

MongoDB and HashiCorp: Capabilities for Use in a Zero Trust Environment



What Is Zero Trust?

It wasn't that long ago that security professionals protected their IT in much the same way that medieval guards protected a walled city: They made it as difficult as possible to get inside. But once someone was past the perimeter, they had generous access to the riches contained within. That mindset has changed as users increasingly access networks and applications from any geography, on any device, on platforms hosted in the cloud. Reliance on perimeter security has become increasingly insufficient.

Zero trust presents a new paradigm for cybersecurity. In a zero trust environment, the perimeter is assumed to have been breached. There are no trusted users, and no user nor device gains trust simply because of its physical or network location. Every user, device, and connection must be continually verified and audited. The creator of zero trust, security expert John Kindervag, summed up the approach: "Never trust, always verify."

Because databases contain so much of an organization's sensitive (and regulated) information, as well as data that may not be sensitive but is critical to keeping the organization running, it's imperative that your database is ready and able to work in a zero trust environment.

That means the database must be secure by default, and it needs to limit users' opportunities

to make it less secure. It must support a wide range of tools to allow users to authenticate themselves to the database. Fine-grained, role based access controls must govern what a user is allowed to do – or not do – once they've been authenticated. And the database should have auditing capabilities to ensure that administrators can track suspicious or unexpected behavior by event, user, or role.

Additional technologies, notably encryption, are necessary to support the successful implementation of zero trust. The National Institute of Standards and Technology (NIST) wrote a [2020 paper](#) on Zero Trust Architecture, which was cited in President Joe Biden's [executive order](#) on cybersecurity; it specifically mentions data protections as a component of zero trust architecture.

We will primarily focus on how MongoDB's native functionality & HashiCorp's Zero Trust suite of products improve an organization's security posture.

There are several crucial aspects of performance in a zero trust environment: security by default; limited and controlled connectivity to the internet; robust authentication for all users; similar control over user authorizations; and encryption and redaction capabilities that can strictly limit access to certain data.



MongoDB and HashiCorp - Secure by Default

A database that is secure by default, such as MongoDB, will be secure out of the box. This takes some of the responsibility for security out of the hands of users. The highest levels of security are in place from the start, without requiring attention – or even knowledge – from users or administrators. To allow access, users and administrators must proactively make changes. No one is automatically granted access because of rank or role.

In the case of MongoDB, secure by default means, in part, that Atlas clusters do not allow for any connectivity to the internet when they're first spun up. Each dedicated Atlas cluster is deployed in a unique virtual private cloud (VPC) configured to prohibit inbound access. (Free and shared Atlas clusters do not support VPCs.) The only way to access these clusters is through the Atlas interface. Users can configure IP access lists to allow certain addresses to attempt to authenticate to the database. Without being included on such a list, application servers are unable to access the database. Even the person who sets up the clusters needs to add their IP address to the access list.

Atlas also allows customers to set up temporary access lists with predetermined expiration dates. This can be helpful when a team member needs access from a temporary work location.

In the case of HashiCorp, Zero trust security is predicated on securing everything based on trusted identities. These are the four foundational categories for identity-driven controls and zero trust security:

1. [HashiCorp Vault](#) is an identity-based security product that centers around enabling enterprises, teams, and individuals to manage secrets and protect sensitive data.

Vault was built on the principle of identity-based security and acts as an identity broker and leverages trusted identity platforms (AD, LDAP, etc) to perform actions within Vault or other products. Vault also acts as an identity provider for applications and machines to quickly authorize and authenticate in automated workflows.

Vault is used by millions to centrally store, access, and distribute dynamic secrets like tokens, passwords, certificates, and encryption keys across any public or private cloud environment.

2. [HashiCorp Consul](#) enables machine-to-machine access by enforcing authentication between applications and ensuring only the right machines are talking to each other. Consul codifies authorization and traffic rules with encrypted traffic while automating identity-based access for maximum scale, efficiency, and security. With Consul, organizations can discover services, automate network configurations, and enable secure connectivity across any cloud or runtime using Consul service mesh.
3. Traditional solutions for safeguarding user access used to require you to distribute and manage SSH keys, VPN credentials, and bastion hosts, which creates risks around credential sprawl and users having access to entire networks and systems. [HashiCorp Boundary](#) secures access to applications and critical systems with fine-grained authorizations without managing credentials or exposing your network.
4. Human authentication and authorization with 3rd party identity tools (Active Directory, Okta, Ping)

Data centers and physical storage

MongoDB Atlas is built to work equally well with any of the three largest cloud providers: Amazon Web Services (AWS), Google Cloud, and Microsoft Azure.

No matter which of these platforms a customer chooses, data stored in clusters of level M10 and above is stored in single-tenant dedicated virtual servers created solely for that Atlas customer. These virtual servers are isolated in their own dedicated virtual private cloud and do not share logical data storage or processing with other customers.



Zero Trust Authentication With MongoDB

An IT organization may use any number of methods to allow users to authenticate themselves to a database, including a username and password. MongoDB enables a variety of other ways to authenticate a user into a system. MongoDB supports LDAP proxy authentication as well as Kerberos authentication.

All forms of MongoDB support transport layer security (TLS) and SCRAM authentication. They are turned on by default and cannot be disabled. Traffic from clients to Atlas is authenticated and encrypted in transit, and traffic between a customer's internally managed MongoDB nodes is also authenticated and encrypted in transit using TLS.

MongoDB uses TLS 1.2 by default. Customers can use TLS 1.1 or 1.0 if needed, but MongoDB 4.0 and later does not support TLS 1.0 if a more recent version is available. Starting with MongoDB 4.4, TLS 1.3 is supported when used with a compatible OpenSSL library; TLS 1.3 support in Atlas is coming soon. The MongoDB security team monitors the status of transport protocols and continually updates requirements to ensure that weak ciphers are deprecated.

For passwordless authentication to MongoDB, MongoDB offers two different options to support the use of X.509 certificates. The first option, called "easy," auto-generates the certificates needed to authenticate database users. The "advanced" option is for organizations already using X.509 certificates, and which already have a certificate management infrastructure. These organizations can upload their CA certificate to MongoDB Atlas and continue to use their in house X.509 certificates for authentication. The advanced option can be combined with LDAPS for authorization. Atlas will send out automated alerts when certificates issued by the Atlas certificate authority, or appearing on the certificate revocation list, are close to expiration.

For dedicated clusters (M10 and above), Atlas provides an easy-to-read log of database authentication events, including both successes and failures. These logs include the database user who attempted to authenticate, source IP address, and time stamp. The logs are available either within the Atlas user interface or via an API.

Access infrastructure can only be reached via bastion hosts and by users whom senior management has approved for backend access. These hosts require multifactor authentication and are configured to require SSH keys, not passwords.



Zero Trust Authorization with MongoDB

Authentication only verifies that someone is who they say they are. Authorization determines what a user is allowed to do. In a zero trust environment, each user has a specific level of allowed access or activity.

To determine each user's privileges, MongoDB uses role-based access controls (RBAC). A user's defined role allows certain activities and denies others. It may allow someone to read data from a database, for example, but not insert data.

MongoDB offers several predefined roles covering the most commonly requested privileges and restrictions. It also allows you to define your own roles, constructing fine-grained access controls tailored to your organization, project, or database. These can reflect a specific functionality that a user needs in their job duties, or a customized role tied to your organizational structure. It also makes it possible to create a separation of duties among different parties accessing and managing data.

Database administrators can also create temporary MongoDB users, which Atlas will automatically delete after a specified period of time. This capability complements granular database auditing (described below). If a user needs temporary access to perform maintenance, for example, the assigned role and its

actions can be comprehensively audited. Once the user is deleted, any client or application attempting to authenticate with that user will not have access to the database.

MongoDB also allows the construction of a multilevel security framework, such as "confidential," "secret," and "top secret," by using a \$redact operator in conjunction with tags. Objects and users can be grouped into different security levels, and unauthorized users are prevented from accessing information at a higher security level than their authorization.

Database Credential Rotation

No longer do database administrators need to be concerned with manual rotation of credentials or human mistakes in password policy enforcement. HashiCorp Vault provides the ability to create, rotate, and revoke MongoDB database credentials through an automated workflow and API leveraging user generated policies. This allows each application, service, or user to dynamically get unique credentials to access the database(s) as well as lease and expiration times for the

credentials. This means that the credentials will expire and reduce the impact of breaches from leaked credentials.

In a scenario where credentials are lost or stolen, the window for those credentials to be valid can be reduced to almost nothing or instant-use only. If credentials are stolen or leaked, the same automated workflow for issuance and rotation can also automatically revoke access and seal Vault and lock down from outside access.



Auditing to Support Zero Trust

MongoDB supports a wide variety of auditing strategies, making it easier to monitor your zero trust environment to ensure that it remains in force and encompasses your database. Administrators can configure MongoDB to log all actions or apply filters to capture only specific events, users, or roles.

MongoDB Enterprise Advanced's role-based auditing allows you to log and report activities by specific role, such as userAdmin or dbAdmin, coupled with any roles inherited by each user,

rather than having to extract activity for each individual administrator. This makes it easier for organizations to enforce end-to-end operational control and maintain the insight necessary for compliance and reporting.

The audit log can be written to multiple destinations in a variety of formats, such as to the console and syslog (in JSON) and to a file (JSON or BSON). It can then be loaded to MongoDB and analyzed to identify relevant events.

MongoDB and HashiCorp Vault in a Zero Trust Environment

Encryption

Encryption is a key technology in a zero trust environment. In essence, it's the last line of defense. If someone manages to convince the system that they are someone they're not, with authorizations they shouldn't have, encryption must still protect your data.

MongoDB allows you to encrypt your data in flight, at rest, or even, with field-level encryption, in use. For data in motion, all versions of MongoDB support TLS and SSL encryption. For data at rest, MongoDB supports AES-256 in both CBC mode and GCM mode. It can also be configured for FIPS compliance.

To encrypt data when it is in use, MongoDB offers an industry-leading capability called client-side field-level encryption. Client-side field-level encryption can be implemented to safeguard data even from database administrators and vendors who otherwise would have access to it.

Client-side field-level encryption is different from other database encryption approaches because the process of encrypting and decrypting is completely separate from the database server. Encryption and decryption are handled exclusively within the MongoDB drivers in the client, before

sensitive data leaves the application. The database only ever uses it as ciphertext.

Client-side field-level encryption is highly flexible. You can selectively encrypt individual fields within a document, multiple fields within the document, or the entire document. Each field can be optionally secured with its own key and decrypted seamlessly on the client.

Securing data with client-side field-level encryption allows you to move to managed services in the cloud with greater confidence. The database only works with encrypted fields, and organizations control their own encryption keys, rather than having the database provider manage them. This additional layer of security enforces an even finer-grained separation of duties between those who use the database and those who administer and manage it.

Client-side field-level encryption also makes it easier to comply with so-called right to be forgotten mandates in modern privacy legislation such as GDPR and CCPA. If a user invokes their right to be forgotten, destruction of the associated field encryption key will render the user's personally identifiable information unreadable and irrecoverable to anyone.



Because the database server has no access to the encryption keys, certain query operations such as sorts, regexes, and range-based queries on encrypted fields are not possible server-side. Because of this, client-side field-level encryption is best applied to selectively protect just those fields containing highly sensitive personal information such as email addresses, phone numbers, credit

card information, or social security numbers. (MongoDB's Queryable Encryption, introduced in June 2022, is shifting the encryption landscape. It allows you to encrypt sensitive data from the client side, store it as fully randomized encrypted data on the server side, and run expressive queries on the encrypted data.)

HashiCorp Enterprise Vault and Client Side Field Level Encryption

Vault can be used as an external Key Management Server to supply encryption keys used by MongoDB's Client Side Field Level Encryption libraries for encrypting sensitive fields in MongoDB documents.

Field level encryption (FLE) allows developers to selectively encrypt specific data fields. It helps protect sensitive data and enhances the security of communication between client apps and server. Pairing an FTE-capable database with a KMIP provider offers the highest level of security and control.

The Key Management Interoperability Protocol (KMIP) standard is a widely adopted approach to handle cryptographic workloads and secrets management for enterprise infrastructure such as databases, network storage, and virtual and physical servers. HashiCorp Vault, being a KMIP compliant Key Management Server (KMS), enables organizations to perform cryptographic operations for their apps and services.

With MongoDB releasing client-side field level encryption with KMIP support, customers are now able to use Vault's KMIP secrets engine to supply the encryption keys. This allows customers to be in full control of their keys.

Example FLE Flow in MongoDB with KMIP Provider

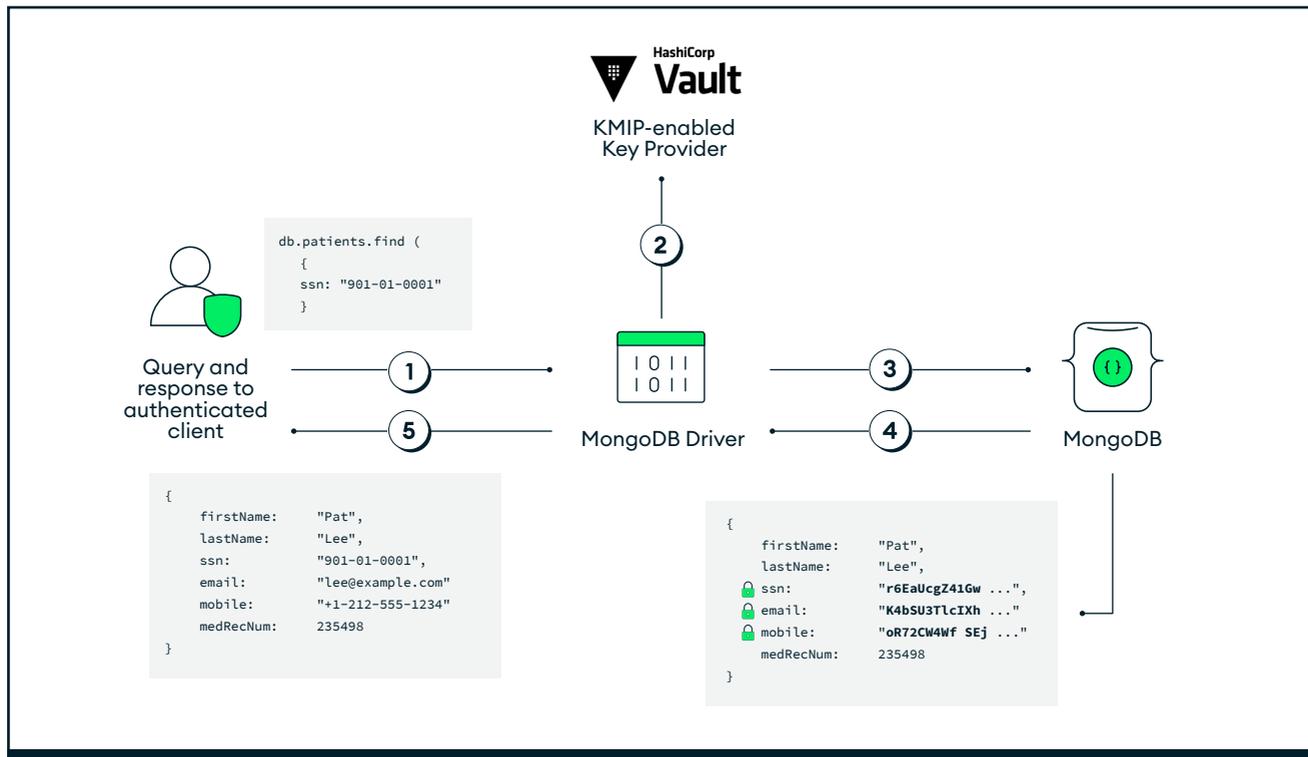


Figure 1: Query flow submitted by an authenticated client using FLE. Encrypted fields are always stored, transmitted, and retrieved as ciphertext.

This example assumes we are retrieving a user's record by their SSN number:

1. When the application submits the query, the MongoDB driver analyzes it to determine if any encrypted fields are involved in the filter.
2. Recognizing that the query is against an encrypted field, the driver requests the key encryption key (KEK) from the KMIP-enabled key provider. The key provider returns the keys to the MongoDB driver and encrypts the key fields, such as SSN, as shown in this example.
3. The driver submits the query to the MongoDB server with the encrypted fields rendered as ciphertext.

4. The MongoDB server returns the encrypted results of the query to the driver.

5. The query results are decrypted with the keys held by the driver and returned to the authenticated client as readable plaintext.

This is one example of how MongoDB and HashiCorp Vault can help benefit organizations with security management across their databases and applications. We have built many integrations with MongoDB Atlas for database credential rotation and key management to help organizations protect and secure their data infrastructure.



Conclusion

MongoDB and HashiCorp's suite of Zero Trust Security products are optimally suited for organizations operating in a cloud environment or interested in improving their security posture. MongoDB's and HashiCorp products are secure by default and have developed best of breed capabilities in the most critical areas of zero trust database management including:

- Secrets Management
- Access, Authorization & Authentication
- Encryption

Together, the [HashiCorp & MongoDB](#) Zero Trust solution ensures that organizations have the controls to authenticate and authorize users and machines at all layers of a dynamic network based on identity.