SQLite vs MySQL vs PostgreSQL: A Comparison Of Relational Database Management Systems

Updated March 19, 2019 1.3m MYSQL POSTGRESQL CONCEPTUAL DATABASES

By ostezer and Mark Drake
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Introduction

The *relational data model*, which organizes data in tables of rows and columns, predominates in database management tools. Today there are other data models, including NoSQL and NewSQL, but relational database management systems (RDBMSs) remain dominant for storing and managing data worldwide.

This article compares and contrasts three of the most widely implemented open-source RDBMSs: SQLite, MySQL, and PostgreSQL. Specifically, it will explore the data types that each RDBMS uses, their advantages and disadvantages, and situations where they are best optimized.

A Bit About Database Management Systems

Databases are logically modelled clusters of information, or *data*. A *database*

All database management systems have an underlying model that structures how data is stored and accessed. A relational database management system is a DBMS that employs the relational data model. In this model, data are organized into tables, which

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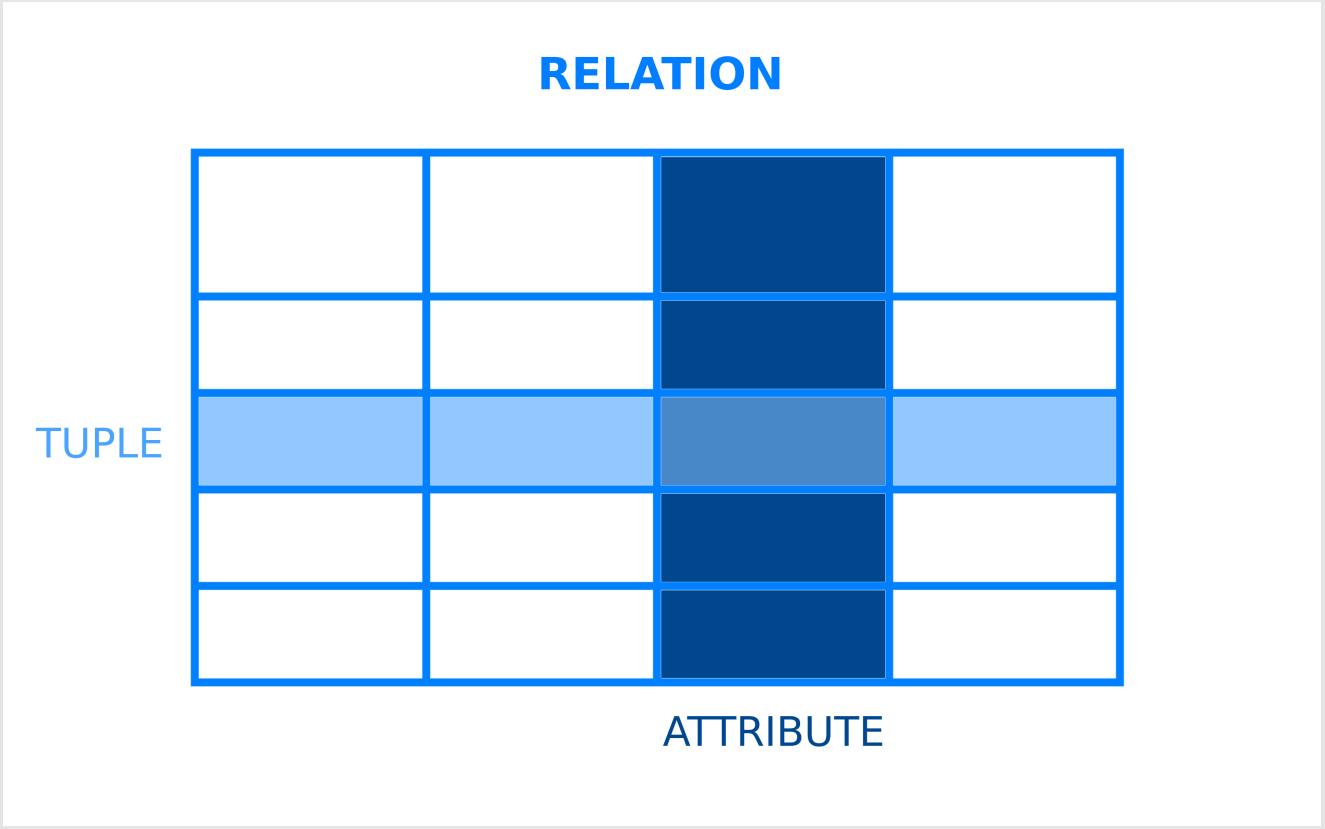
ns:



Most relational databases use *structured query language* (SQL) to manage and query data. However, many RDBMSs use their own particular dialect of SQL, which may have certain limitations or extensions. These extensions typically include extra features that allow users to perform more complex operations than they otherwise could with standard SQL.

Note: The term “standard SQL” comes up several times throughout this guide. SQL standards

standard, although some do come closer to full compliance than others.

allowed in always directly interchangeable. Some common data types include dates, strings, integers, and Booleans.

Numeric data types can either be *signed*, meaning they can represent both positive and negative numbers, or *unsigned*, which means they can only represent positive numbers. For example, MySQL's `tinyint` data type can hold 8 bits of data, which equates to 256 possible values. The signed range of this data type is from -128 to 127, while the unsigned range is from 0 to 255.

Sometimes, a database administrator will impose a *constraint* on a table to limit what values can be entered into it. A constraint typically applies to one particular column, but some constraints can also apply to an entire table. Here are some constraints that are commonly used in SQL:

- `UNIQUE`: Applying this constraint to a column ensures that no two entries in that column are identical.
- `NOT NULL`: This constraint ensures that a column doesn't have any `NULL` entries.
- `PRIMARY KEY`: A combination of `UNIQUE` and `NOT NULL`, the `PRIMARY KEY` constraint ensures that no entry in the column is `NULL` and that every entry is distinct.
- `FOREIGN KEY`: A `FOREIGN KEY` is a column in one table that refers to the `PRIMARY KEY` of another table. This constraint is used to link two tables together: entries to the `FOREIGN KEY` column must already exist in the parent `PRIMARY KEY` column for the write process to succeed.
- `CHECK`: This constraint limits the range of values that can be entered into a column. For

- `INDEX`: Used to help retrieve data from a table more quickly, this constraint is similar to an index in a textbook: instead of having to review every entry in a table, a query only has to review entries from the indexed column to find the desired results.

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els.

Now that we've covered relational database management systems generally, let's move onto the first of the three open-source relational databases this article will cover: SQLite.

SQLite

SQLite is a self-contained, file-based, and fully open-source RDBMS known for its portability, reliability, and strong performance even in low-memory environments. Its transactions are ACID-compliant, even in cases where the system crashes or undergoes a power outage.

The SQLite project's website describes it as a "serverless" database. Most relational database engines are implemented as a server process in which programs communicate with the host server through an interprocess communication that relays requests. With SQLite, though, any process that accesses the database reads from and writes to the database disk file directly. This simplifies SQLite's setup process, since it eliminates any need to configure a server process. Likewise, there's no configuration necessary for programs that will use the SQLite database: all they need is access to the disk.

SQLite is free and open-source software, and no special license is required to use it. However, the project does offer several extensions — each for a one-time fee — that help with compression and encryption. Additionally, the project offers various

Data Type	Explanation
`null`	Includes any `NULL` values.
`real`	Real numbers, or floating point values, stored as 8-byte floating point numbers.
`text`	Text strings stored using the database encoding, which can either be UTF-8, UTF-16BE or UTF-16LE.
`blob`	Any blob of data, with every blob stored exactly as it was input.

In the context of SQLite, the terms “storage class” and “data type” are considered interchangeable. If you’d like to learn more about SQLite’s data types and SQLite type affinity, check out SQLite’s official documentation on the subject.

Advantages of SQLite

- **Small footprint**: As its name implies, the SQLite library is very lightweight. Although the space it uses varies depending on the system where it’s installed, it can take up less than 600KiB of space. Additionally, it’s fully self-contained, meaning there aren’t any external dependencies you have to install on your system for SQLite to work.
- **User-friendly**: SQLite is sometimes described as a “zero-configuration” database that’s ready for use out of the box. SQLite doesn’t run as a server process, which means that it never needs to be stopped, started, or restarted and doesn’t come with any configuration files that need to be managed. These features help to streamline the path from installing SQLite to integrating it with an application.
- **Portable**: Unlike other database management systems, which typically store data as a large batch of separate files, an entire SQLite database is stored in a single file. This file can be located anywhere in a directory hierarchy, and can be shared via removable

embedded database management systems, but not as much as client/server RDBMSs like MySQL or PostgreSQL.

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d tables.
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erating
system. This makes SQLite a poor choice for applications that require multiple users with special access permissions.

- **Security**: A database engine that uses a server can, in some instances, provide better protection from bugs in the client application than a serverless database like SQLite. For example, stray pointers in a client cannot corrupt memory on the server. Also, because a server is a single persistent process, a client-server database cancontrol data access with more precision than a serverless database, allowing for more fine-grained locking and better concurrency.

When To Use SQLite

- **Embedded applications**: SQLite is a great choice of database for applications that need portability and don't require future expansion. Examples include single-user local applications and mobile applications or games.
- **Disk access replacement**: In cases where an application needs to read and write files to disk directly, it can be beneficial to use SQLite for the additional functionality and simplicity that comes with using SQL.
- **Testing**: For many applications it can be overkill to test their functionality with a DBMS that uses an additional server process. SQLite has an in-memory mode which can be used to run tests quickly without the overhead of actual database operations, making it an ideal choice for testing.

When Not To Use SQLite

- **Working with lots of data**: SQLite can technically support a database up to 140TB in

- **Network access is required**: Because SQLite is a serverless database, it doesn't provide direct network access to its data. This access is built into the application, so if the data in SQLite is located on a separate machine from the application it will require

ve,
choice.

MySQL

According to the DB-Engines Ranking, MySQL has been the most popular open-source RDBMS since the site began tracking database popularity in 2012. It is a feature-rich product that powers many of the world's largest websites and applications, including Twitter, Facebook, Netflix, and Spotify. Getting started with MySQL is relatively straightforward, thanks in large part to its exhaustive documentation and large community of developers, as well as the abundance of MySQL-related resources online.

MySQL was designed for speed and reliability, at the expense of full adherence to standard SQL. The MySQL developers continually work towards closer adherence to standard SQL, but it still lags behind other SQL implementations. It does, however, come with various SQL modes and extensions that bring it closer to compliance. Unlike applications using SQLite, applications using a MySQL database access it through a separate daemon process. Because the server process stands between the database and other applications, it allows for greater control over who has access to the database.

MySQL has inspired a wealth of third-party applications, tools, and integrated libraries that extend its functionality and help make it easier to work with. Some of the more widely-used of these third-party tools are phpMyAdmin, DBeaver, and HeidiSQL.

MySQL's Supported Data Types

Data Type	Explanation
`tinvint`	A very small integer. The signed range for this numeric data type
	...e is -32768
`mediumint`	A medium-sized integer. The signed range for this numeric data type is -8388608 to 8388607, while the unsigned range is 0 to 16777215.
`int` or `integer`	A normal-sized integer. The signed range for this numeric data type is -2147483648 to 2147483647, while the unsigned range is 0 to 4294967295.
`bigint`	A large integer. The signed range for this numeric data type is -9223372036854775808 to 9223372036854775807, while the unsigned range is 0 to 18446744073709551615.
`float`	A small (single-precision) floating-point number.
`double`, `double precision`, or `real`	A normal sized (double-precision) floating-point number.
`dec`, `decimal`, `fixed`, or `numeric`	A packed fixed-point number. The display length of entries for this data type is defined when the column is created, and every entry adheres to that length.
`bool` or `boolean`	A Boolean is a data type that only has two possible values, usually either `true` or `false`.
`bit`	A bit value type for which you can specify the number of bits per value, from 1 to 64.

Data Type	Explanation
`datetime`	A timestamp showing the date and time, displayed as
	...och
`time`	A time of day, displayed as `HH:MM:SS`.
`year`	A year expressed in either a 2 or 4 digit format, with 4 digits being the default.

String types:

Data Type	Explanation
`char`	A fixed-length string; entries of this type are padded on the right with spaces to meet the specified length when stored.
`varchar`	A string of variable length.
`binary`	Similar to the `char` type, but a binary byte string of a specified length rather than a nonbinary character string.
`varbinary`	Similar to the `varchar` type, but a binary byte string of a variable length rather than a nonbinary character string.
`blob`	A binary string with a maximum length of 65535 (2^16 - 1) bytes of data.
`tinyblob`	A `blob` column with a maximum length of 255 (2^8 - 1) bytes of data.
`mediumblob`	A `blob` column with a maximum length of 16777215 (2^24 - 1) bytes of data.
`longblob`	A `blob` column with a maximum length of 4294967295 (2^32 - 1) bytes of data

Data Type	Explanation
`longtext`	A `text` column with a maximum length of 4294967295 (2^32 - 1)
	alue from a
`set`	Similar to an enumeration, a string object that can have zero or more values, each of which must be chosen from a list of allowed values that are specified when the table is created.

Advantages of MySQL

- **Popularity and ease of use**: As one of the world's most popular database systems, there's no shortage of database administrators who have experience working with MySQL. Likewise, there's an abundance of documentation in print and online on how to install and manage a MySQL database, as well as a number of third-party tools — such as phpMyAdmin — that aim to simplify the process of getting started with the database.
- **Security**: MySQL comes installed with a script that helps you to improve the security of your database by setting the installation's password security level, defining a password for the **root** user, removing anonymous accounts, and removing test databases that are, by default, accessible to all users. Also, unlike SQLite, MySQL does support user management and allows you to grant access privileges on a user-by-user basis.
- **Speed**: By choosing not to implement certain features of SQL, the MySQL developers were able to prioritize speed. While more recent benchmark tests show that other RDBMSs like PostgreSQL can match or at least come close to MySQL in terms of speed, MySQL still holds a reputation as an exceedingly fast database solution.
- **Replication**: MySQL supports a number of different types of *replication*, which is the practice of sharing information across two or more hosts to help improve reliability,

- **Licensing and proprietary features**: MySQL is *dual-licensed* software, with a free and open-source community edition licensed under GPLv2 and several paid commercial editions released under proprietary licenses. Because of this, some features and

systems in 2008, and later by Oracle Corporation in 2009, there have been complaints from users that the development process for the DBMS has slowed down significantly, as the community no longer has the agency to quickly react to problems and implement changes.

When To Use MySQL

- **Distributed operations**: MySQL's replication support makes it a great choice for distributed database setups like primary-secondary or primary-primary architectures.
- **Websites and web applications**: MySQL powers many websites and applications across the internet. This is, in large part, thanks to how easy it is to install and set up a MySQL database, as well as its overall speed and scalability in the long run.
- **Expected future growth**: MySQL's replication support can help facilitate horizontal scaling. Additionally, it's a relatively straightforward process to upgrade to a commercial MySQL product, like MySQL Cluster, which supports automatic sharding, another horizontal scaling process.

When Not To Use MySQL

- **SQL compliance is necessary**: Since MySQL does not try to implement the full SQL standard, this tool is not completely SQL compliant. If complete or even near-complete SQL compliance is a must for your use case, you may want to use a more fully compliant DBMS.
- **Concurrency and large data volumes**: Although MySQL generally performs well with read-heavy operations, concurrent read-writes can be problematic. If your application will have many users writing data to it at once, another RDBMS like PostgreSQL might

PostgreSQL, also known as Postgres, bills itself as "the most advanced open-source relational database in the world." It was created with the goal of being highly extensible and standards compliant. PostgreSQL is an object-relational database, meaning that

databases.

Postgres is capable of efficiently handling multiple tasks at the same time, a characteristic known as *concurrency*. It achieves this without read locks thanks to its implementation of Multiversion Concurrency Control (MVCC), which ensures the atomicity, consistency, isolation, and durability of its transactions, also known as ACID compliance.

PostgreSQL isn't as widely used as MySQL, but there are still a number of third-party tools and libraries designed to simplify working with with PostgreSQL, including pgAdmin and Postbird.

PostgreSQL's Supported Data Types

PostgreSQL supports numeric, string, and date and time data types like MySQL. In addition, it supports data types for geometric shapes, network addresses, bit strings, text searches, and JSON entries, as well as several idiosyncratic data types.

Numeric types:

Data Type	Explanation
`bigint`	A signed 8 byte integer.
`bigserial`	An autoincrementing 8 byte integer.
`double precision`	An 8 byte double precision floating-point number.

Data Type	Explanation
`smallserial`	An autoincrementing 2 byte integer.

Character types:

Data Type	Explanation
`character`	A character string with a specified fixed length.
`character varying` or `varchar`	A character string with a variable but limited length.
`text`	A character string of a variable, unlimited length.

Date and time types:

Data Type	Explanation
`date`	A calendar date consisting of the day, month, and year.
`interval`	A time span.
`time` or `time without time zone`	A time of day, not including the time zone.
`time with time zone`	A time of day, including the time zone.
`timestamp` or `timestamp without time zone`	A date and time, not including the time zone.
`timestamp with time zone`	A date and time, including the time zone.

Geometric types:

Data Type	Explanation
`lseg`	A line segment on a plane.

`polygon`	A closed geometric path on a plane.

Network address types:

Data Type	Explanation
`cidr`	An IPv4 or IPv6 network address.
`inet`	An IPv4 or IPv6 host address.
`macaddr`	A Media Access Control (MAC) address.

Bit string types:

Data Type	Explanation
`bit`	A fixed-length bit string.
`bit varying`	A variable-length bit string.

Text search types:

Data Type	Explanation
`tsquery`	A text search query.
`tsvector`	A text search document.

Other data types:

Data Type	Explanation
	lse.
	ata.
`money`	An amount of currency.
`pg_lsn`	A PostgreSQL Log Sequence Number.
`txid_snapshot`	A user-level transaction ID snapshot.
`uuid`	A universally unique identifier.
`xml`	XML data.

Advantages of PostgreSQL

- **SQL compliance**: More so than SQLite or MySQL, PostgreSQL aims to closely adhere to SQL standards. According to the official PostgreSQL documentation, PostgreSQL supports 160 out of the 179 features required for full core SQL:2011 compliance, in addition to a long list of optional features.
- **Open-source and community-driven**: A fully open-source project, PostgreSQL's source code is developed by a large and devoted community. Similarly, the Postgres community maintains and contributes to numerous online resources that describe how to work with the DBMS, including the official documentation, the PostgreSQL wiki, and various online forums.
- **Extensible**: Users can extend PostgreSQL programmatically and on the fly through its catalog-driven operation and its use of dynamic loading. One can designate an object code file, such as a shared library, and PostgreSQL will load it as necessary.

Disadvantages of PostgreSQL

fewer third-party tools that can help to manage a PostgreSQL database. Similarly, there aren't as many database administrators with experience managing a Postgres database compared to those with MySQL experience.

- **Data integrity is important**: PostgreSQL has been fully ACID-compliant since 2001 and implements multiversion currency control to ensure that data remains consistent, making it a strong choice of RDBMS when data integrity is critical.
- **Integration with other tools**: PostgreSQL is compatible with a wide array of programming languages and platforms. This means that if you ever need to migrate your database to another operating system or integrate it with a specific tool, it will likely be easier with a PostgreSQL database than with another DBMS.
- **Complex operations**: Postgres supports query plans that can leverage multiple CPUs in order to answer queries with greater speed. This, coupled with its strong support for multiple concurrent writers, makes it a great choice for complex operations like data warehousing and online transaction processing.

When Not To Use PostgreSQL

- **Speed is imperative**: At the expense of speed, PostgreSQL was designed with extensibility and compatibility in mind. If your project requires the fastest read operations possible, PostgreSQL may not be the best choice of DBMS.
- **Simple setups**: Because of its large feature set and strong adherence to standard SQL, Postgres can be overkill for simple database setups. For read-heavy operations where speed is required, MySQL is typically a more practical choice.
- **Complex replication**: Although PostgreSQL does provide strong support for replication, it's still a relatively new feature and some configurations — like a primary-primary architecture — are only possible with extensions. Replication is a more mature feature on MySQL and many users see MySQL's replication to be easier to implement, particularly for those who lack the requisite database and system administration

Today, SQLite, MySQL, and PostgreSQL are the three most popular open-source relational database management systems in the world. Each has its own unique features and limitations, and excels in particular scenarios. There are quite a few

nple as re in need of a relational database solution, be sure to research these and other tools in depth to find the one that best suits your needs.

If you'd like to learn more about SQL and how to use it to manage a relational database, we encourage you to refer to our How To Manage an SQL Database cheat sheet. On the other hand, if you'd like to learn about non-relational (or NoSQL) databases, check out our Comparison Of NoSQL Database Management Systems.

References

- DB-Engines Rankings
- SQLite Official Documentation
- SQLite Is Serverless
- Appropriate Uses For SQLite
- MySQL Official Documentation
- Comparing MySQL and Postgres 9.0 Replication
- PostgreSQL Official Documentation
- Has the time finally come for PostgreSQL?

By ostezer and Mark Drake

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adsfas March 20, 2014

0

nosql comparison link is broken

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Foo March 20, 2014

1

I question the claim that MySQL is "The most popular and commonly used RDBMS". It depends on what you mean by "popular and commonly used", but SQLite is used almost everywhere these days. I honestly don't know how to do anything on my computer or phone today that doesn't use SQLite. It's in iOS and Android, it's in Firefox and Chrome, it's in OS X (and used by every OS X application, indirectly, and several of them directly) and Linux. It's used by Dropbox and Skype and Lightroom and Airbus and pretty much every major software company in the world.

> Yes. SQLite is much more popular than any other database. every Mac OS X and iPhone and iPod and iPad and Android and Skype and Dropbox and Firefox and Chrome and Windows 10 installation comes with SQLite built in, and they try to say MySQL is more

es. MySQL by

> **mounir1003** November 15, 2015
>
> 1
>
> We're talking web apps here, MySql is a mix of complexity and speed, the best for web apps, not the fat slow complex pgsql and not the very simple/fast SQLite, but of corse it depends on apps.
> almost every website/CMS/Framework today uses MySql.
>
> Reply Report

lucas586955 March 20, 2014

2

I would like to point out that the JSON and hstore datatypes in PostgreSQL aren't mentioned, and are extremely useful.

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anon587193 March 20, 2014

3

Please rename "Glossary" to "Table of Contents"

Reply Report

> **msx** February 21, 2015
>
> 0
>
> Thank you for pointing that.
>
> Reply Report

lauris March 20, 2014

1

There was an interesting poll recently. It appears that Postgres is currently more popular among developers than MySQL http://www.databasefriends.co/2014/03/favorite-relational-database.html

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valdis.veidelis+digitalocean March 20, 2014

kiliankoe March 20, 2014

0

It seems you forgot the link where it says

ticle:

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joe587723 March 20, 2014

0

I'd love to see this comparison when using a hosted solution like Amazon's RDS. The reason I say this is that the complexity issues with postgres go away, and I believe you're left with all of the benefits of postgres, and very few of the downsides.

Reply Report

patrick.hetu March 20, 2014

0

"understanding databases" link is broken

Reply Report

milan March 20, 2014

0

Regarding PostgreSQL read performance,
you just need to put some connection pooling on front, and you will solve that problem.

Reply Report

dghaegtrdgasf March 20, 2014

2

"Unless you require absolute data integrity, ACID compliance or complex designs, PostgreSQL can be an over-kill for simple set-ups."

People who don't need those things probably have no business using a database at all. It's shocking how many people think that the average self-hosted Wordpress site is actually dynamic and thus requires a database. The vast majority of things out there using a database are static sites with a silly, over-engineered backend.

Reply Report

trent.lloyd March 21, 2014

3

Reply Report

kamaln7 March 30, 2014

2 As other's have said JSON support in PostgreSQL is a huge benefit over other RDBMS. The fact that I can throw in a simple JSON object and then query against its property fields using a SQL query makes PostgreSQL immensely powerful.

Reply Report

rbmovingforward July 8, 2014

1 Just joined D.O. because of this post. Great information for someone looking to get more familiar with databases. Thanks to everyone who commented as well.

Reply Report

barry244139 July 18, 2014

6 There's a whole lot of things missing from the PostgreSQL benefits section. Just off the top of my head:

Full Text Search

PG has full text search capabilities that rival standalone dedicated search engines like Solr, Sphinx, and Elastic Search. The full text search that exists in MySQL is scary by comparison. If your are only searching data in the database, its the way do go. You don't have to setup and manage another system. You don't have to worry about data syncing issues either or encoding issues transitioning your data from PG to another search engine. It has multiple dictionaries that you can implement all over the place. You can even add your own, weight searchable parts, etc.

Multi Index Queries

This is big and ties into the previous one. By default, PostgreSQL does multi-index queries so when you're creating an index you just add them for individual columns that you will need to search on. You don't need to create an index over multiple fields unless it's there to maintain

PG is extensible and allows the creation of custom data types as well as having 2 types of indexes built for working with those custom data types. JSON and hstore were mentioned earlier and they are the result of this. There are many other custom data types (XML, ISBN, etc) to

x queries...well,

Functions are amazing

Database functions are great for use in queries or manipulating data that comes back, but PostgreSQL takes them to another level. You can you create an index with the results of a function that will automatically get used when the matching function is used in a where clause. Things like a unique index on a lowercase username come to mind. This is extremely helpful if you're working with XML too because you can't index an XML file...but you can index the result of an XPATH function on the XML datatype.

Wasted space is TOASTed

TOAST is the compression layer behind PG's TEXT field types. It automatically zip's large data. I dropped a 2.2 mb XML file in and it stored in as 81 kb.

Stored procedures aren't painful

You can write stored procedures in other languages including Python and Javascript. This makes putting logic that belongs in your database in there a whole lot simpler.

LISTEN/NOTIFY will change your life

Never have a long running process poll for changes to data again. Long running server processes can now hold a connection and let the database tell them when a change happened. These remove your dependence on framework "AFTER SAVE" hooks, which really comes in handy when you need to connect to your database with another language. If it changes in the database, it changes everywhere.

A few quick use cases for this:

- A process that listens for data changes and pushes them to a 3rd party service, statsd, or standalone search engine if needed

ause you can do that with PostgreSQL.

Because of multi-index queries, this means that in one query you can search for basic where conditions, full text, and filter by geospatial parameters like distance. In ONE. DANG. QUERY.

This is off the top of my head. There's a lot more.

Reply Report

iphoon August 21, 2014

0

There is one topic not normally address: using PostgreSQL for analytic or data warehouse. Has anyone experiences to share?

Reply Report

barry244139 August 21, 2014

0

For Big Data or Analytics with PostgreSQL there are a few options:

PostgreSQL + Cassandra and Hadoop
http://www.bigsql.org/se/

MySQL AND PostgreSQL options here:
https://www.infobright.com/index.php/introducing-iee-postgres-edition/

Many of the columnar databases that you'd use for analytics are built to take data from any sources. If you have enough data (pay per TB) to warrant an specialized analytic system it won't be all that big of a concern. That's generally what ETL is for (moving data from it's origin into an analytic system).

For more normalized datasets, PostgreSQL queries are pretty impressive thanks to it's query optimizer. The ability to do multi-index queries is fairly huge in this regard, but every "big data"

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