood without specialized descriptions from all these players.

The challenge of maintaining documentation throughout the evolution of a project compounds these challenges. Software is constantly updated and changed, and the documentation needs to be updated to reflect these changes. Outdated documentation is often worse than a lack of documentation, as bad assumptions about the behavior of code can result in more wasted time than when a developer is forced to derive code's behavior from the code itself.

Databases are particularly difficult to document well. While it is generally easy to generate documentation from source code, there is little analogous tool-support for databases. The tools that do exist require human attention to manage and maintain, and the generated documentation is not easily collaborated over and consequently lacks perspective. The hampered utility of these documents, coupled with the challenges of a small group of people trying to manually keep this documentation updated – often leads to documentation-stagnation.

Here we present ModelDoc, a MediaWiki ([4]) extension that provides a wiki-based approach to documenting database schemas. The benefits of collaborative documentation via a wiki are well-known, but a development team cannot simply install a wiki and expect documentation to suddenly become easy to maintain. ModelDoc is an attempt to address many of the obstacles between development teams and quality documentation by integrating the classic benefits of creating documentation with a wiki (easy collaboration, versioning, etc.) with auto-generated and auto-synched content.

At the time of this writing, ModelDoc queries metadata from a live database to generate structured wiki pages from that metadata. This design choice is partly due to ease-of-implementation, but it should be noted that today's gigantic, web-accessible databases are expected to be online 24/7, and there are many attempts to reorganize databases while keeping them online [14] [11]. Regardless, ModelDoc can readily be extended to use SQL files, ORM mapping-files, XML files, and perhaps even source code.

2. GOALS / CONTRIBUTIONS
ModelDoc seeks to achieve mutual consistency between a database and its documentation. When someone makes a change to a project's database, the corresponding documentation should be updated in a useful way. Further, people interested in that documentation should be notified of the update so they may investigate/affirm it. The author of a

bit of documentation should be identifiable, and the version-history for documentation should be explorable. Generated data should be clearly presented, and relationships to other data/entities should be clear.

Some of these goals – e.g. versioning, authorship – are accomplished by the underlying wiki. ModelDoc's contribution is its bridging of the benefits wikis have provided static documentation to the dynamic needs of software projects.

An important side-goal has been to provide a platform for future extensions. As implied by the Future Work section, there are multiple promising ways in which this approach could be extended to address other documentation challenges in software development.

3. RELATED WORK

As far as we know, this is the first attempt to utilize a wiki to document a database system.

Industry tools for database documentation have generally taken the approach of having users manually creating and laying out an ER diagram; such is the approach of tools like Microsoft Visio and Omnigroup's Omnigraffle. There is some industry support for the auto-generation and regeneration of database documentation: Visio has some support for keeping an ER diagram in synch with a database's metadata, and SchemaSpy will generate a series of graphical and textual documents based on this metadata. However, these auto-generated diagrams rarely capture the right visual organization that makes such diagrams useful.

There are also tools for auto-generating documentation for non-database work, such as the *Doc family of tools for documenting source code (JavaDoc, PHPDoc, JSDoc, Doxygen, etc). These tools generally, however, produce read-only documentation. JavaDoc, for example, generates HTML files; once generated there can be little collaboration and discussion on whether the business domain has been successfully modeled.

There has been work at creating algorithms for summarizing complex schemas [17] [16], but as with the *Doc tools, this is a read-only view of the schema. These approaches are helpful for querying complex systems, but they assume their users correctly understand what the fields and entities truly *mean*; there still needs to be collaborative documentation and agreement on the semantics of a system, and how/why they have evolved over time.

Algorithms have also been explored for "redocumentation" [13], creating new/different documentation for/from a system, as well as attempts to automate this process [9].

Temporal informatics, the study of how information changes over time (e.g. on the web [7]), is certainly relevant, but has not yet been applied specifically to software documentation, and the obstacles and issues surrounding documentation's evolution over time.

4. MODELDOC

ModelDoc extends MediaWiki's existing functionality through MediaWiki's standard extension framework. ModelDoc currently works with Postgres databases, but features an extension API for interfacing with other entity-relational data sources, and potentially non-relational database data sources as well.

4.1 Overview

ModelDoc is MediaWiki extension, built using PHP5 and deployed into an existing MediaWiki installation using the standard procedure. Unlike wikis that encourage more open collaboration, though, a ModelDoc-enabled wiki for a proprietary project will likely involve stronger security considerations.

Database metadata is obtained via live database connections. A single ModelDoc installation can work with an arbitrary number of databases – the configuration for these connections is stored in a special ModelDoc wiki page (see Special Pages).

Members of a project use the wiki in the standard way, collaborating through the creation and updating of wiki pages. All the standard wiki-functionality is maintained and encouraged: version-history for pages, using the "discussion" pages for meta-documentation of a page, "watching" pages to be notified when they are updated, etc.

ModelDoc extends MediaWiki, however, with special tags that users can use when creating documentation. For example, by adding an "entity-list" tag to a page, and specifying a data source (see Tags section), when later viewing that page, ModelDoc will query the data source and generate a list of the tables in that database. Further, each entry in this list will be a link to a ModelDoc-generated page containing the table's metadata (columns, constraints, etc.) and documentation.

For each of these entity-pages, ModelDoc also creates a corresponding HISTORY page containing – in XML format – the last-seen set of metadata for the table. This metadata is compared to the live data every time the tag generates content; ModelDoc compares this information to see what has been added and what is missing, and appends these changes to the respective pages. Thus, when viewing an entity-page, the user sees not only the current information for the database table, but also an auto-generated history of how that table has evolved over time. These sections are editable, the project members can (and are encouraged to – see the Special Pages section for "ModelDoc::To Document") update/replace these sections with documentation that is more comprehensive and user-friendly.

4.2 Data Sources

In ModelDoc, a data source represents a resource that contributes information about the model of an application – currently Postgres and MySQL databases, but potentially data sources ranging from other relational databases to XML files to annotated source code to other wiki pages. ModelDoc queries metadata from data sources for information about the entities, and then monitors the data sources for changes to those entities.

Each data source may contribute its own set of entities. Currently, data sources are considered independent of each other, and it is further assumed that a database table represents a single database entity. A possible extension is to follow the example of object-relational mappers and provide a way to map an entity to multiple database tables, or a database table to multiple entities.

For example, consider a "Person" entity. In a properly-normalized database, chances are that the information that constitutes a "Person" will be spread out over multiple tables, such as an "Address" table. ModelDoc currently requires that these be considered separate entities in the documentation.

4.3 Versioning

For each entity, ModelDoc automatically generates a companion read-only page that maintains the entity's history. This companion page maintains XML-based metadata on the entity.

Whenever an entity is viewed, the metadata from its version page is compared to the current information from the data source itself. If there are differences between the two, the version-page is updated to reflect the current state of the model.

Because ModelDoc is based on MediaWiki, the architecture natively supports a publish-subscribe mechanism when pages are updated. That is, when a page is updated, a list of people "watching" that page can optionally be e-mailed about the change. The relevant developers, then, can be auto-subscribed to the version-page for the entities they work with, and whenever a change is detected, those developers may be e-mailed about the change and therefore encouraged to offer a human-readable description of the change.

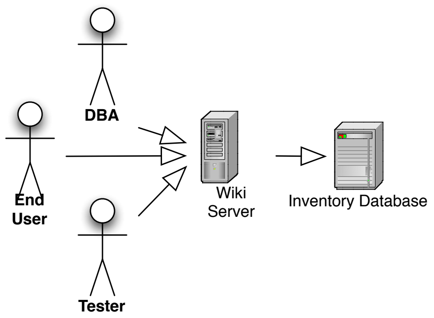


Figure 1: Overview of a sample ModelDoc system.

4.4 Plugin Architecture

ModelDoc features a plugin architecture to allow for easy extension. To utilize a new data source, for example, one need only create a new implementation of the data source API and plug that in.

The immediate use case for this is getting ModelDoc to work with databases that are not currently supported (e.g. Microsoft SQL Server). There is no standard way of accessing metadata in database management systems, and so each

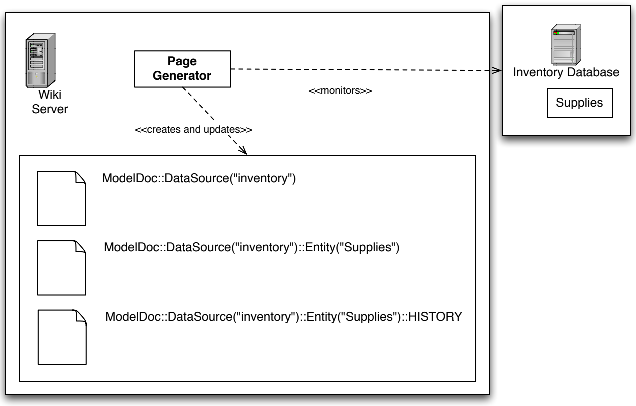


Figure 2: The role of ModelDoc's page-manager component.

DBMS requires an adapter in ModelDoc in order to present a consistent interface.

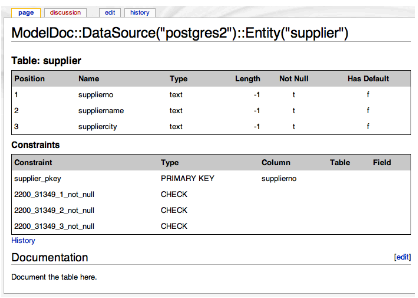
However, this plugin architecture may also be used to create abstractions on top of data sources. For example, as previously discussed, an application may not have a simple "table = entity" design. The components of a Person entity, for example, may be normalized over several tables. In turn, these tables may not be located in the same data source. Perhaps some components are in a Postgres database, while other components are in a MySQL database located elsewhere. A custom data source coupled with some metadata could provide a way to relate datasources together and document distributed entities.

4.5 Usage

4.5.1 Tags

Here is a rundown of the user-facing tags that ModelDoc provides. These tags can be added to any wiki page and will be generated with the appropriate dynamic content.

<entity-info datasourcename="" entityname="" /> Generates a table in the wiki-page that contains the database table's metadata, including not-null constraints and i containing



page | discussion | edit | history

ModelDoc::DataSource("postgres2")::Entity("supplier")

Table: supplier

Position	Name	Type	Length	Not Null	Has Default
1	supplierno	text	-1	t	f
2	suppliername	text	-1	t	f
3	suppliercity	text	-1	t	f

Constraints

Constraint	Type	Column	Table	Field
supplier_pkey	PRIMARY KEY	supplierno		
2200_31349_1_not_null	CHECK			
2200_31349_2_not_null	CHECK			
2200_31349_3_not_null	CHECK			

History

Documentation [edit]

Document the table here.

Figure 3: A generated entity-info page.

<entity-list datasourcename="" /> Generates a table containing links to the entity-info page for each table in the specified data source, as well as a link to the page documenting the data source itself (which also contains this table).

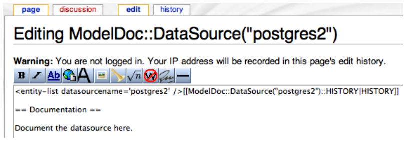


Figure 4: A generated entity-list (data source) page.

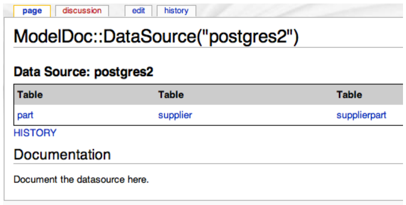


Figure 5: The source of a generated entity-list (data source) page.

<datasource-info datasourcename="" /> Generates metadata on the specified data source

<datasource-list /> Generates a list of links to the datasource-info pages for all the registered data sources.

4.6 Special Pages

ModelDoc::Configuration This wiki-page contains XML specifying the data sources the wiki should be connected to.

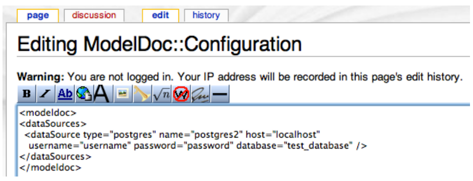


Figure 6: Example of the XML-based configuration page.

ModelDoc::To Document This page maintains a "todo"-list for developers. While we cannot automatically judge whether a change has properly been documented, we can track whether the page for a table has been documented since the table was last updated. We currently only track whether the page has been updated at all, but this could be extended to further require that a certain type of user (e.g. the database administrator), or a set of users (e.g. the DBA as well as the UI designer and test writer) have viewed/updated the content. This serves to help avoid documentation becoming stale because a developer changed code while forgetting to look at the accompanying comments.

ModelDoc::DataSource("[name]") This page provides links to all the entities found in that data source. This is also where users would provide documentation of the data source itself.

If changes to the data source are detected, an automated and editable description of the change is appended to this page (and any designated users are notified by e-mail).

A corresponding **ModelDoc::. . . ::HISTORY** page is created along with this page that contains an XML description of the last-seen metadata for the data source, including its list of tables. This is the baseline that ModelDoc compares the live database metadata to in order to detect changes.

ModelDoc::DataSource. . . ::Entity. . . This page displays the table's metadata, and provides a place for users to document the table.

If changes to the table's metadata are detected (e.g. an added/removed column, a changed constraint, etc.), an automated and editable description of the change is appended to this page (and any designated users are notified by e-mail).

As above, a corresponding **ModelDoc::. . . ::HISTORY** page stores the last-seen version of the table's metadata.

5. EVALUATION

The performance overhead of using ModelDoc, examined in the next section, cannot be ignored, though much of that overhead are a consequence of implementation details that should be straightforward to overcome. We also evaluate the utility of ModelDoc by looking at defined database refactorings and how ModelDoc would document them.

5.1 Performance

ModelDoc degrades the performance of a wiki in two primary ways: the disabling of wiki-caching and the overhead of determining if a table has been updated (and if so, updating the relevant pages). Both of these issues can be mitigated.

By default, MediaWiki uses an aggressive caching strategy. Once a page has been created/edited, the page is maintained in a cache for subsequent reads. This makes sense for the classical wiki-approach, wherein users edit static content. ModelDoc, however, currently requires that caching be disabled, so that the content that a dynamic tag generates is not cached. For example, every time an entity-page is viewed, the corresponding table in the database is examined and, if it has been updated, the page is updated to reflect this. If MediaWiki were allowed to cache this, the displayed data could fall out of synch with the underlying database.

The algorithm for comparing table-metadata can add substantially to the loading-time of a page. The worst-case is the very first time a page is viewed that contains an "entity-list" tag for a data source. In this initial case, the info/history pages for all the database tables are created. Against a ModelDoc installation on a MacbookPro (2.8 GHz Intel Core 2 Duo, 4 GB 1067 MHz DDR3), using a database with 96 tables with an average of 7.3 columns and 2.8 constraints per table, this initial process took an average of 4.08 minutes. Fortunately, this only happens the first time, and this should be done when ModelDoc is first installed by the administrator.

Thereafter, viewing an "entity-list" page took an average of 33.36 seconds. The difference is that wiki pages are not often being created/edited at that point – the bottleneck is primarily the database connections for retrieving the current metadata, and retrieving the previously-cached metadata XML for the table from its respective HISTORY wiki page.

Viewing an "entity-info" page – and therefore refreshing the version-information for only a single table, rather than for all of them – took an average of 5.6 seconds.

We are in the process of moving this work into a background process that will almost entirely mitigate these issues. For many projects, a page being a maximum of an hour, or even a day, outdated should be sufficient, especially if the time-of-last-update is clearly displayed on the page. Further, it would then be a minor implementation detail to allow privileged users to kick off the versioning-process manually at any time, so they could guarantee current data when necessary.

5.2 Usage

We can use refactorings from [8] to both illustrate where ModelDoc currently stands and where it can go with regard to where it can be used in a database's evolution.

Any refactoring that reduces to the addition/drop of a table, column, or constraint, are currently detected by ModelDoc.

The renaming of a table, for example, will be tracked by ModelDoc, but it will be reflected as a table-deletion and a table-addition. Similarly, "moving" a column from one table to another will look like a column-removal and a column-addition.

Table 1 and Table 2 enumerate through the refactorings in [8], indicating whether a refactoring will be indicated in a reasonably straightforward way (indicated with ✓, e.g. "Drop Column"), the refactoring will be indirectly and/or poorly captured (indicated with *, e.g. "Merge Columns", since this could ambiguously appear as either a column deletion-and-addition, or simply a deletion), or the refactoring will (essentially, at least) not be detected at all by ModelDoc.

As indicated, while ModelDoc documents structural changes well, it does not capture refactorings that deal with the data itself, such as new semantics or data-formats. Further, ModelDoc does not detect refactorings that are made up of both column and table changes, such as the "Replace Type Code With Property Flags" refactoring, which entails replacing a single "code"-type column with multiple boolean columns, e.g. replacing an "AddressType" column with "isHomeAddress", "isWorkAddress", etc. columns. ModelDoc also clearly needs to be extended to monitor stored procedures.

6. FUTURE WORK

6.1 Database Visualization

ModelDoc, being wiki-based, offers a web-flavored view of an application's model. To see how two entities are interrelated, users can examine the hyperlinks between the two. This can offer a very limited window, however, when an application's entity-relationships make up a complex graph.

ModelDoc may be extended to incorporate better ways to understand and work with the data. For example, graph-visualization software, such as Graphviz [2] or SchemaSpy [5], could be incorporated to better-indicate where an entity fits in the larger scheme.

Table 1: Structural Refactorings

Refactoring	Detected
Drop Column	✓
Drop Table	✓
Drop View	✓
Introduce Calculated Column	*
Introduce Surrogate Key	*
Merge Columns	*
Merge Tables	*
Move Column	✓
Rename Column	✓
Rename Table	✓
Rename View	✓
Replace LOB With Table	
Replace Column	✓
Replace 1-to-Many With Assoc. Tbl	✓
Replace Surrogate Key With Natural Key	*
Split Column	*
Split Table	*

Table 2: Data Quality Refactorings

Refactoring	Detected
Add Lookup Table	*
Apply Standard Codes	
Apply Standard Type	
Consolidate Key Strategy	
Drop Column Constraint	✓
Drop Default Value	✓
Drop Non-Nullable Constraint	✓
Introduce Column Constraint	✓
Introduce Common Format	
Introduce Default Value	✓
Make Column Non-Nullable	✓
Move Data	
Replace Type Code With Property Flags	*

6.2 Heterogeneous Databases

While, at the time of this writing, a single ModelDoc installation can support multiple databases, there is no automatic inter-linking between the documentation generated between those databases. An obvious challenge is that since these data sources are created separately, the relationship between the data in each cannot easily be inferred. There has been some work on auto-generating a user-friendly visualization of heterogeneous database systems like this [10].

6.3 Inferring ModelDoc Semantics From User Documentation

To achieve mutual-consistency between the human documentation and the database metadata, ModelDoc could be extended to infer, for example, that a user is referring to a given entity even on a non-ModelDoc page. If that entity is updated, ModelDoc could then notify the user that this other documentation may also need to be updated.

6.3.1 Higher-Level Model Descriptions

Table 3: Referential Integrity Refactorings

Refactoring	Detected
Add Foreign Key Constraint	✓
Add Trigger For Calculated Column	✓
Drop Foreign Key Constraint	✓
Introduce Cascading Delete	*
Introduce Hard Delete	
Introduce Soft Delete	*
Introduce Trigger For History	*

Table 4: Architectural Refactorings

Refactoring	Detected
Add CRUD Methods	
Add Mirror Table	
Add Read Method	
Encapsulate Table With View	*
Introduce Calculation Method	
Introduce Index	✓
Introduce Read-Only Table	
Migrate Method From Database	
Migrate Method To Database	
Replace Method(s) With View	
Replace View With Method(s)	
Use Official Data Source	

The model of an application is rarely exclusively contained in the database schema. Most applications contain an object model that abstracts on top of the data model. For example, as previously discussed, in a database a Person entity and its associated Address may be normalized into two tables. In the object-oriented application, however, this relationship would take the form of a Person object composed with an Address object.

While a DBA may be more interested in the database-view of the model, the application developers (and perhaps the end-users as well) could stand to benefit more from documentation at the object-abstraction level.

ModelDoc should be extended to document models at the source code level, similar to Doxygen and JavaDoc solutions – in fact, these other approaches could likely simply be integrated. By further incorporating version-control and IDE

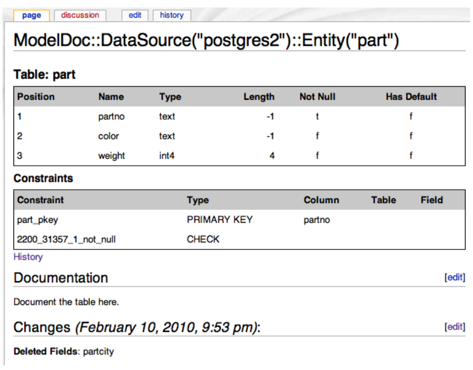


Figure 7: The entity-info page after a dropped column is detected

Table 5: Transformations

Refactoring	Detected
Insert Data	
Introduce New Column	✓
Introduce New Table	✓
Introduce View	✓
Update Data	

Figure 8: The result of a column-rename

support, this could become a very powerful tool for documenting source code.

See the "Architectural Refactorings" table for further motivation for extending support for taking the higher-level application layers into account: some refactorings involve corresponding changes at multiple levels, and it should be possible to clearly document these changes.

6.4 Semantic Structure

Currently, the data in the pages created by ModelDoc are semi-structured. If ModelDoc were extended to work with heterogeneous data sources, and also to document multiple levels of abstraction, we would be providing a common semi-structure to all these sources. This could allow for semantic querying of this data, similar to other semantic querying approaches such as that of WolframAlpha [6].

6.5 Ability to Mutate Data Sources

There is little current tool-support for performing database refactoring [8]. Instead of documenting in a read-only way, ModelDoc could be used to allow mutation of the underlying data sources, including carrying out complex refactorings. This would allow ModelDoc to know for sure that such refactorings were intended – a column-rename, for example, would no longer be seen as a column-deletion and column-addition.s

7. COMPARISON TO SOURCE CODE DOCUMENTATION GENERATION

Documentation generators such as Doxygen [1] and JavaDoc [3] consume the static-structure of source code along with annotated comments, and produce human-readable output in the form of HTML or PDF.

Relational databases could be extended to allow more meta-documentation to be stored along with the existing meta-data. Column names, for example, are often not self-describing. These comments could be used for tooling similar to above generators.

On the other hand, source code documentation generators could be extended to create/update a mini-wiki so that its documentation could be collaboratively documented.

8. CONCLUSIONS

Motivated by the widespread lack of quality documentation, and the consequences of that lack, we presented ModelDoc. Combining the collaborative documentation capabilities of MediaWiki with custom extensions, ModelDoc continuously maintains a baseline level of documentation that is guaranteed to be in synch with the database in use.

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