Dashlane's Security Principles & Architecture

DASHLANE

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Dashlane Password Manager is designed using zero-knowledge architecture, with the data encrypted locally on the user's device. Only the user can access the data by using a password or another form of authentication. Since Dashlane doesn't have access to the user's vault and doesn't store the user's Master Password, malicious actors can't steal the information, even if Dashlane's servers are compromised.

1 General Security Principles

Before storing each individual's vault on its servers, Dashlane encrypts it using Advanced Encryption Standard (AES) 256-bit encryption. Access to the vault requires either a User Master Password, which is only known to the account holder, or, for a passwordless user, a machine-generated unique password. In both cases, this password is not stored on Dashlane's servers and is not accessible to Dashlane employees. Dashlane uses a separate User Device Key to authenticate each person on its servers. When someone creates a new Dashlane account or enables an additional device for data synchronization, Dashlane first verifies the authorized user by sending a token through the registered email address or mobile phone number, then auto-generates the User Device Key. For passwordless login, access to the additional device is conditioned by authorization from an already registered device, so it is not necessary to send the token through email or mobile.

When a person enters their Master Password into the Dashlane app, the data is loaded into the memory of the authorized device. For additional security, individuals who log in with their Master Password can link their Dashlane accounts to a 2-factor authentication (2FA) app such as Google Authenticator. Enabling the 2FA option means that both the Master Password and the authenticator code are necessary for decrypting the vault. All communication between the Dashlane app on the local device and Dashlane's servers takes place over SSL/TLS cryptographic protocol. And while a variety of security processes occur in the background during user registration and authentication, the user experience is simple and streamlined. Dashlane Business account admins can enable an optional account recovery feature through their Admin Console. This feature allows employees to reset their Master Password and recover their data while preserving Dashlane's zero-knowledge architecture. When an employee initiates account recovery, the admin acts as the trusted third party to verify the user's identity and approve the request. In addition, an Account Recovery Key is an available mechanism for all Master Password based and passwordless users to recover access to their account using a single-use key.

1.1 List of secrets

Dashlane uses many secrets to secure user data. The main ones are summarized in the following table:

Key Name	Key Symbol	Description
User Master Password	$User_{MP}$	Password/Passphrase generated by the user. Serves to derive the key to encrypt the user's vault. The User Master Password is expected to be as random as possible.
Intermediate Key	$Intermediate_{Key}$	Random 32-byte key, generated by local devices. Serves for local encryption purposes.
User Device Key	$Device_{Key}$	Random 32-byte key, generated by local devices. Serves as authentication secret for authentication to servers.
User Secondary Key	$UserSecondary_{Key}$	Random 32-byte key, generated server side at 2FA activation. Provided by servers to client upon 2FA challenge validation.
Account Recovery Key	$AccountRecovery_{Key}$	28-character unique string generated with password generator (≈ 145 bits of entropy). Key for the Account Recovery mechanism.
Machine-Generated Master Password	$MachineGenerated_{MP}$	40-character unique string generated with password generator (≈ 243 bits of entropy). Serves as encryption key of the vault for MPLess accounts.
Mass Deployment Team Key	$MassDeploymentTeam_{Key}$	Random 32-byte key, generated by Dashlane servers. Serves as authentication secret to authentify logged-out users from a specific team and give them restricted permissions.

Table 1: Dashlane Secrets Overview

1.2 Protection of User Data in Dashlane

Protection of user data in Dashlane relies on 3 separate secrets:

- The **User Master Password**:
  - Dashlane uses the library **zxcvbn**[1] to validate the strengh of a $User_{MP}$ generated by the user. The library checks the $User_{MP}$ against many policies (common passwords, complexity, and so on) to compute a score. The score (integer between 0-4) provides a global range of guesses to find the password, from 0 (too guessable) to 4 (very unguessable). The library provides actionnable feedback to choose better passwords.

    Dashlane applications enforce a score greater or equal to 3 (safely unguessable, with an estimated number of guesses between 10^8 and 10^{10}).
  - It is never stored on Dashlane servers, nor are any of its derivatives (including hashes).
  - By default, it is not stored locally on the disk on any of the user's devices; we simply use it to decrypt the local files containing the user data.
  - It is stored locally upon user request when enabling the feature "Remember my Master Password".
  - In addition, we ensure that the user's Master Password is never transmitted over the internet.[2]

[1] https://github.com/dropbox/zxcvbn

- The **Intermediate Key**: in some cases (local storage), we use $Intermediate_{Key}$ encrypted with a derivative of $User_{MP}$.
- The **User Device Keys**: unique key for each device enabled by a user:
  - Auto-generated for each device.
  - Used for authentication.
- The **Machine-Generated Master Password** (as an alternative to the User Master Password):
  - Is a strong, unique 40-character machine-generated string, generated with password generator.
  - It is never stored on Dashlane servers, nor are any of its derivatives (including hashes).
  - By default, it is not stored locally on the disk on any of the user's devices; we simply use it to decrypt the local files containing the user data.
  - It is stored locally when logging into the Dashlane web extension.
  - In addition, we ensure that the $MachineGenerated_{MP}$ is never transmitted over the internet.[3]

1.3 Local Access to User Data

Access to the user's data requires using the $User_{MP}$, which is only known by the user. It is used to generate the symmetric Advanced Encryption Standard (AES) 256-bit key for encryption and decryption of the user's personal data on the user's device. In the case of passwordless, the $MachineGenerated_{MP}$ is not visible for the user, but transported securely between devices when the user adds a new device, and then used exactly like the $User_{MP}$.

We use Web Crypto API for most browser-based cryptography and the native libraries for iOS and Android. We use the Argon2 reference library compiled into Web Assembly (Wasm) or linked to the mobile app.

1.4 Local Data Usage After Decrypting

Once the user has input their $User_{MP}$ locally in Dashlane or validated their $MachineGenerated_{MP}$ via PIN Code or biometrics and their user data has been decrypted, data is loaded in memory.

The Dashlane client operates within significant constraints to use decrypted user data effectively and securely:

- Dashlane processes access individual passwords to autofill them on websites or to save credentials without having to ask the user for $User_{MP}$ or $MachineGenerated_{MP}$ each time.
- The Argon2d (or PBKDF2) derivation used to compute the AES keys adds significant latency (the purpose of this is to protect against brute force attacks).

  See paragraph Section 3.6 for more on memory management.

[2]The only derivative of it that is sent over the internet is the final encrypted vault. The following paragraphs outline how we ensure its resilience to attacks.

[3]The only derivative of it that is sent over the internet is the final encrypted vault. The following paragraphs outline how we ensure its resilience to attacks.

1.5 Use of 2FA Applications to Increase User Data Safety

At any time, a user can link their Dashlane account to a 2FA application on their mobile device (such as Google Authenticator). All of their data (both the data stored locally and the data sent to Dashlane servers for synchronization purposes) is then encrypted with a new key, which is generated by a combination of $User_{MP}$ and a randomly generated key $UserSecondary_{Key}$ stored on the Dashlane server, as described in the following steps:

- The user links their Dashlane account with their 2FA application.
- Dashlane servers generate and store $UserSecondary_{Key}$, which is sent to the user's client application.
- All personal data are encrypted with a new symmetric AES-256 bit key generated client-side from both $User_{MP}$ and $UserSecondary_{Key}$.
- $UserSecondary_{Key}$ is never stored locally.
- The next time the user tries to log into Dashlane, they will be asked by Dashlane servers to provide a One-Time Password generated by the 2FA application. Upon receiving and verifying this One-Time Password, Dashlane servers will send the $UserSecondary_{Key}$ to the client application, allowing the user to decrypt their data.

User data can be decrypted only by having both $User_{MP}$ and the 2FA application linked to the user's account.

1.6 Authentication

As some of Dashlane's services are cloud-based (data synchronization between multiple devices, for instance), there is a need to authenticate the user on Dashlane servers.

Authentication of the user on Dashlane servers is based on $Device_{Key}$ and has **no relationship with the User Master Password or** $MachineGenerated_{MP}$.

When a user creates an account or adds a new device to synchronize their data, a new User Device Key is generated by the servers. $Device_{Key}$ is composed of 40 random bytes generated using the *OpenSSL* RAND_byte function. The 8 first bytes are the access key, and 32 remaining bytes are the secret key.

$Device_{Key}$ is received by the user's device and is stored locally in the user data, encrypted as all other user data, as explained earlier. On the server side, the secret key part is encrypted so that employees cannot impersonate a given user device. When a user has gained access to their data using $User_{MP}$ or $MachineGenerated_{MP}$, Dashlane is able to access $Device_{Key}$ to authenticate them on our servers without any user interaction.

As a result, Dashlane does not have to store $User_{MP}$ or $MachineGenerated_{MP}$ to perform authentication.

1.7 Communication

All communications between the Dashlane application and the Dashlane servers are secured with HTTPS.

dashlane.com domain is HSTS preloaded to prevent any downgrade on any subdomain and we keep our TLS endpoints cipher suites up-to-date with the current recommendations.

It's important to note that we never rely on HTTPS alone and we build everything to ensure that the confidentiality of the data is not affected even if the transport protocol is compromised.

1.8 Details on Authentication Flow

The initial registration for a user follows the flow described in Figure 1.

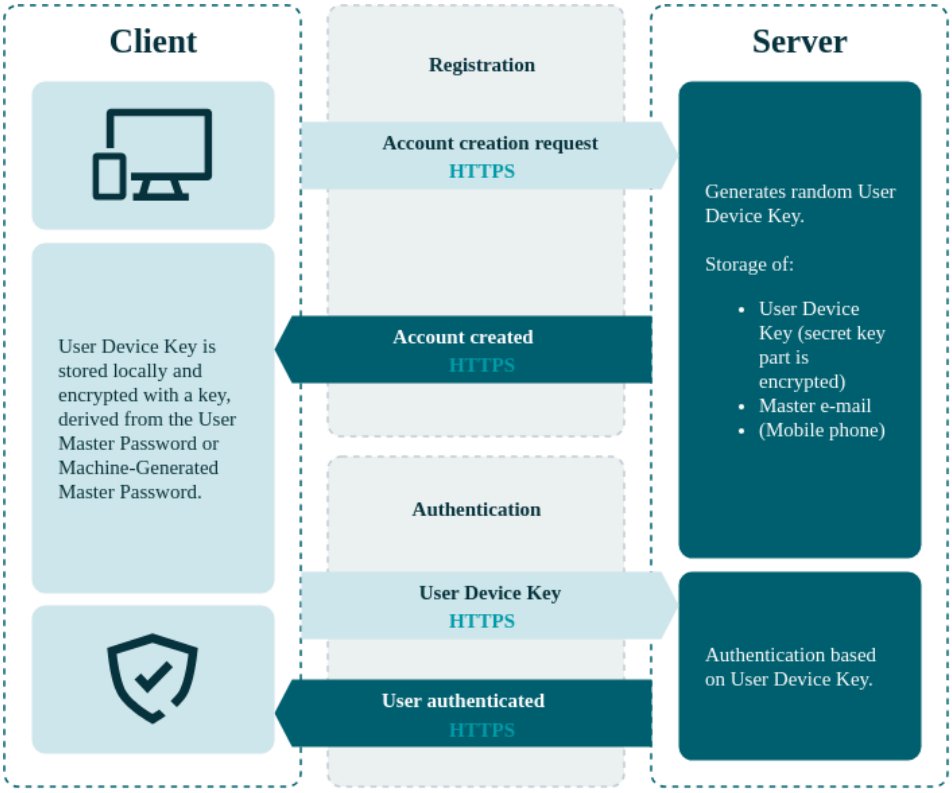


Figure 1: Authentication Flow During Registration

As seen in Figure 1, $\mathrm{User}_{\mathrm{MP}}$ is never used to perform server authentication, and the only keys stored on our servers are the User Device Keys.

1.8.1 Adding a new device for Master Password based users

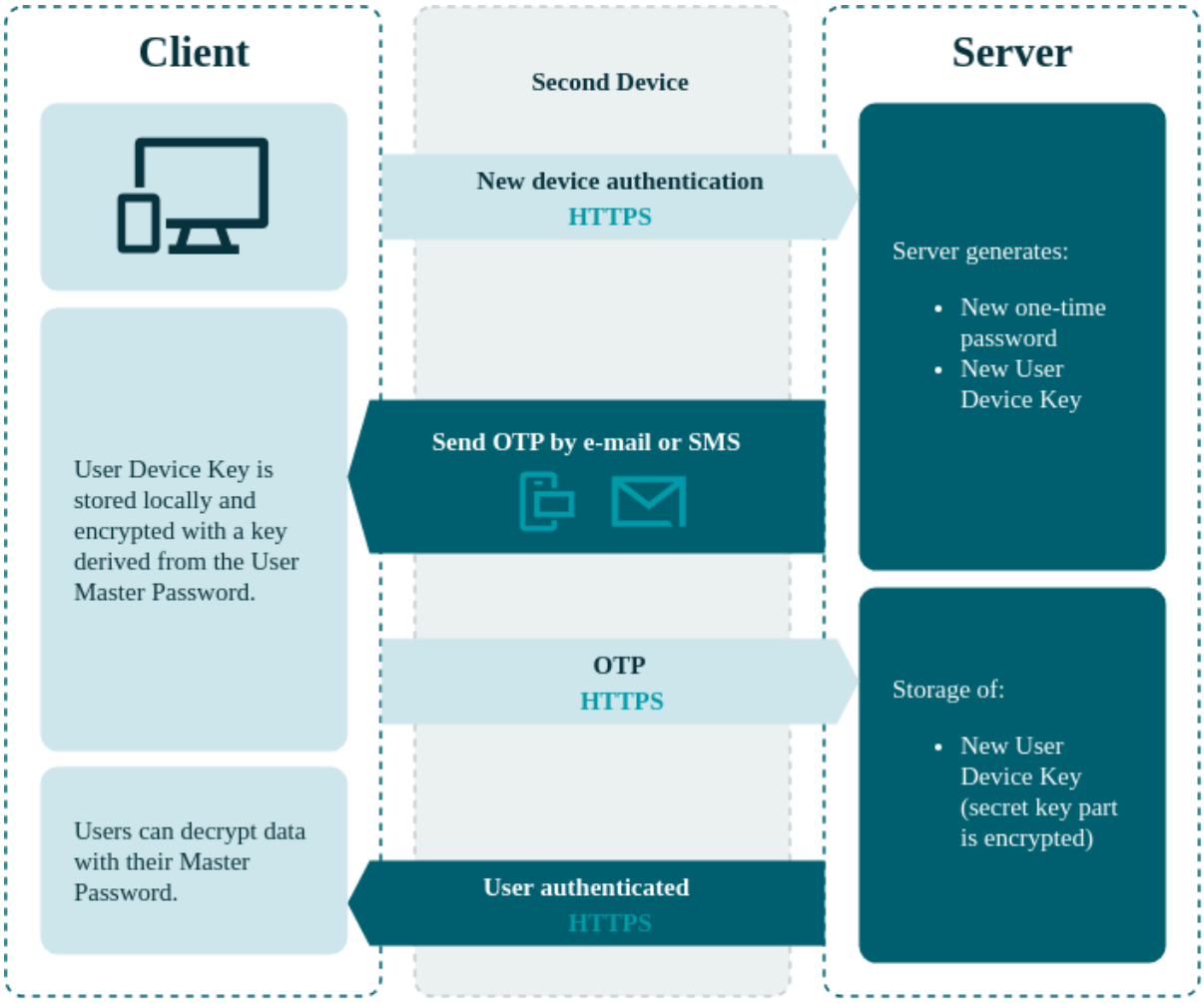


Figure 2: Authentication Flow for second device

When a user adds an additional device, Dashlane needs to make sure that the user adding said device is indeed the legitimate owner of the account. This is to gain additional protection in the event $\mathrm{User}_{\mathrm{MP}}$ has been compromised and an attacker who does not have access to their already-enabled device is trying to access the account from another device.

As shown in Figure 2, when a user is attempting to connect to a Dashlane account on a device that has not yet been authorized for that account, Dashlane generates a One-Time Password (a token) that is sent to the user either to the email address used to create the Dashlane account initially or by text message to the user's mobile phone if the user has chosen to provide their mobile phone number.

To enable the new device, the user has to enter both $\mathrm{User}_{\mathrm{MP}}$ and the token. Only once this two-factor authentication has been performed will Dashlane servers start synchronizing the user data on the new device. All communication is handled with HTTPS, and the user data only travels in AES-256 encrypted form. Please note again that $\mathrm{User}_{\mathrm{MP}}$ never transmits over the internet.

1.8.2 Adding a new device for Passwordless users

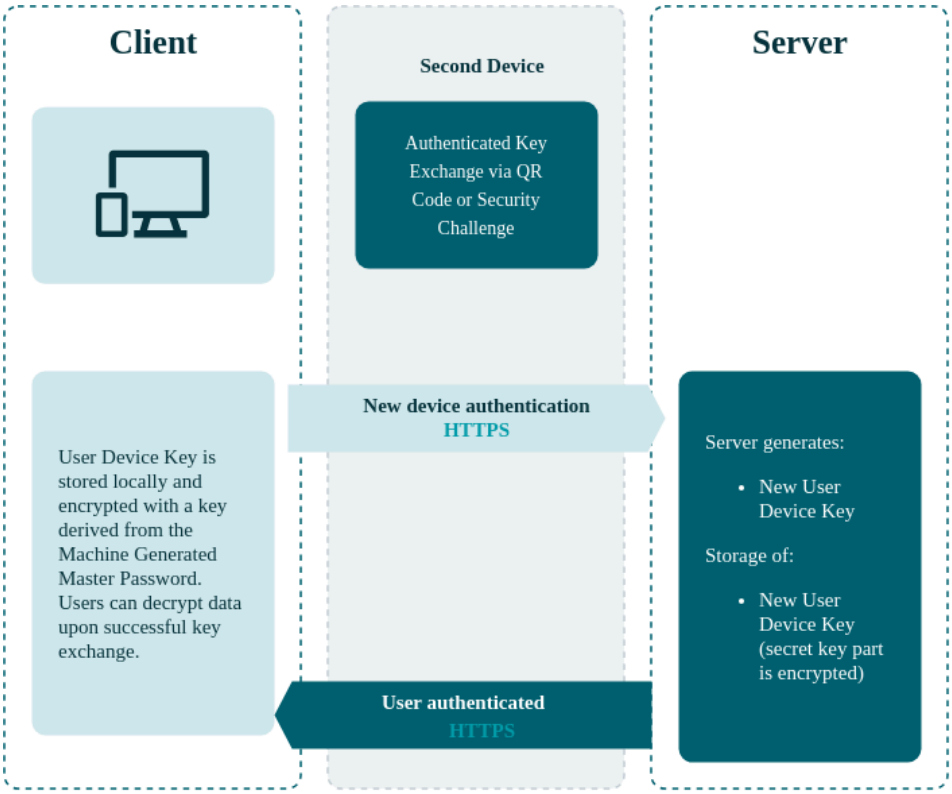


Figure 3: Authentication When Adding a New Device - Passwordless flow

When a passwordless user adds a new device, they can use an existing logged in device to complete the setup process. Depending on the type of logged in device, the user can either complete the new device setup with a QR code scan, or complete a security challenge. The goal of the exchange is to securely transmit the $\mathrm{MachineGenerated}_{\mathrm{MP}}$ from an already trusted device to a new device. This key exchange is based on Elliptic Curve Cryptography, using Curve25519.

1.8.2.1 Proximity transfer with QR code scan

If a passwordless user has a logged in mobile device, a QR code scan can be used to add a new device. When a user enters their email address into the new device (untrusted), a X25519 key pair is generated on the device and the public key is displayed on the screen as a QR code. That QR code must be scanned by a logged in device (trusted). Upon successful key exchange, the two devices generate the same shared secret, derived into a cryptographic key, which will be used to encrypt/decrypt the $\mathrm{MachineGenerated}_{\mathrm{MP}}$ passed between the devices. The vault can be then decrypted locally on the new device.

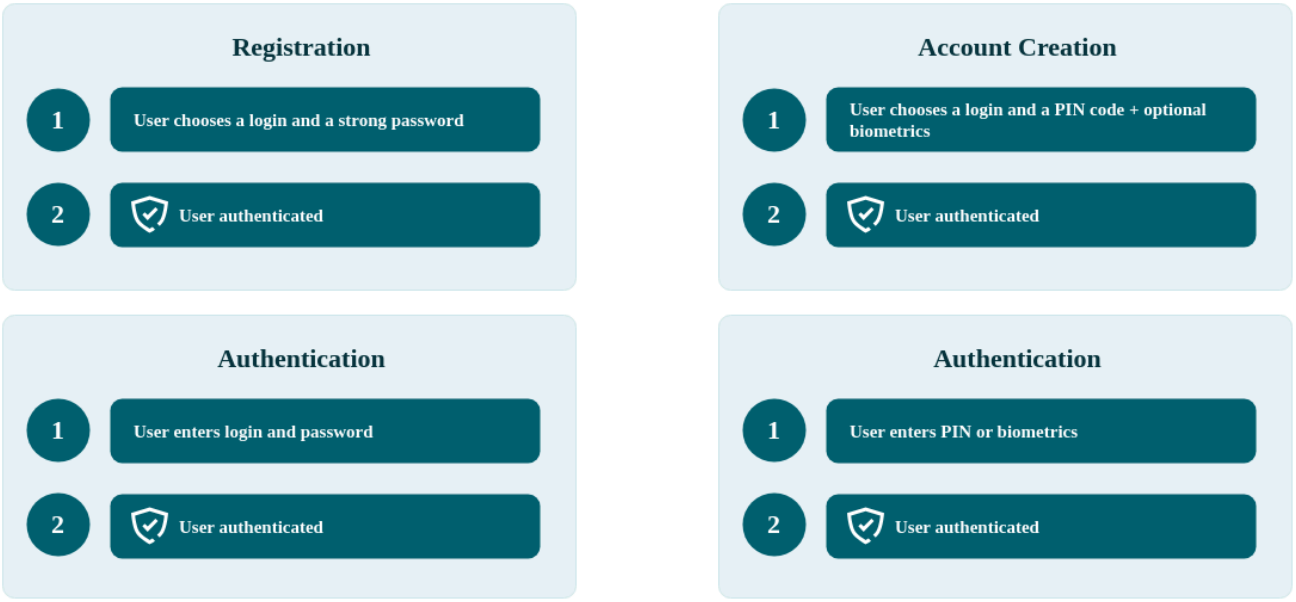
1.8.2.2 Exchange via server with visual check

If a passwordless user does not have a mobile logged in device or is unable to use the camera functionality, then a security challenge can be performed. Without the ability to use proximity to exchange the secret, the two devices need to use the server to transport the public keys. Dashlane ensures an attacker cannot tamper with the keys during the exchange by authenticating the key exchange with Short Authenticated String:

- From the shared secret (output of the key exchange), we derive a key seen as a source of entropy to choose five random words in a word list.
- The wordlist is https://www.eff.org/files/2016/07/18/eff_large_wordlist.txt.
- If the key exchange was not tampered with, the two lists will match. We ask the user to input one missing word (chosen at random) in the list of words, to incentivize them to check that the two lists match. This confirmation happens on the trusted (authenticated) device.
- We complement this security mechanism with a Public Key Commitment: the untrusted device sends a hash of its X25519 public key at the beginning of the exchange, and releases it to the untrusted device only upon receiving its public key. This mechanism would force an active Man in The Middle eavesdropping the key exchange to provide a public key to the trusted device before being able to know what Short Authenticated String it should match, deeply decreasing the probability to successfully hijack the key exchange.

Upon successful completion of the challenge, the $\mathrm{MachineGenerated}_{\mathrm{MP}}$ can be transmitted to the new device, and the vault is decrypted locally on the user's new device.

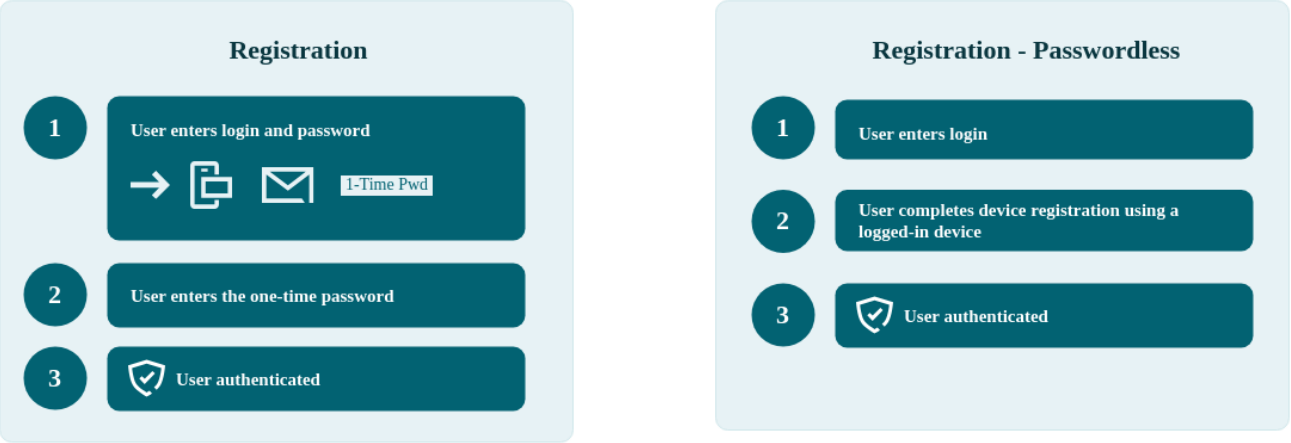
1.9 Keeping the User Experience Simple



(a) Master Password (b) Passwordless

Figure 4: Registration and Authentication Steps

All along, our goal has been to keep the user experience simple and to hide all the complexity from the user. Security is growing more and more important for users of cloud services, but they are not necessarily ready to sacrifice convenience for more security.



(a) Master Password (b) Passwordless

Figure 5: Second Device Registration Steps

Even though what goes on in the background during the initial registration steps is complex (see Figure 4.a), the user experience is very simple. All they have to do is choose between creating a (strong) $\mathrm{User}_{\mathrm{MP}}$ or going passwordless, and all the other keys are generated by the application without user intervention.

When adding an additional device, the process is equally simple while remaining highly secure through the use of two-factor authentication described in Figure 5.a or using an existing logged in device.

1.10 Use of 2FA Application to Secure the Connection to a New Device

At any time, a user can link their Dashlane account to a 2FA application on their mobile device. When they attempt to connect to a new device, instead of sending them a one-time password by email, Dashlane asks the user to provide a one-time password generated by the 2FA application.

After receiving and verifying the one-time password provided by the user, Dashlane servers will store the $\mathrm{Device}_{\mathrm{Key}}$ generated by the client application, as described in Figure 5.b.

1.11 2-Factor Authentication

Dashlane offers 2-factor authentication that can be activated from the security settings in the web extension or mobile app to force the usage of a second factor each time the user logs into Dashlane.

Supported two-factor methods include 2FA applications such as Google Authenticator or U2F-compatible devices such as Yubikeys. U2F is an open protocol from the FIDO Alliance. Dashlane is a board-level member of the FIDO Alliance.

1.12 Sharing Data Between Users

Dashlane allows users to share credentials, Secure Notes, or secrets with other users, or with groups of users, in such a way that Dashlane never directly accesses a user's data at any point. In fact, Dashlane's servers never have access to the content of shared data.

Dashlane's sharing relies on asymmetric encryption; upon account creation, a unique pair of public and private RSA keys are created by the Dashlane application for each user. The private

key is stored in the user's personal data, and the public key is sent to Dashlane's servers. RSA public and private keys are generated using the OpenSSL function RSA_generate_key_ex, using a key length of 2048 bits, with 3 as a public exponent.

Here is the process for a user, Alice, to share a credential with another user, Bob:

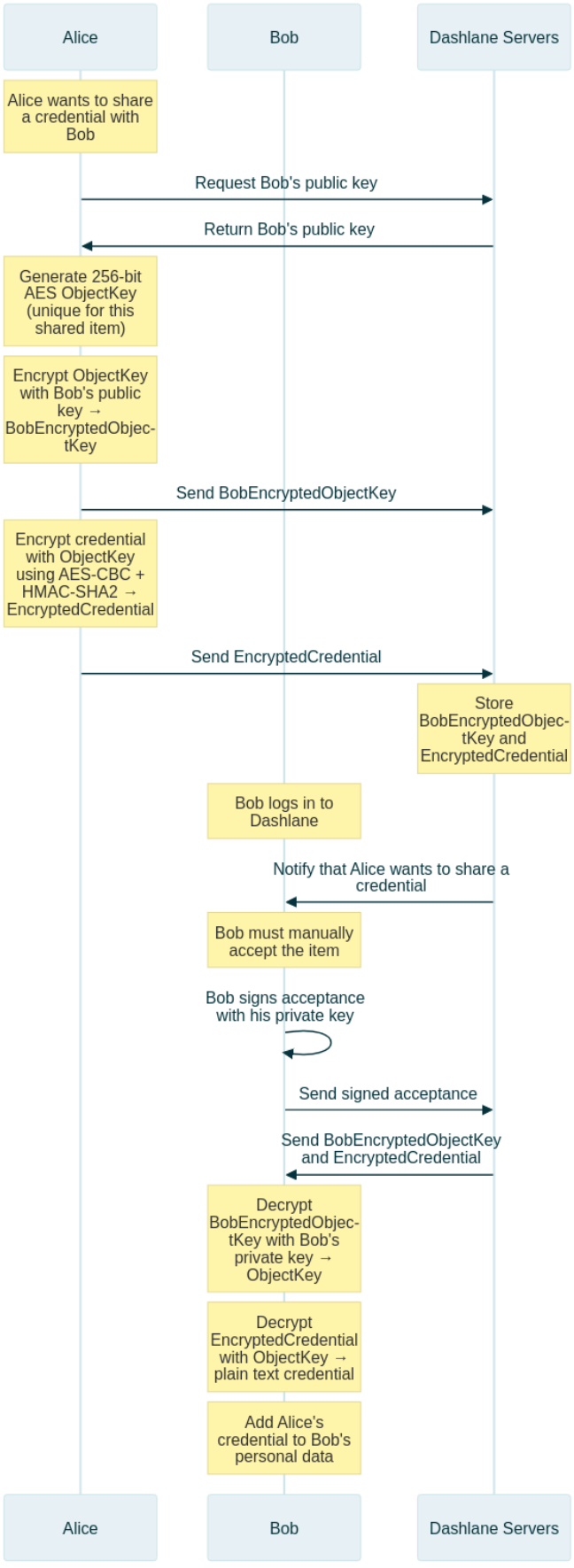


Figure 6: Credential Sharing

Sharing an item with a group of users or sharing a collection of multiple items follows similar security principles:

- An AES key, the GroupKey is created for the group or collection and encrypted with each user's public key.
- An RSA public and private key pair is also created for the group.
- The private key is encryped with the GroupKey and used to sign the item or items in the group while the public key is used to encrypt the ObjectKeys within this group.

Users are then able to access the keys needed to decrypt individual items without Dashlane's servers being able to.

To summarize:

- Each user has a pair of public and private RSA 2048-bit keys:
  1. Public keys are used to encrypt information only a specific user can decrypt.
  2. Private keys are used to sign actions users are performing.
- For each credential or secure note shared, an intermediary AES 256-bit key is created and used to perform data encryption and decryption.

1.13 Account Recovery

Dashlane has two recovery methods available for users: Admin-Assisted Account Recovery for business users who login with a Master Password, and Account Recovery Key, available for all consumer users.

1.13.1 Admin-assisted Account Recovery

Admin-Assisted Account recovery allows Dashlane Business users to regain access to Dashlane by resetting $\mathrm{User}_{\mathrm{MP}}$. Our patented process preserves zero-knowledge. Through account recovery, master passwords are never stored on any servers nor transmitted in any form.

Our solution allows users to reset $\mathrm{User}_{\mathrm{MP}}$ and recover the data stored on an authorized device. Account recovery is an optional feature admins can activate for their Dashlane Business account in the Admin Console.

To enable recovery, the user's local key — itself encrypted with $\mathrm{User}_{\mathrm{MP}}$ — is also encrypted using a unique user recovery key, which is generated and used for all of the user's devices when they opt into account recovery. This user recovery key is then encrypted using a unique server-side recovery key, which is only known to Dashlane and the user's client devices. When an admin enables account recovery, their public key is used to encrypt the server-side recovery key, which as aforementioned, was already used to encrypt the user's recovery key. An admin can then, via their private key, later access the user's recovery key protected by the server-side recovery key.

When a user requests account recovery, they are asked to verify their account and create a new $\mathrm{User}_{\mathrm{MP}}$. A critical step of the recovery process is the verification of the identity of the user. It is up to the admin, acting as a trusted third party, to ensure the user requesting recovery is indeed the owner of the account. If an admin approves the request, the server-side recovery key, which protects the user's recovery key, is securely exchanged from the admin to the user through a public/private key system. On the user's device, the user's recovery key is then decrypted using the server-side recovery key, provided by Dashlane after the user's identity and request have been validated. The user's recovery key is then used to decrypt the user's local key, which in turn

is used to decrypt the user's data. The recovered data is then re-encrypted with $\mathrm{User}_{\mathrm{MP}}$ and re-synced to the Dashlane servers.

As this process involves a master password change, all of the user's devices have to be registered once again to Dashlane for the user to access their newly encrypted data.

Important privacy note: the account recovery process relies on the admin being a trusted third party. In case the Dashlane admin has access to both the user's device and the user's email used as a Dashlane account, the admin would be in a position to trigger an account recovery from the user's device and get access to the user's vault and personal data.

1.13.2 Account Recovery Key

Account Recovery Key allows users to set up a single-use recovery mechanism in order to recover their data if they cannot access it anymore. The recovery key is a 28-character alphanumeric string that must be saved and confirmed by the user during setup. It is generated from the user personal settings using password generator, and a key derived from it with user crypto settings is used to encrypt the $\mathrm{User}_{\mathrm{MP}}$ (AES-256 encryption). Once encrypted, it is sent and stored on the server.

The Account Recovery Key mechanism can be disabled at any time from the user's security settings, invalidating the current account recovery key for the user.

In the event a user has forgotten their Master Password or lost access to all of their devices, the user can initiate the recovery mechanism. First, the user must complete an additional identity verification step, being either an email verification code or a 2FA token, depending on the user's security settings. Once identity verification is succesfully performed, the user inputs the recovery code, and the server will release the encrypted $\mathrm{User}_{\mathrm{MP}}$ to the client, which will attempt to decrypt it with the Account Recovery Key. If successful, the user will be prompted to change their $\mathrm{User}_{\mathrm{MP}}$.

Upon successfully completing the process, the current account recovery key is no longer valid. A new account recovery key must be configured from the user's security settings. The recovery key will also be disabled after those 2 events: change of master password, and master password to SSO Migration.

1.14 Dark Web Monitoring for Master Password

This feature allows Dashlane users to be alerted if their master password or an employee's master password has been identified in a data breach. To check if the master password of a user is compromised, we are going to check if it is present in the databases resulting from the various data leaks that we collect from third parties. We collect the data through API requests, and transform all data into hashes using the Argon2 function before storing them on our servers. When a user enters his master password on his mobile or Web application, we start by transforming it using the Argon2 function and a salt[4] present in the client application, giving us a 32 bytes long hash.

[4]The salt we use is specific for this feature and different from the one used to build the user's encryption key

Algorithm	Iterations	Mem. usage	Parallelism	Threads	Hash length
Argon 2d v1.3	3	32768	2	2	32

Table 2: Argon2 configuration

To respect our zero-knowledge architecture, we use a process called “K-anonymity” to guarantee that no one, not even Dashlane can access the master password. For this, the complete hash never leaves the user’s device, but we only send the first three bytes of it to our servers and compare those bytes to the entries we have in our database. If we have one or more matches, we send the list to the users and finally, the application is able to make a complete comparison between the local hash and the one(s) coming from Dashlane’s servers, and at the end, warn the user if his master password has been found in a data leak.

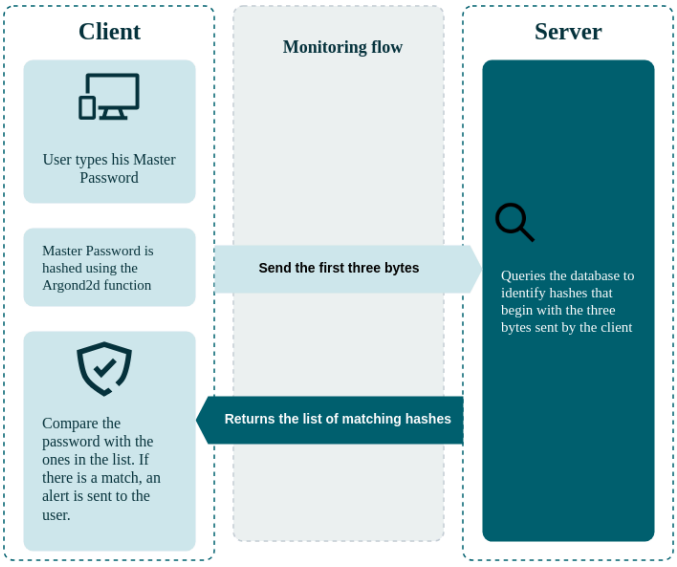


Figure 7: Dark Web monitoring for Master Password flow

1.15 Activity Logs

Dashlane provides business customers with Activity Logs, a timestamped report available in the Admin Console that lists actions taken by admins and team members in Dashlane. This feature is important for Admins to gain insight on the security posture of your organization.

To produce this report, Dashlane generates two types of events:

- Activity Logs: General events of members’ activity. These are generated by default on the server-side.
- Sensitive Activity Logs: Additional events generated by client applications and sent to an endpoint to be collected on the server-side. Those logs aren’t enabled by default and require Admins’ actions to be enabled.

Activity Logs are generated from various actions performed by team members and admins, with the complete list of available events provided in Appendix Section A.

Activity Logs and Sensitive Activity Logs are first stored in a database for queuing purposes. Then a batch cleans the queue and forwards events to an Object Storage for persistence. The Object Storage is replicated on two different geographical zones (Ireland and Germany) to achieve reliable storage of Activity Logs.

Activity Logs can be recovered by Admins. This can be done in a two-steps process:

1. A query is sent to the server; the server replies with a query identifier.
2. Server can be requested with the query identifier to get the state of the query and eventually get the result when the query has been finalized.

1.16 Credential Risk Detection

Credential Risk Detection is a Dashlane Business feature which allows admins to monitor weak and compromised passwords being used by users in their organization that are not actively using Dashlane (i.e. these users are not logged in). This is made possible by using an endpoint management solution to deploy the Dashlane web extension on the browsers of team members along with a configuration (also called policy in some endpoint management tools). This process of distributing and installing the Dashlane extension to a number of devices simultaneously via an endpoint management solution will sometimes be refered to as “Mass Deployment” in this document. The configuration contains the information that will be included in the sensitive activity log to allow the admin to identify the user as well as the $\mathrm{MassDeploymentTeam}_{\mathrm{Key}}$ that will be used to sign the request and link it to a team. As can be seen in Figure Figure 8 the Admin triggers the generation of the $\mathrm{MassDeploymentTeam}_{\mathrm{Key}}$ from the Team Amin Console (TAC). The key is then included in the automatically generated scripts that the admin will run to deploy the configuration and mass deploy the Dashlane extension through his unified endpoint management software.

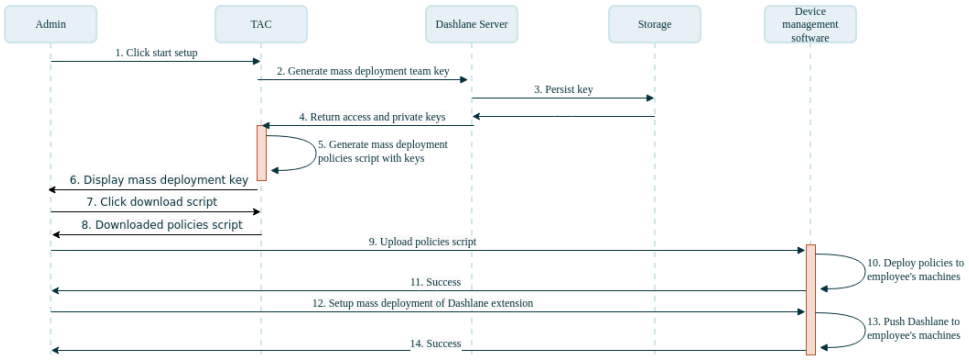


Figure 8: Credential Risk Detection Mass Deployment process

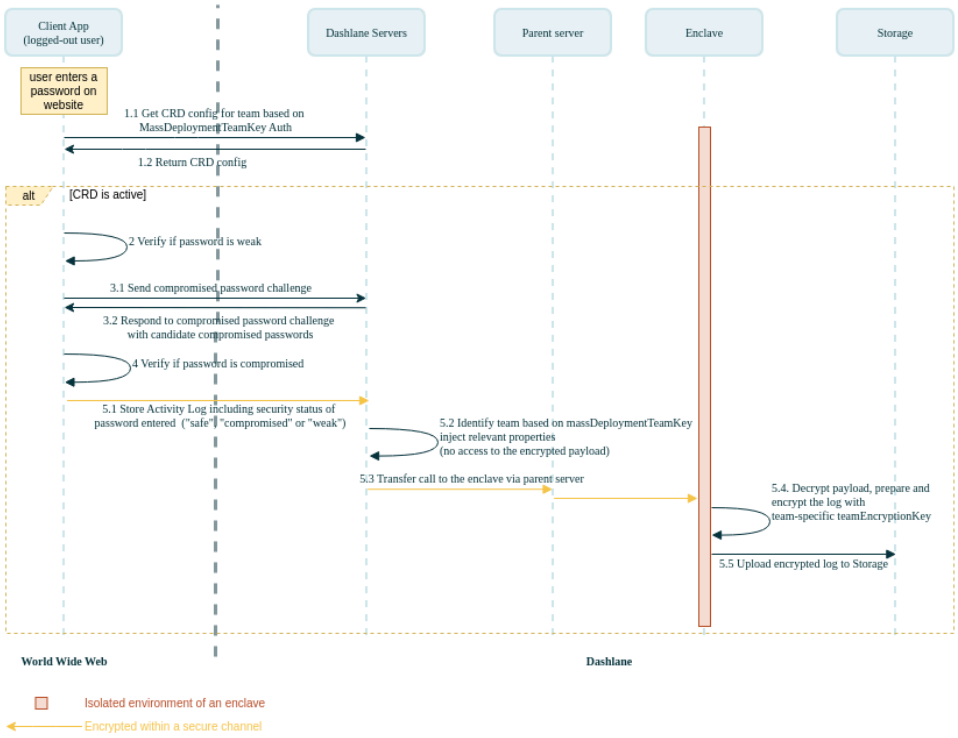


Figure 9: Credential Risk Detection activity log upload

Once the extension and policies have been mass deployed to a team-member's device the risk detection process begins. As shown in Figure Figure 9, when said team-member enters a password on the internet while not logged into Dashlane, the mass deployed extension will run the following steps:

1. Get the Credential Risk Detection configuration from the servers to control that the feature has been activated by the team admin.
2. Check if the entered password is "weak" (this check is based on an open-source password strength estimator called **zxcvbn**[5] and happens locally).
3. Check if the entered password is "compromised" (these checks require information from the server, we use the same process as described in Figure Figure 7 to complete this check without uploading the password to the servers).
4. Based on the results of the previous checks, send a sensitive activity log (encrypted in transit via an encrypted tunnel to the enclave and at rest by the enclave) to the secure enclave. The encrypted payload of the log will contain the security status of the password entered: "compromised", "weak" or "safe" in this order of priority (i.e. if a password is both "compromised" and "weak" then it is classified as "compromised" as this considered a bigger threat).

1.17 Nudges

Nudges is a Dashlane Business feature through which admins can define a schedule to send reminders to team members about security issues with the content of their vault. The users to target are identified based on the data from the pre-exitising password health report. Admins can define a schedule for each type of vulnerability (weak, compromised and reused passwords).

[5]https://github.com/dropbox/zxcvbn

Nudges are sent to the end-users via a slack integration but new channels might be added in the future. There are 3 major steps in the nudge lifecycle:

1. The admin installs the Dashlane slack app in their slack workspace and uploads the slack token to the Dashlane servers (see Figure Figure 10). The permissions assigned to the slack token are detailled in table Table 3.
2. The admin sets up / updates a nudge via TAC (see Figure Figure 11).
3. A routine on the Dashlane servers runs on a schedule and sends nudges to the relevant end-users (see Figure Figure 12). The content of the nudges is generated based on fixed localized templates that the Dashlane team maintains directly.

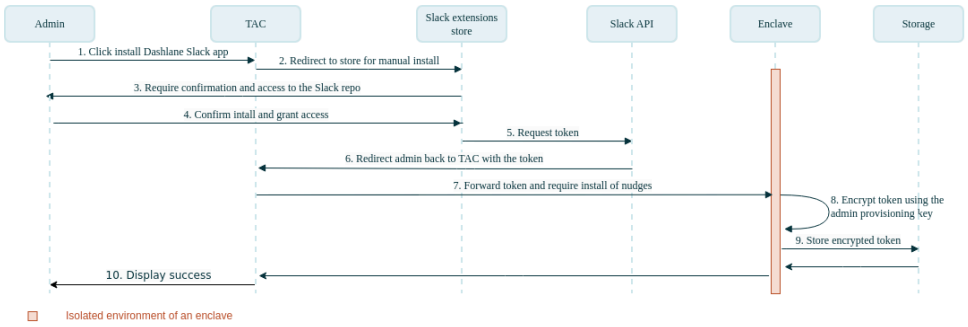


Figure 10: Dashlane Slack app installation

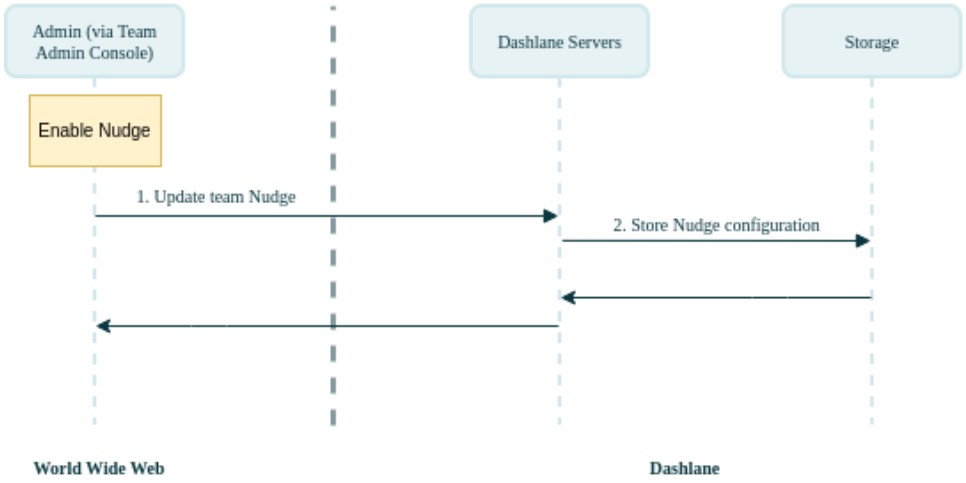


Figure 11: Nudge configuration

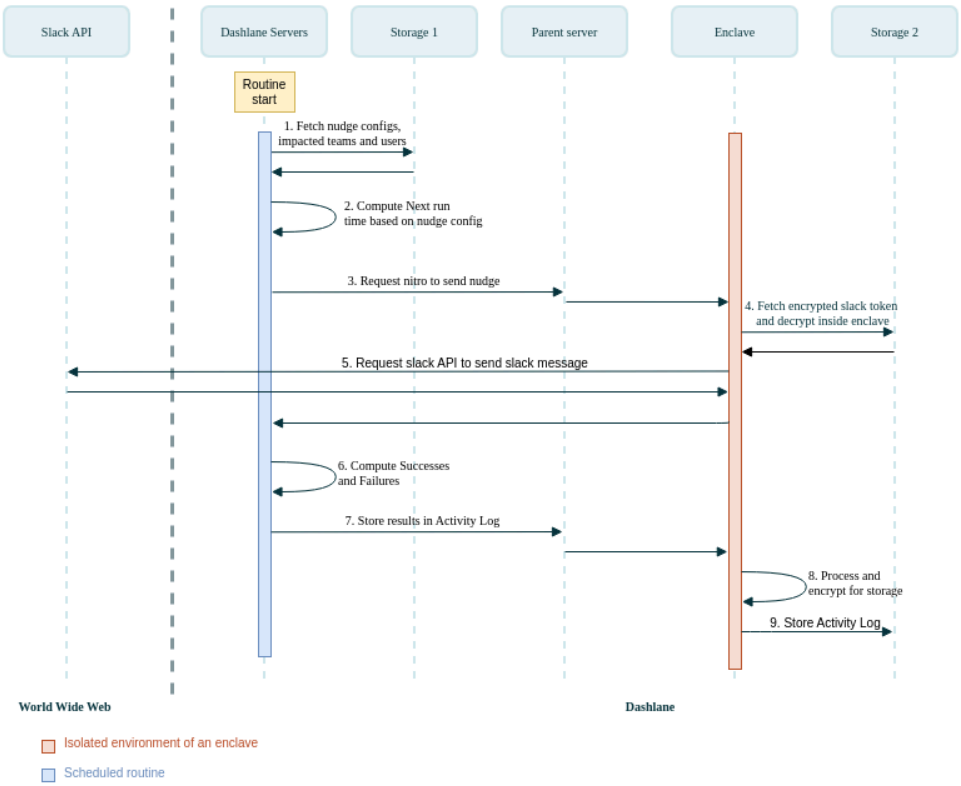


Figure 12: Nudge routine

View permissions	Send permissions
“View people in your workspace”	“Send messages as @dashlane”
“View email addresses of people in your workspace”	“Send messages as @dashlane with a customized username and avatar”

Table 3: Permissions required by Nudges Slack token

The slack token being a sensitive piece of information, it transits to the nitro enclave via a secure tunnel established between the Admin’s web extension and the enclave, and it is stored encrypted with a team-specific encryption key which is available only to the admin via their vault and to the enclave meaning the Dashlane team can never access it (see Figure Figure 10 & Figure 12).

1.18 Machine Learning for Autofill and Phishing Detection

Dashlane leverages machine learning models to power both our autofill engine and real-time phishing detection systems. These AI-powered features operate entirely on users’ devices, maintaining our zero-knowledge architecture while providing intelligent form field recognition and threat detection capabilities. This section details the different techniques employed in our machine learning pipelines.

1.18.1 Privacy-First Data Collection

Our machine learning models are trained exclusively on data collected through internal crowd-sourcing and publicly available sources, ensuring no user personal data is used in the training process.

As illustrated in the data collection pipeline Figure 13, our training data acquisition follows a privacy-preserving methodology:

- **Internal Crowdsourcing**: Internal team members voluntarily contribute anonymized form data through our "Vortex for Dashlaners" tool, providing diverse real-world form patterns. We remove all personally identifiable information through our redactor API.
- **Public Pages Crawling**: We automatically collect phishing pages from publicly available sources, including threat intelligence feeds, research databases, and open-source repositories.

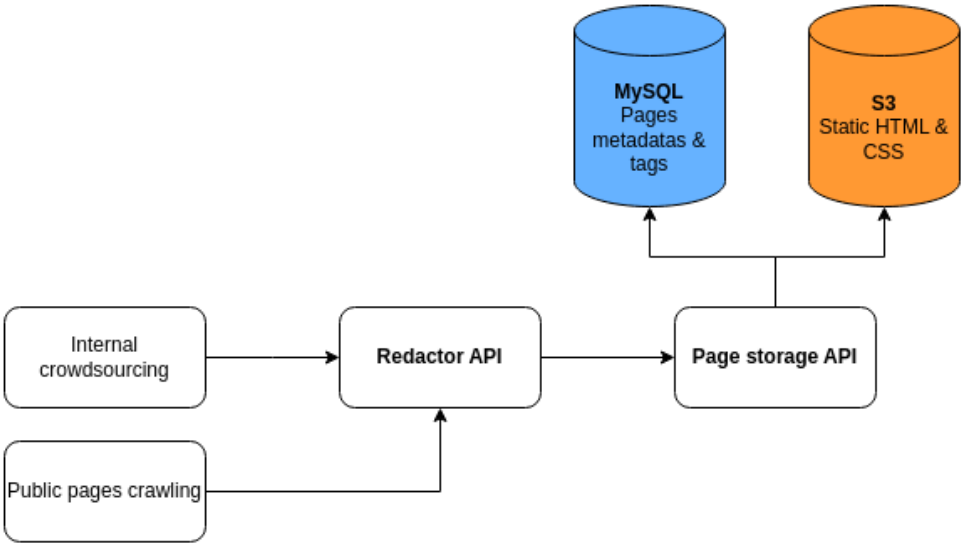


Figure 13: Data collection pipeline

1.18.2 Model Architecture

Our machine learning approach prioritizes privacy and efficiency through the use of compact, optimized models that can run entirely within browser extensions.

1.18.2.1 Model Development Pipeline

The machine learning development process follows these steps:

1. **Training with Scikit-learn**: Models are developed using the open-source scikit-learn library, focusing on lightweight algorithms such as Random Forest, Gradient Boosting, and Support Vector Machines that provide excellent performance while maintaining small footprints.
2. **Model Serialization**: Trained models are initially serialized in Python's PKL format for development and testing purposes, allowing for comprehensive validation and performance tuning.
3. **ONNX Conversion**: Production models are converted to the Open Neural Network Exchange (ONNX) format, ensuring cross-platform compatibility and optimized inference performance across different browser environments.
4. **Runtime Optimization**: The ONNX runtime is stripped of unnecessary components to minimize the extension's size while maintaining prediction accuracy.

1.18.2.2 Model Specifications

Our production models maintain the following characteristics to ensure optimal performance:

- **Size Constraint**: Average model size remains under 3MB, ensuring fast loading times and minimal impact on browser performance and memory usage.
- **Local Execution**: All model inference occurs locally on the user's device, with no data transmitted to external servers, preserving our zero-knowledge architecture.
- **Performance Optimization**: Models are optimized for real-time inference, typically completing predictions within 50-100 milliseconds to provide seamless user experience.

1.18.3 Feature Extraction

Both autofill and phishing detection rely on local webpage analysis to extract relevant features for model inference, ensuring data remains on the user's device.

1.18.3.1 Autofill Feature Extraction

As demonstrated in the login form analysis diagram Figure 14, our autofill system follows a three-step process for comprehensive form field analysis:

1. **Detection**: The system first identifies the presence and location of forms and pseudo-forms within the webpage DOM structure, including dynamically generated form elements that may not follow standard HTML patterns.
2. **Scraping**: Once forms are detected, the system extracts critical information from each field, including:
   - **Human Readables**: Visible text such as labels, placeholders, and surrounding contextual content
   - **HTML Attributes**: Technical field properties including names, IDs, classes, and input types
3. **Auto Labelling**: We use generative AI models on our internal database to automatically label forms and fields, enabling accurate supervised learning without manual annotation overhead.

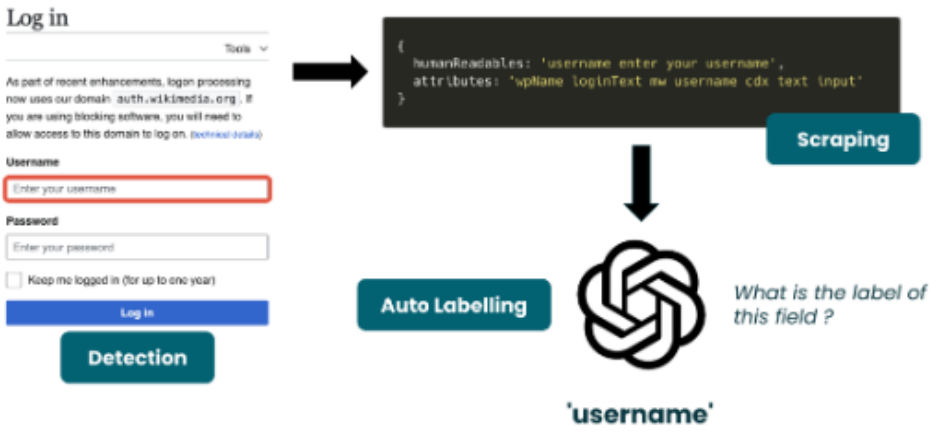


Figure 14: Feature extraction for autofill

1.18.3.2 Phishing Detection Feature Extraction

Our phishing detection system analyzes multiple webpage characteristics to identify potential threats Figure 15 (more info):

- **URL Analysis**: URL structure anomaly detection helps identify suspicious destinations.

- **Content Indicators**: Detection of suspicious text patterns, deliberate misspellings, and brand mimicry attempts that are common in phishing attacks.
- **Structural Anomalies**: Identification of hidden form fields, unusual redirect patterns, iframe abuse, and other technical indicators of malicious intent.

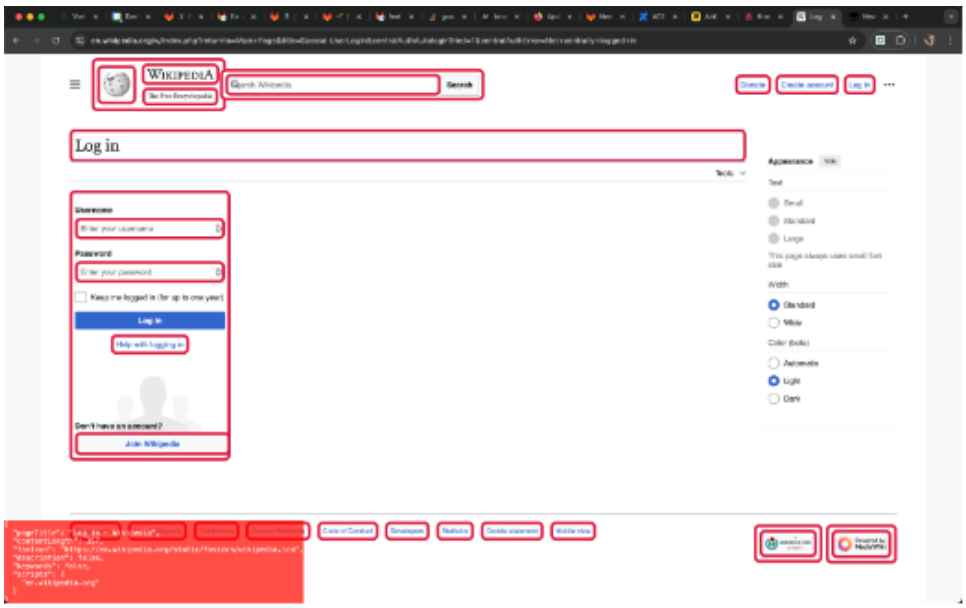


Figure 15: Example of extracted phishing indicators on Wikipedia

2 Single Sign-On (SSO)

Dashlane integrates with SSO Identity Providers (IdPs) that use the SAML 2.0 open standard authentication protocol, such as Okta, Azure AD, and ADFS. This integration allows employees to unlock their Dashlane vaults with their SSO credentials rather than their Master Password. To maintain Dashlane's zero-knowledge architecture, the SSO integration requires an SSO connector to store the user data encryption keys and deliver them upon user authentication. You can either self-host the SSO connector inside your own infrastructure or opt to have it hosted by Dashlane in a secure enclave.

If you choose the self-hosted option, the SSO connector acts as the service provider in the SAML workflow. Dashlane distributes the service, and you host and manage it as a server component, either on-premises or in the cloud. To preserve the zero-knowledge principle, the SSO connector stores the first part of the data encryption key (64 random bytes), and Dashlane's cloud servers store the other half (another 64 random bytes). Upon successful authentication and retrieval of both key parts by the Dashlane app, they are compared using the Boolean logic operation XOR, generating another 64-byte key that decrypts or encrypts the user data. If Dashlane hosts and manages the SSO connector, the zero-knowledge principle is enabled by the secure enclave — an environment that isolates the data and processes of the computing unit from the operating system and other processes on the host machine. The secure enclave encrypts the storage data and has an attestation mechanism to ensure that only authorized code can process the data. Dashlane cannot access the user encryption keys or any other data the SSO connector processes.

2.1 Introduction

Dashlane Business supports login with single sign-on (SSO), using any SAML 2.0 enabled IdP.

In a single-sign-on setup, the user doesn't have to input $\mathrm{User}_{\mathrm{MP}}$. Instead, a random key is generated at account creation. This key (the data encryption key) is delivered to the Dashlane app after the user successfully logs in to the IdP, and it is used as a symmetric encryption key to encrypt and decrypt the user data.

This section details how the key is stored and delivered to the user in order to make sure that the zero-knowledge principle is maintained.

2.2 General Principle

The integration of SSO with the Dashlane app requires an entity storing users' encryption keys and delivering them upon authentication. This entity has the knowledge of every user's key, so it's highly sensitive. Moreover, Dashlane can't host such an entity without more concerns because this would break our zero-knowledge principle by providing us access to the encryption keys of our users.

The previous entity in charge of users' encryption keys is called the Encryption Service and it could be hosted two different ways to follow our zero-knowledge rule:

- **Self-hosted:** the Encryption Service is a server deployed inside the infrastructure of Dashlane Business customer.
- **Hosted in a secure enclave by Dashlane:** the Encryption Service is a service running in Dashlane infrastructure, in a secure enclave to respect our zero-knowledge principle.

2.3 Single Sign-On with the Self-Hosted Connector

2.3.1 Overview

To avoid storing all the keys in one place, the data encryption key is composed of 2 parts:

- 64 random bytes held by the Encryption Service.
- 64 random bytes held by Dashlane's servers in the cloud.

The Encryption Service is a server component that the customer operates (either in the cloud or on premises). It acts as the service provider in the SAML 2.0 flow. After a successful authentication to the Encryption Service using SAML, the first part of the key is delivered to the Dashlane client application along with a token that allows it to get the second part from the Dashlane server.

Once both parts of the keys are retrieved by the client app, they are XORed together, and the resulting 64 bytes are used as a symmetric key to encrypt and decrypt user data.

This system ensures zero-knowledge as the first part of the key and is only known by the Encryption Service and the client app, both of which are managed by the customer.

It also makes sure that a compromised Encryption Service cannot be used to fetch the keys of users without leaving traces on Dashlane servers (an API call to the Dashlane server is required to fetch the second part of the key).

2.3.2 Services

Dashlane Server/API (API) The servers operated by Dashlane in the cloud, where user data is stored encrypted.

Encryption Service (SP) A service acting as the service provider in the SAML 2.0 flow. The service is distributed by Dashlane, but it's hosted and managed by the customer on premises or in the cloud.

Identity Provider (IdP) The SAML 2.0 identity provider (e.g. ADFS, Azure AD, Okta) of the customer. This service is not provided by Dashlane. It is operated by the customer or by a third party.

2.3.3 Keys, secrets, and certificates

IdP key and certificate (IdP_{Key} / IdP_{Cert}**)** Public and private keys of the IdP. The private key is held by the IdP, while the certificate needs to be provided to the SP in the configuration file. It is used by the IdP to sign and by the SP to verify the SAML assertions.

Master SP Key / Encryption Service Key ($Master\_SP_{Key}$**)** A 64 bytes secret key, generated randomly by the Team Admin Console (client side). It is stored in the configuration file of the SP, and is only known by the Team Admin. It is used by the SP to encrypt/decrypt the $User\_SP_{key}$ before storing them in the API.

User SP Key ($User\_SP_{Key}$**)** A 64 bytes secret key, generated randomly by the SP. It is stored and encrypted in the API.

User Server Key ($Server_{Key}$**)** A 64 bytes secret key, generated randomly by the client. It is stored unencrypted in the API.

User vault key ($Vault_{Key}$**)** $User\_SP_{Key}$ *oplus* $Server_{Key}$. It is used by the client to encrypt/decrypt users' data before storing them in the API.

2.3.4 Workflow

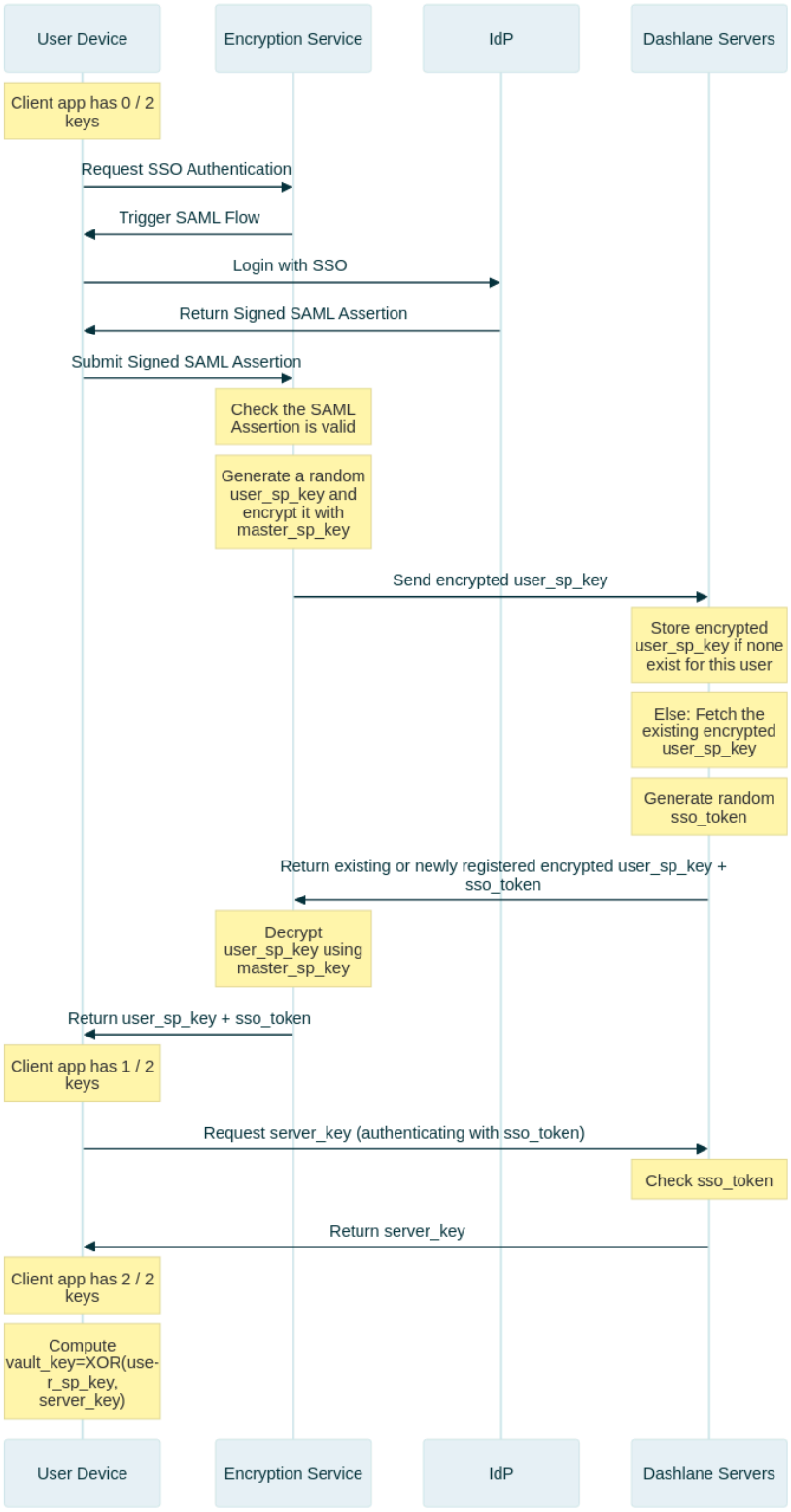


Figure 16: Self-Hosted SSO Workflow

2.4 Single Sign-On with the Dashlane-Hosted Connector

2.4.1 Overview

In the Dashlane-hosted connector setup, the Encryption Service service is hosted and managed by Dashlane. To prevent Dashlane from accessing users' encryption key, breaking the zero-knowledge principle, the Encryption Service runs in a so-called secure enclave.

A secure enclave is a term coming from the field of trusting computing. This is the name given to an isolated computing unit or a Trusted Execution Environment (TEE). This technology provides a way to process data inside an environment that is not readable by any other process of the hosting machine besides the process running inside the enclave. Moreover, secure enclaves can generate attestation with the fingerprint of the code they run. This way, clients communicating with an enclave can get assurances of the code they are communicating with and decide if they trust this code to process their data.

Secure enclaves are just computing units with CPU and volatile memory resources. They are not provided with persistent storage. To circumvent this problem, a Key Management Service (KMS), which can authenticate that requests are coming from trusted enclaves, is required to encrypt the storage of secure enclaves.

Dashlane leverages secure enclave technology to run a Encryption Service service without being able to access users' encryption keys processed by the Encryption Service.

2.4.2 Cryptographic materials

Dashlane confidential SSO workflows require a lot of cryptographic keys and certificates defined in the table Table 4. All keys defined is 32 bytes long.

Key Name	Key Symbol	Description
Enclave Master Key	EM_{Key}	Key generated and stored within the KMS in order to encrypt/decrypt $EL#sub[Key]$
Enclave Local Key	EL_{Key}	Key generated within the KMS at the first enclave bootstrap and sent to this enclave in order to derive $EE#sub[Key]$
Enclave Unseal Key	EU_{Key}	Key generated by the deployment process at the first bootstrap and sent to the enclave, in order to derive $EE#sub[Key]$
Enclave Encryption Key	EE_{Key}	Key derived from $EL#sub[Key] \oplus EU#sub[Key]$ in order to encrypt $SPMaster#sub[Key]$
Service Provider Master Key	$SPMaster_{Key}$	Key generated within the enclave on a new team registration in order to encrypt/decrypt $UserSP#sub[Key]$
User Service Provider Key	$UserSP_{Key}$	Key generated within the enclave when the user is provisioned for SSO authentication, in order to encrypt $Remote#sub[Key]$
SSO Server Key	$SSOServer_{Key}$	Generated by the server at account creation, in order to encrypt $Remote#sub[Key]$
Remote Key	$Remote_{Key}$	Generated by the client at account creation, in order to encrypt user's vault
Identity Provider Certificate	IdP_{Cert}	Certificate of public key of the IdP to verify SAML assertion

Table 4: Cryptographic keys and certificates implied in Dashlane-hosted workflows

2.4.3 Workflows

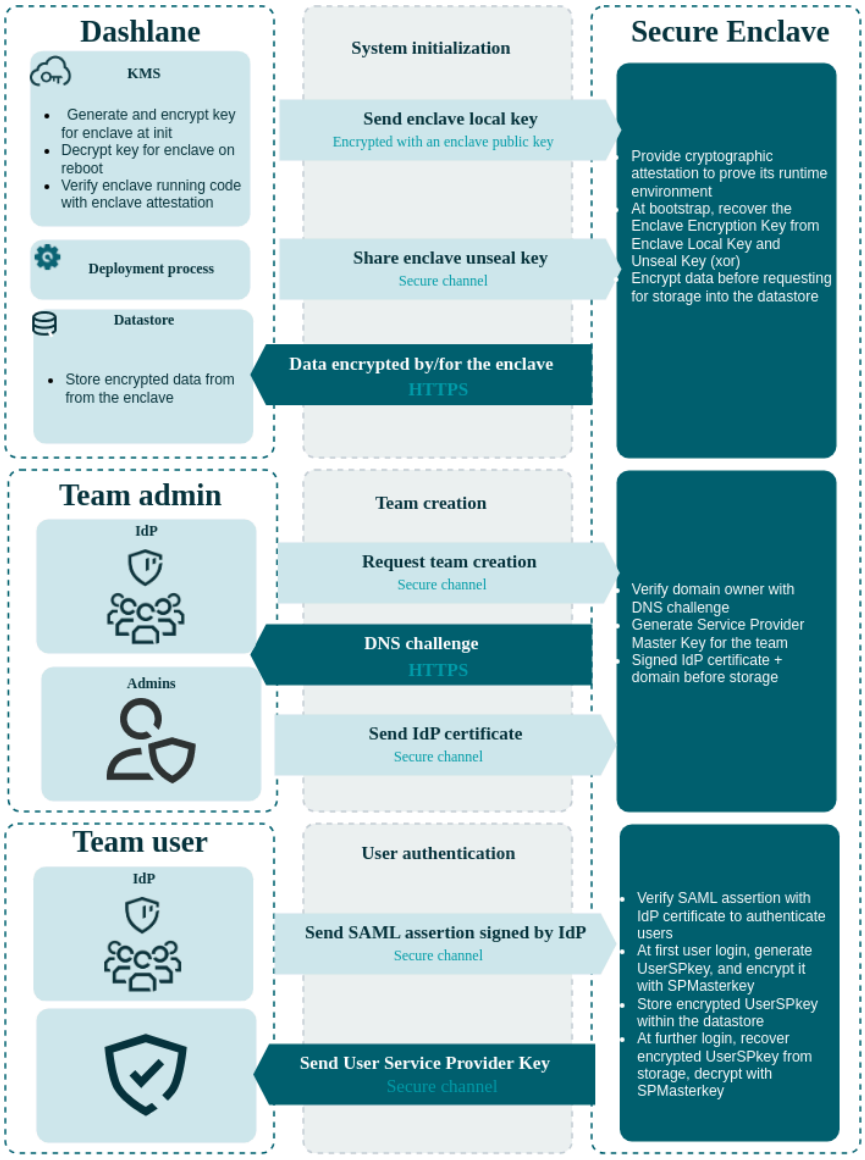


Figure 17: Dashlane-Hosted SSO Workflow

2.4.3.1 Enclave initialization step

The first step is to generate an Enclave Master Key in the KMS and to build access policies to that Enclave Master Key so access is granted only to the enclave. This is done by basing policies on information provided by the attestation of the enclave: when the KMS get a request for the Enclave Master Key, it matches the attestation provided with the policies to grant or deny the request.

Then, the enclave is deployed and requests the KMS to generate an Enclave Local Key and to securely send back to the enclave two versions of the Enclave Local Key: one encrypted by the Enclave Master Key and one encrypted with an ephemeral public key provided by the attestation. The enclave requests the storage of the encrypted Enclave Local Key and keeps the plaintext Enclave Local Key in this volatile memory. This way, if the enclave reboots or a new instance is deployed, the instance will then request from the storage the encrypted Enclave Local Key

then the KMS will decrypt it with the Enclave Master Key. This way, the enclave is provided with the Enclave Local Key to encrypt data, and the Enclave Local Key is never in plaintext outside a secured environment; the enclave or the KMS.

Figure Figure 18 describes the workflow to provide secure enclaves with $\mathrm{EL}_{\mathrm{Key}}$.

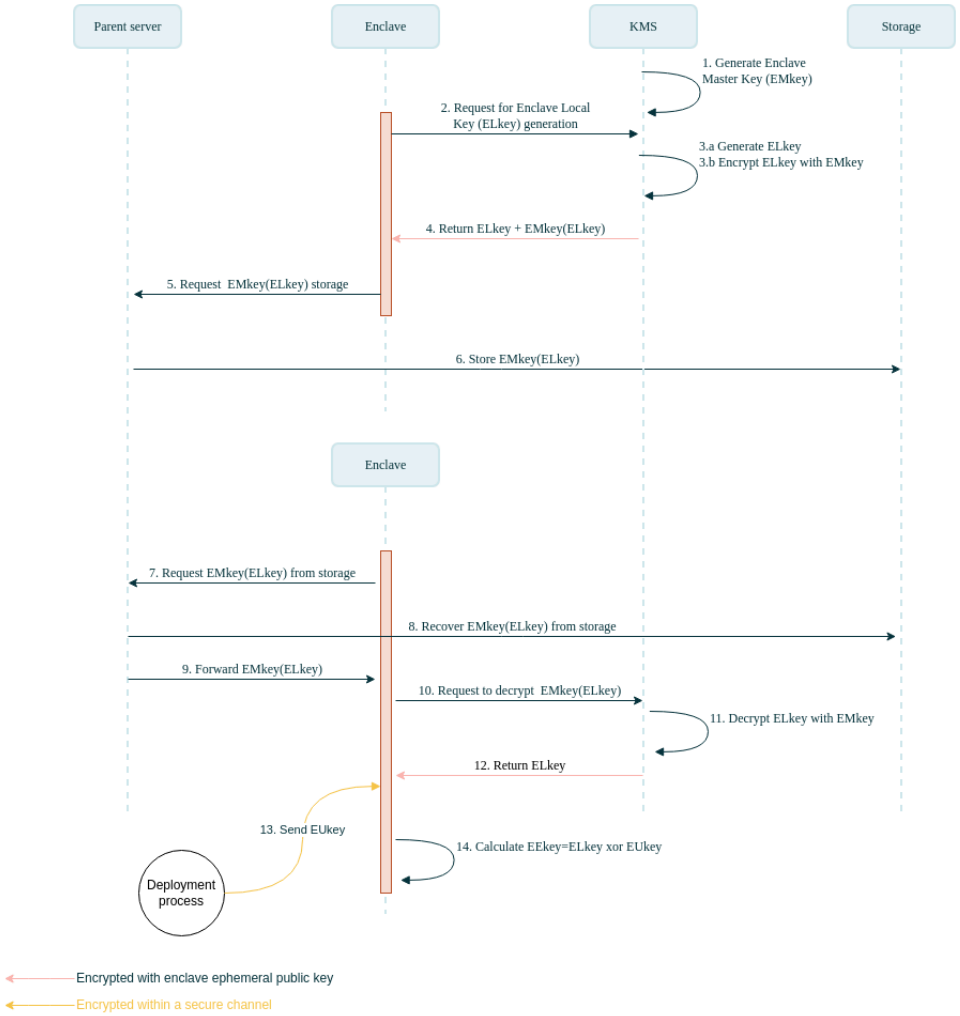


Figure 18: Dashlane Confidential SSO Initialization

Then, the deployment process can mount a secure channel (based on the attestation of the enclave) to send $\mathrm{EU}_{\mathrm{Key}}$ to the enclave. This way, the secure enclave can derivate the Enclave Encryption Key as follows: $\mathrm{EE}_{\mathrm{Key}} = \mathrm{EL}_{\mathrm{Key}} o + \mathrm{EU}_{\mathrm{Key}}$

2.4.3.2 Storage of the secure enclave

A secure enclave is a runtime environment with no persistent storage. Data needs to be encrypted before being passed through the parent server toward the datastore.

Data within the secure enclave requiring persistent storage are the following:

- the Enclave Local Key $\mathrm{EL}_{\mathrm{Key}}$, encrypted by the Enclave Master Key $\mathrm{EM}_{\mathrm{Key}}$.
- Service Provider Master Keys $\mathrm{SPMaster}_{\mathrm{Key}}$ of each team, encrypted by the Enclave Encryption Key $\mathrm{EE}_{\mathrm{Key}}$.
- User Service Provider Keys $\mathrm{UserSP}_{\mathrm{Key}}$ of each user, encrypted by the $\mathrm{SPMaster}_{\mathrm{Key}}$ of their team.

2.4.3.3 Team creation

The team creation step is the configuration of the SSO for an organization: the enclave is provided with the IdP certificate to verify SAML assertions for authenticating users of a domain (e.g users with an email from a given domain). The enclave still needs to verify that the admin performing the operation is the owner of the claimed domain: this is to prevent anyone from providing a rogue IdP certificate for a domain they don't own. Indeed, SSO is based on the domain of the email of the user. For example, if a user requests to log in with the username `user@example.com`, and the domain "example." + "com" is linked to an IdP, the user will go through the authentication flow with that IdP. This way, registering an IdP for a domain is a sensitive operation, requiring the secure enclave to perform the domain verification.

The team creation flow is described in Figure Figure 19

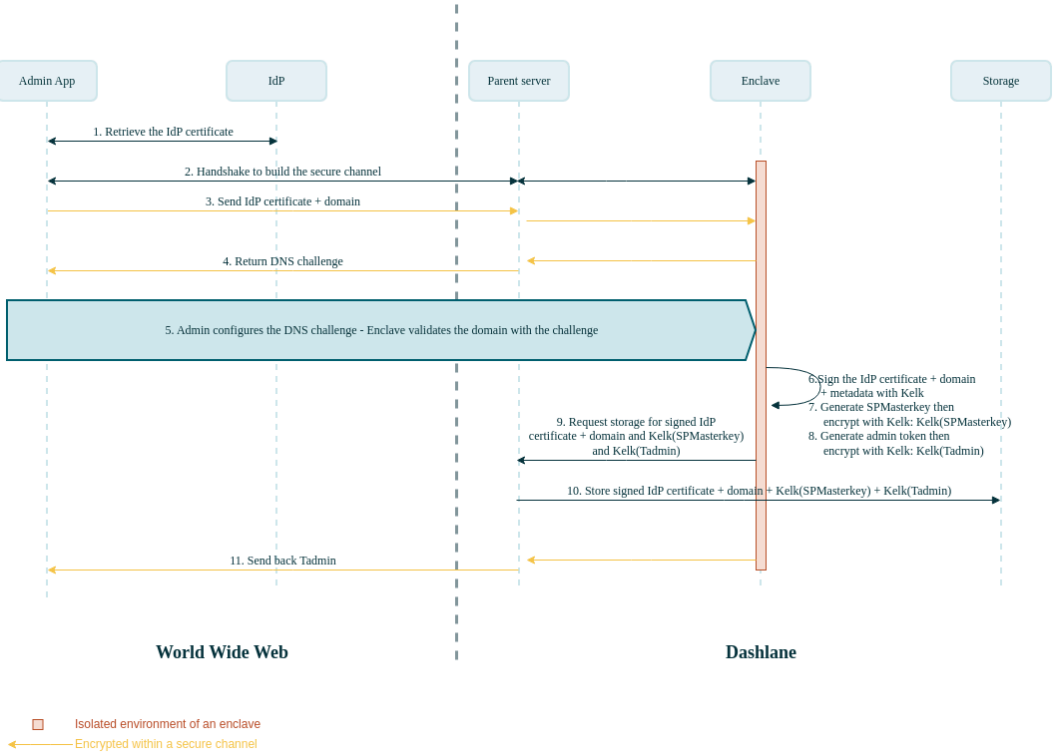


Figure 19: Dashlane Confidential SSO Team Creation Flow

1. IT admin of the organization configures the IdP and gets the URL for the IdP endpoint and the IdP certificate of the key, which will sign further users' proof of authentication; IT admin starts the configuration flow of the SSO in the Admin application.
2. The Admin application performs a handshake with the enclave to build a secure channel.
3. Through the secure channel, the client application sends the IdP certificate and domain; this is done in the secure channel to protect the IdP certificate's integrity (to prevent the certificate from being replaced in transit by a rogue certificate).
4. The enclave sends back a random value to initiate the verification of the domain.
5. IT Admin and enclave perform the DNS challenge: the goal is to let the enclave confirm that it is speaking with an owner of the claimed domain; for that, the IT Admin has to place the random value at the root of the domain and then the enclave can check this value with the

DNS (better with a secured version of the protocol); this way, the enclave validates that the IT admin is the owner of the claimed domain.

6. The enclave generates a Message Authentication Code (MAC) for the IdP certificate + domain + metadata from $\mathrm{EE}_{\mathrm{Key}}$.
7. The enclave generates the Service Provider Master Key for the domain $\mathrm{SPMaster}_{\mathrm{Key}}$, then encrypts it with $\mathrm{EE}_{\mathrm{Key}}$.
8. The enclave generates a token to authenticate admins of the domain (the token will be shared between admin accounts of the domain), then encrypts it with $\mathrm{EE}_{\mathrm{Key}}$.
9. The enclave requests the parent instance to store the signed IdP certificate + domain, the encrypted $\mathrm{SPMaster}_{\mathrm{Key}}$, and the encrypted token admin.
10. The parent instance stores the signed IdP certificate + domain, the encrypted $\mathrm{SPMaster}_{\mathrm{Key}}$, and the encrypted token admin.
11. The instance sends back the token admin through the secure channel.

2.4.3.4 User SSO login

After the team creation, a user can expect to open their vault with the SSO flow. Reaching the login page of their client application which redirects them to the login page of their IdP. After the IdP authenticates the user, it redirects the user to the client application with a SAML assertion proving their identity. Then, the client application can send the assertion to the Encryption Service to receive back $\mathrm{UserSP}_{\mathrm{Key}}$, decrypting the user's vault.

Until the proof of authentication is sent, the flow is the same for users who perform their first login and users who have already enabled their account.

The beginning of the flow is described by Figure 20

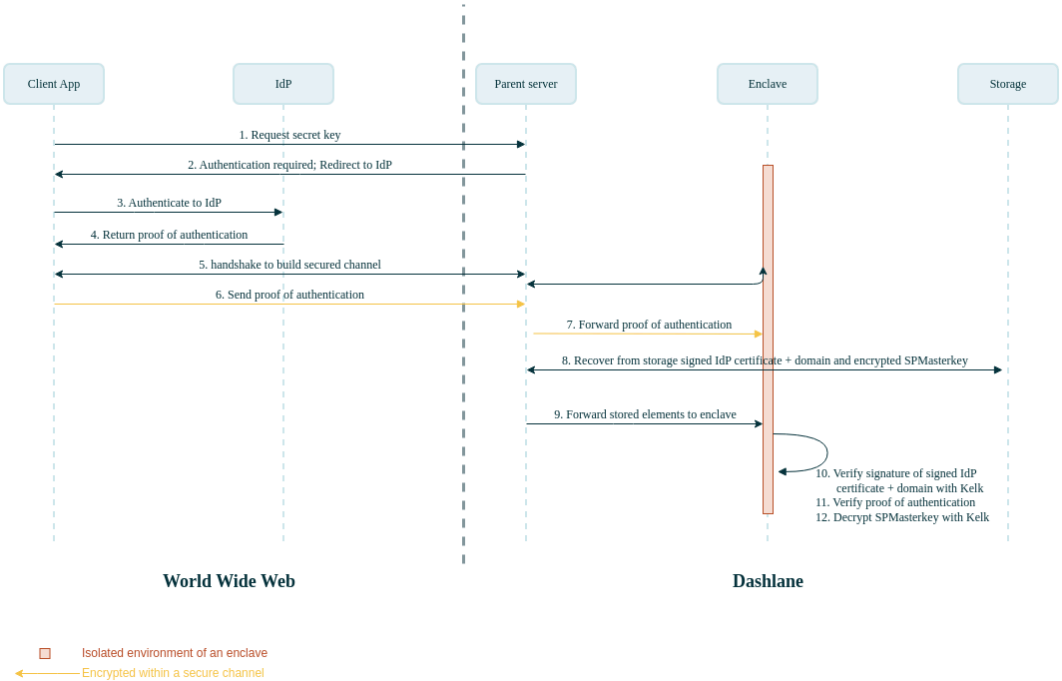
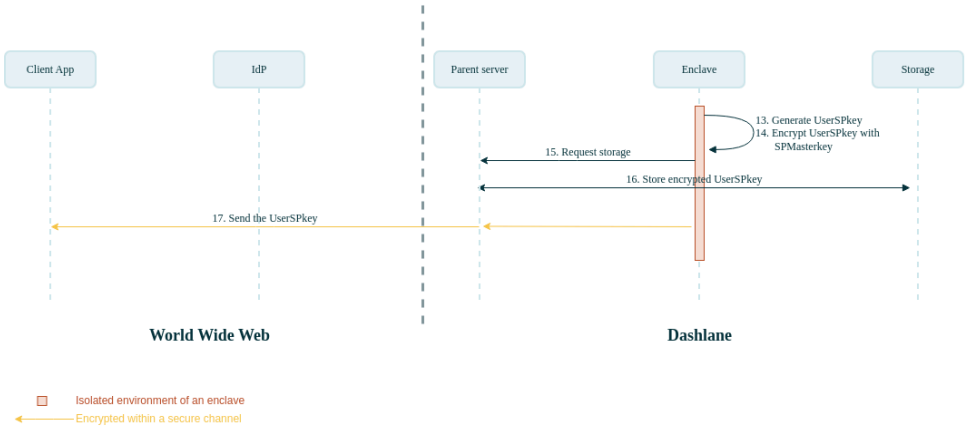
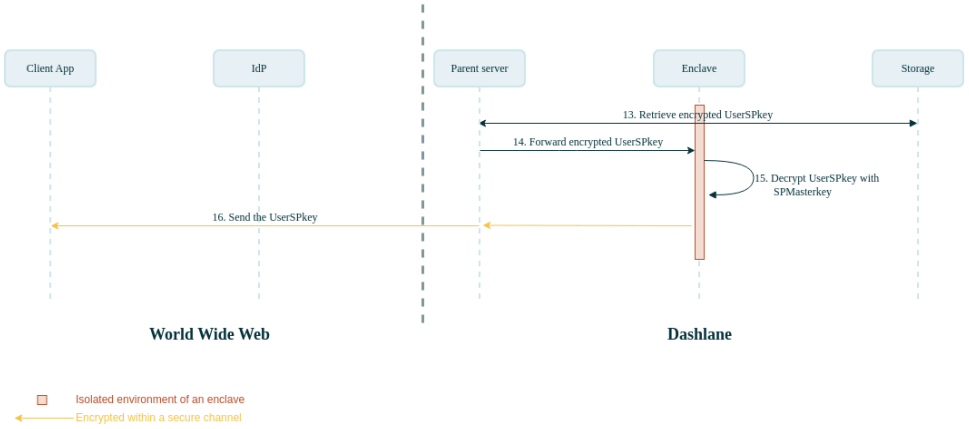


Figure 20: Dashlane Confidential SSO - User Login Flow

From this point, the user is authenticated in the enclave. The flow diverges between the first connection account and already enabled account.



(a) First login



(b) Standard login

Figure 21: Dashlane-Hosted SSO - User Login Flow Part 2

After users are authenticated (the signature of their proof of authentication is verified) for first connection, the workflow is as described in Figure 21.a:

13. The enclave generates the $UserSP_{Key}$.
14. The enclave encrypts $UserSP_{Key}$ with $SPMaster_{Key}$.
15. The enclave requests the parent server store $SPMaster_{Key}(\text{UserSP}_{\text{Key}})$.
16. After confirmation that $SPMaster_{Key}(\text{UserSP}_{\text{Key}})$ is stored, the enclave sends back to the client application the $UserSP_{Key}$, encrypted in the secure channel.

After users are authenticated (the signature of their proof of authentication is verified), for an account already enabled, the workflow is as described in Figure 21.b:

13. The parent server retrieves $SPMaster_{Key}(\text{UserSP}_{\text{Key}})$ from the storage.
14. The parent server forwards stored elements to the enclave.
15. The enclave decrypts the $SPMaster_{Key}(\text{UserSP}_{\text{Key}})$.
16. The enclave sends back to the client application the $UserSP_{Key}$, encrypted in the secure channel.

2.4.3.5 SCIM User provisioning

The admin can configure confidential user provisioning in the Team Admin Console (TAC). To complete this configuration the Dashlane extension generates a bearer token using uuidv4. This bearer token is then transmitted via a secure tunnel to the secure enclave where it is encrypted and stored.

In the meantime, the admin manually adds this token in their IdP along with the URL of the team-specific SCIM endpoint where the IdP should send the updates (the later is provided to the admin in TAC).

Once these configuration steps are completed, updates can start being sent by the IdP to the enclave via HTTPS requests. As seen in figure Figure 22, the enclave validates the SCIM bearer token before forwarding the operations to the Dashlane servers to update the users accordingly. On user creation the enclave will generate a Uuid (scimId) and return this identifier to the IdP so that the IdP and Dashlane can share a common identifier for this SCIM user in the future.

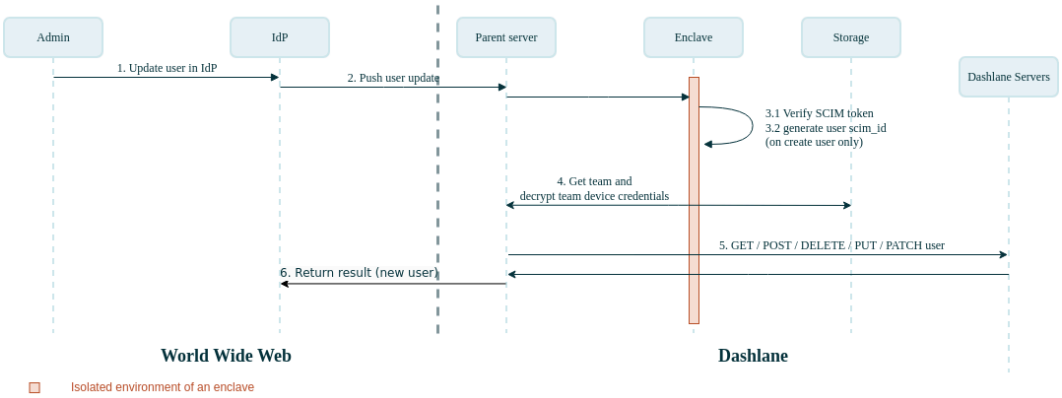


Figure 22: Dashlane Confidential User provisioning

2.4.3.6 Group provisioning

If activated by the admin in TAC, confidential group provisioning happens at user login.

It is based on the SAML assertion which is transmitted during the SSO-login flow, as described in figure Figure 23.

When a user logs into Dashlane with SSO the enclave receives from the extension a SAML assertion which includes the names of the groups said user is a member of. The enclave then gets the groups associated to that team from the Dashlane server and determines:

- new groups to be created,
- existing groups to invite the user to,
- existing groups to revoke the user from.

The Dashlane server is called to execute these actions. This group provisioning flow is idempotent: We receive a list of groups the user is supposed to be a member of, and by the end of the flow the user is a member of each of them and no other.

The list of groups is signed by the IdP as part of the SAML assertion and the secure enclave validates this signature. This check guarantees that the list of groups has not been tampered with by a third party.

Security Model of Group Provisioning

Group Provisioning can give access to shared secrets, making it highly sensitive.

The SCIM protocol doesn't provide a way to authenticate an enclave on the IdP side, posing a risk for group provisioning inside our boundaries. SAML assertions are preferred because they transit through the secure tunnel created by the extension and are signed by the IdP. This way, group provisioning can't be tampered with.

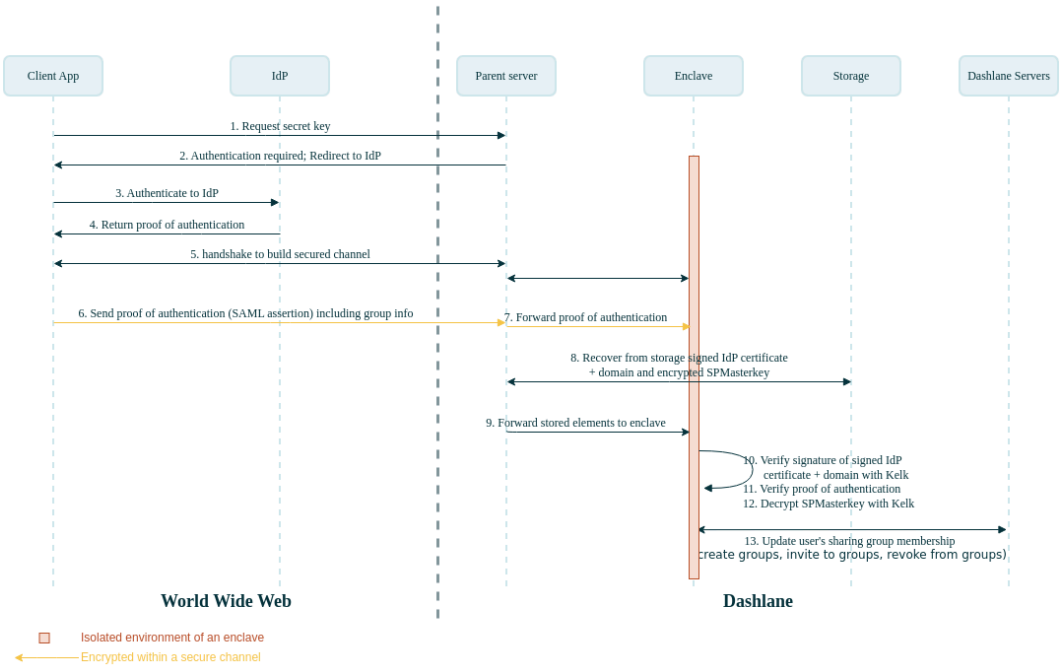


Figure 23: Dashlane Confidential Group provisioning

3 Impact on Potential Attack Scenarios

Dashlane has embedded a variety of security protocols into the architecture to prevent user data compromise due to an attack from external or internal malicious actors. Some examples of these protocols include:

- Separation of the key for encrypting the user data and the key for authenticating the user on the Dashlane server, which ensures user data encryption keys are not stored anywhere and cannot be accessed by Dashlane employees or by attackers if the Dashlane servers are compromised.
- Web protection measures including anti-clickjacking provisions, which prevent rogue websites from triggering a malicious click and extracting data from the Dashlane app; and same-origin policy, which only autofills a saved password on exact URL subdomains.
- Using the Argon2 function, which protects the encrypted user data against brute-force or dictionary attacks.

3.1 Minimal Security Architecture

Cloud services can use a **single private secret**, usually under their control, **to encrypt all user data**. This is obviously a simpler choice from an implementation standpoint, plus it offers the advantage of facilitating **deduplication** of data, which can provide important economic benefits when the user data volume is high. Obviously, this is not an optimal scenario from a security standpoint since if the key is compromised (hacker attack or rogue employee), all user data is exposed.

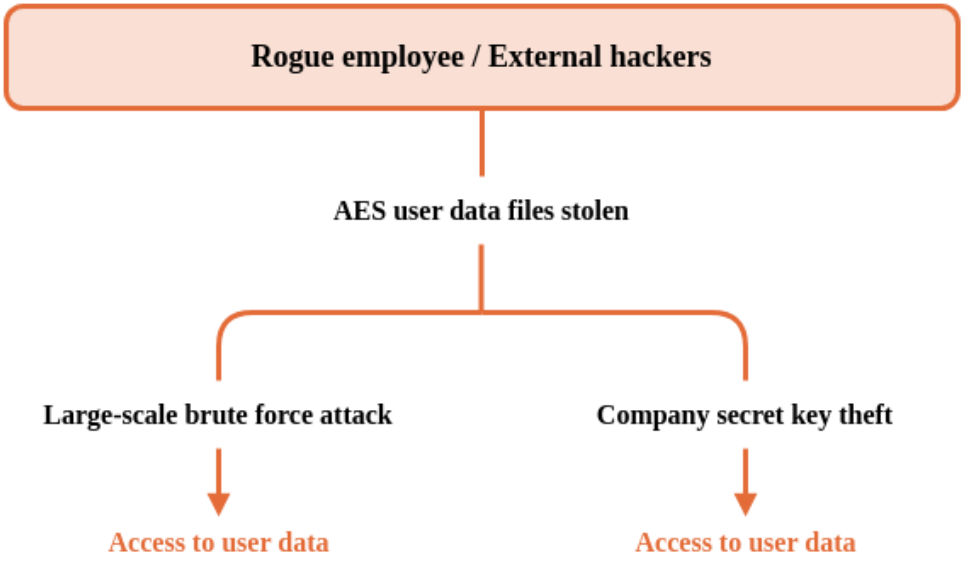


Figure 24: Potential Attack Scenarios With Minimal Security

3.2 Most Common Security Architecture

A better alternative is to use a different key for each user. The most common practice is to ask the user to provide a (strong) $\mathrm{User}_{\mathrm{MP}}$ and to derive the encryption key for each user from their $\mathrm{User}_{\mathrm{MP}}$. However, to keep things simple for the user, many services or applications tend to also use the as an authentication key for the connection to their services. This implies that an attacker could access a user's vault by just knowing the Master Password. It could also easily lead to implementation errors (missing salt/rainbow tables attacks, wrong/weak hashing, etc.).

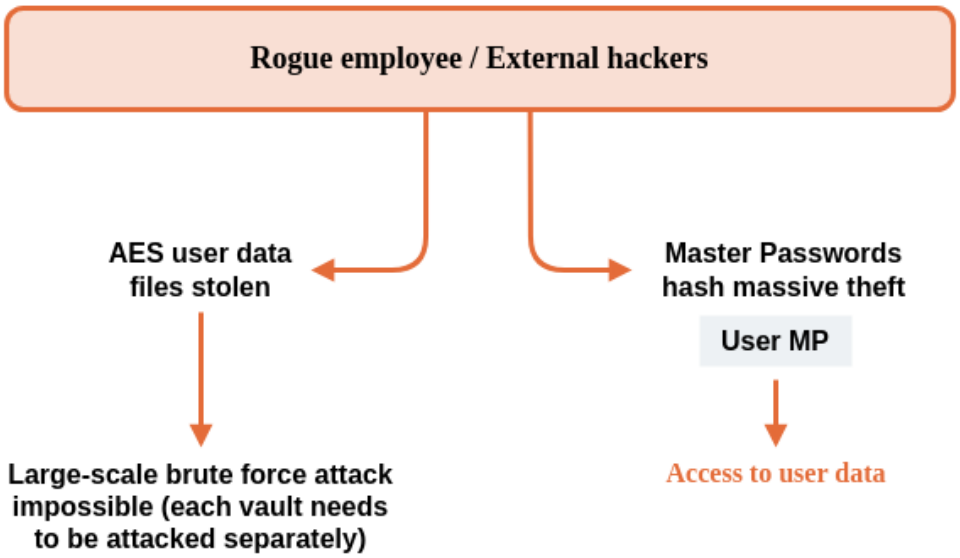


Figure 25: Potential Attack Scenarios With Most Cloud Architecture

3.3 Dashlane Security Architecture

To make this attack scenario impossible, we have made the decision to separate the key used for user data encryption and the key used for server-based authentication (see Figure 26). The user data is encrypted with a key, which is a derivative of $\mathrm{User}_{\mathrm{MP}}$ or $\mathrm{MachineGenerated}_{\mathrm{MP}}$. A separate $\mathrm{Device}_{\mathrm{Key}}$ (unique to each device-user couple) is used to perform authentication on Dashlane servers. $\mathrm{Device}_{\mathrm{Key}}$ is automatically generated by Dashlane. As a result:

- Encryption keys for user data are not stored anywhere.
- No Dashlane employee can ever access user data.
- User data is protected by $\mathrm{User}_{\mathrm{MP}}$ or $\mathrm{MachineGenerated}_{\mathrm{MP}}$ even if Dashlane's servers are compromised.

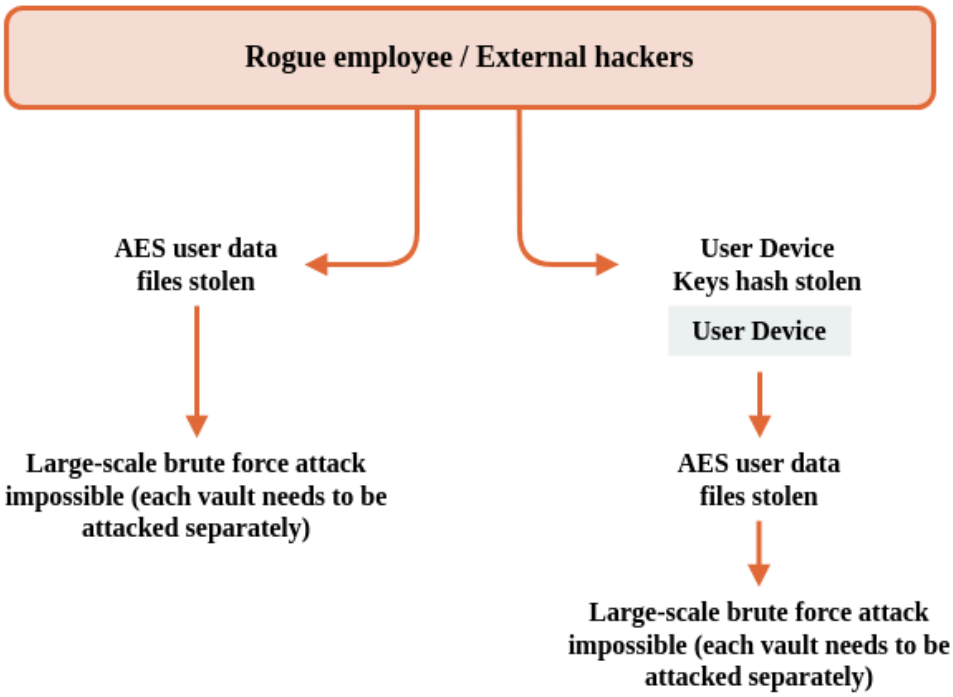


Figure 26: Potential Attack Scenarios With Dashlane's Security Architecture

Even if this scenario happens, a rogue employee or an external hacker would have a very hard time executing a brute force or dictionary attack on the AES user data files, as we use the Argon2d (or PBKDF2-SHA2) algorithm. As the user's data is encrypted using a salted key, which is a derivative of $\mathrm{User}_{\mathrm{MP}}$ or $\mathrm{MachineGenerated}_{\mathrm{MP}}$, no precomputed attacks should be possible.

3.4 Anti-Clickjacking Provisions

To protect Dashlane users from rogue websites that would attempt to use clickjacking tactics or other JavaScript-based attacks to extract data from the Dashlane application, we have made sure none of the webpage-based interactions involving user data unrelated to this website use JavaScript.

The popups used to trigger form-filling on a webpage use various browser security APIs to prevent control from the JavaScript of the visited page. As a result, a rogue website cannot trigger a click that would cause Dashlane to believe that the user has actually clicked, and therefore, cannot extract information unless the user explicitly clicks in the field.

3.5 Same-Origin Policy

Dashlane automatically logs users into websites. To avoid providing users' information to rogue websites, the same-origin policy is always respected.

First, a credential saved by Dashlane when it has been used on a website with the URL of *mysubdomain.mydomain.com* will not be automatically filled on another website with the URL of myothersubdomain.mydomain.com. This prevents the credential of a specific website from being provided to another website that share the same top-level domain name.

Also, a credential saved by Dashlane when it has been used on a website with a URL beginning with https will not be automatically filled on another website with a URL beginning with http.

3.6 Memory Protection

A problem can arise if an attacker takes control of the user's client device. In that scenario, the attacker could retrieve the decrypted user data from the memory.

This is an extreme scenario as, in that case, the attacker can take control of many parts, including adding a keylogger to capture $\mathrm{User}_{\mathrm{MP}}$ or PIN Code for passwordless users.

- Mobile operating systems (Android, iOS) ensure that no process can ever access the memory of another process and *are not directly affected.*

Finally, we believe the system integrity and security between processes is a system function and Dashlane cannot (and should not) reinvent the wheel and add useless complexity that could lead to other vulnerabilities and have negative side-effects.

Appendices

A Activity Log - List of Events

A.1 Default Activity Logs

Event Name	Event Message
master_password_reset_accepted	Accepted an Account Recovery request from [email]
master_password_reset_refused	Denied an Account Recovery request from [email]
user_device_added	Added the device [name]
user_device_removed	Removed the device [name]
requested_account_recovery	Requested Account Recovery
completed_account_recovery	Recovered their account through Account Recovery
dwm_email_added	Added [email] to Dark Web Monitoring
dwm_email_removed	Removed [email] from Dark Web Monitoring
user_group_created	Created a group named [groupName]
user_group_renamed	Renamed the [oldGroupName] group to [newGroupName]
user_group_deleted	Deleted the [groupName] group
user_joined_user_group	Joined the [groupName] group
user_invited_to_user_group	Invited [email] to the [groupName] group
user_declined_invite_to_user_group	Declined to join the [groupName] group
user_removed_from_user_group	Removed [email] from the [groupName] group
team_name_changed	Changed your company name to [name]
new_billing_period_created	Extended your account until [date]
seats_added	Added [count] seats to your account
domain_requested	Added [domain] as an unverified domain
domain_validated	Verified the domain [domain]
collect_sensitive_data_audit_logs_enabled	(user) turned on unencrypted vault logs
collect_sensitive_data_audit_logs_disabled	(user) turned off unencrypted vault logs
sso_idp_metadata_set	Updated SSO identity provider metadata
sso_service_provider_url_set	Configured SSO service provider URL
sso_enabled	Enabled SSO
sso_disabled	Disabled SSO
contact_email_changed	Changed contact email to [email]
master_password_mobile_reset_enabled	Turned on biometric recovery for [deviceName]
two_factor_authentication_login_method_added	Activated a 2FA method
two_factor_authentication_login_method_removed	Removed a 2FA method
user_invited	Invited [email] to your account
user_removed	Revoked [email] from your account
team_captain_added	Changed [email] to admin rights
team_captain_removed	Changed [email] to member rights
group_manager_added	Changed [email] to group manager rights
group_manager_removed	Changed [email] to member rights

Event Name	Event Message
user_reinvited	Resent an invite to [email]
billing_admin_added	Made [name] the billing contact
billing_admin_removed	Revoked [name] as the billing contact
nitro_user_provisioning_activated	Activated confidential user provisioning
nitro_user_provisioning_deactivated	Deactivated confidential user provisioning
nitro_group_provisioning_activated	Activated confidential group provisioning
nitro_group_provisioning_deactivated	Deactivated confidential group provisioning
nitro_siem_activated	Activated export of activity logs to SIEM provider
nitro_siem_edited	Edited the configuration of the SIEM integration
nitro_siem_deactivated	Deactivated export of activity logs to SIEM provider
nitro_integration_app_installed	Installed [integration_app] integration
nitro_integration_app_uninstalled	Uninstalled [integration_app] integration
nudge_configured	Set [nudge_name] to [status]
nudge_executed	Nudged [successes] users for [nudge_name]
user_received_nudge	Received [nudge_received] nudge
mass_deployment_configuration_updated	Set mass deployment risk detection to [status]

Table 5: Dashlane Activity Logs

A.2 Additional Sensitive Activity Logs

Event Name	Event Message
collect_sensitive_data_audit_logs_enabled	(user) turned on additional activity logs (unencrypted)
collect_sensitive_data_audit_logs_disabled	(user) turned off additional activity logs (unencrypted)
user_shared_credential_with_group	(user) shared [rights [limited/full]] rights to the [domain] login with [group]
user_shared_credential_with_email	(user) shared [rights [limited/full]] rights to the [domain] login with [email]
user_shared_credential_with_external	(user) shared [rights [limited/full]] rights to the [domain] login with the external user [email]
user_accepted_sharing_invite_credential	(user) accepted a sharing invitation for the [domain] login
user_rejected_sharing_invite_credential	(user) rejected a sharing invitation for the [domain] login
user_revoked_shared_credential_group	(user) revoked access to the [domain] login from [group]
user_revoked_shared_credential_external	(user) revoked access to the [domain] login from the external user [email]
user_revoked_shared_credential_email	(user) revoked access to the [domain] login from [email]
user_created_credential	(user) created a login for [domain]
user_modified_credential	(user) modified the login for [domain]
user_deleted_credential	(user) deleted the login for [domain]
user_created_collection	(user) created a Collection [name]
user_imported_collection	(user) imported [#] logins into the Collection [name]
user_added_credential_to_collection	(user) added the login for [domain] to the Collection [name]
user_removed_credential_from_collection	(user) removed the login for [domain] from the Collection [name]
user_renamed_collection	(user) modified the name for the Collection [name]
user_shared_collection_with_user	(user) shared Collection [name] with [roles] role with [email]
user_shared_collection_with_usergroup	(user) shared Collection [name] with [roles] role with [group]
user_accepted_collection_invite	(user) accepted the sharing invitation to the Collection [name]
user_rejected_collection_invite	(user) rejected the sharing invitation to the Collection [name]
user_added_credential_to_shared_collection	(user) added the [domain] login with [rights] to to the Collection [name]
user_updated_collection_usergroup	(user) updated [group] from [roles] role to [roles] role for the Collection [name]
user_updated_collection_user	(user) updated [email] from [roles] role to [roles] role for the Collection [name]
user_revoked_collection_usergroup	(user) revoked access to the Collection [name] for [group]
user_revoked_collection_user	(user) revoked access to the Collection [name] for [email]
user_typed_password	(user) typed [security_status [weak/compromised]] password on [domain_url]

Table 6: Dashlane Sensitive Activity Logs

A.3 Diagrams

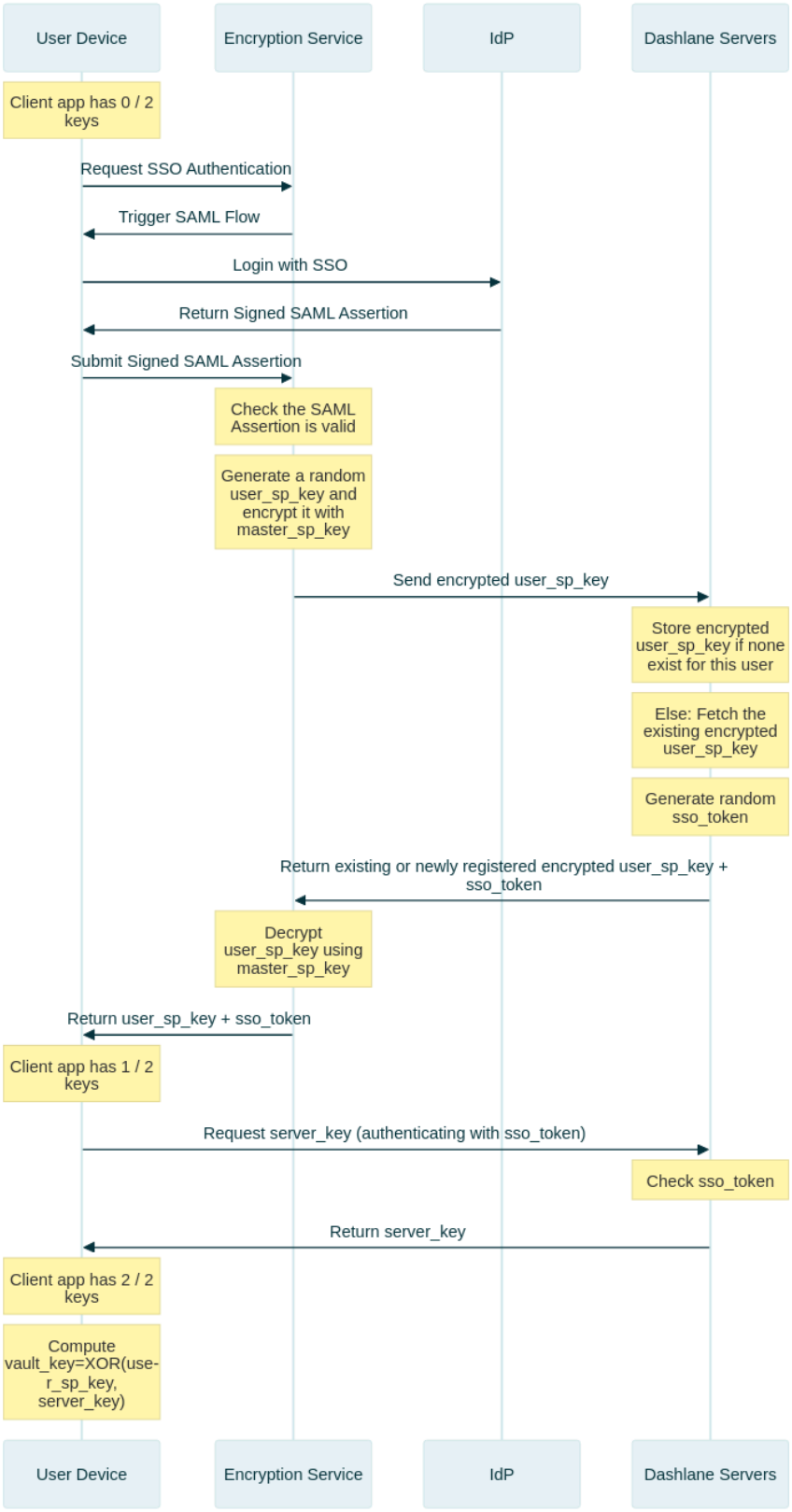


Figure 27: SSO Flow

B Change History

v2.2.0 (2024-01-08)

- fix: resize and rename Table 1
- fix: change page numbering in the table of contents
- feat: adding new collection activity logs
- feat: add change history section

v2.3.0 (2024-02-02)

- fix: remove some format misconfigurations
- feat: add info about entropy in tab.1
- fix: remove specific antivirus mention in section 3.6
- fix: simplify section 1.7

v2.4.0 (2024-03-18)

- feat: add paragraph about zxcvbn for Master Password

v2.5.0 (2024-05-29)

- feat: add sections about confidential user & group provisioning

v2.6.0 (2024-06-10)

- chore: remove Dashlane Authenticator mentions

v2.7.0 (2025-01-29)

- feat: add sections about CRD and Nudges
- fix: update figure 4 and figure 5 caption and labels
- chore: add Nudges activity logs to the appendix## 2.7.0 (2025-09-02)## 3.0.0 (2025-09-02)

v3.0.0 (2025-09-02)

- Add new AI and Antiphishing section
- chore(revamp) - Migrate from LaTeX to Typst