SHA-256 Algorithm Overview

By N-able
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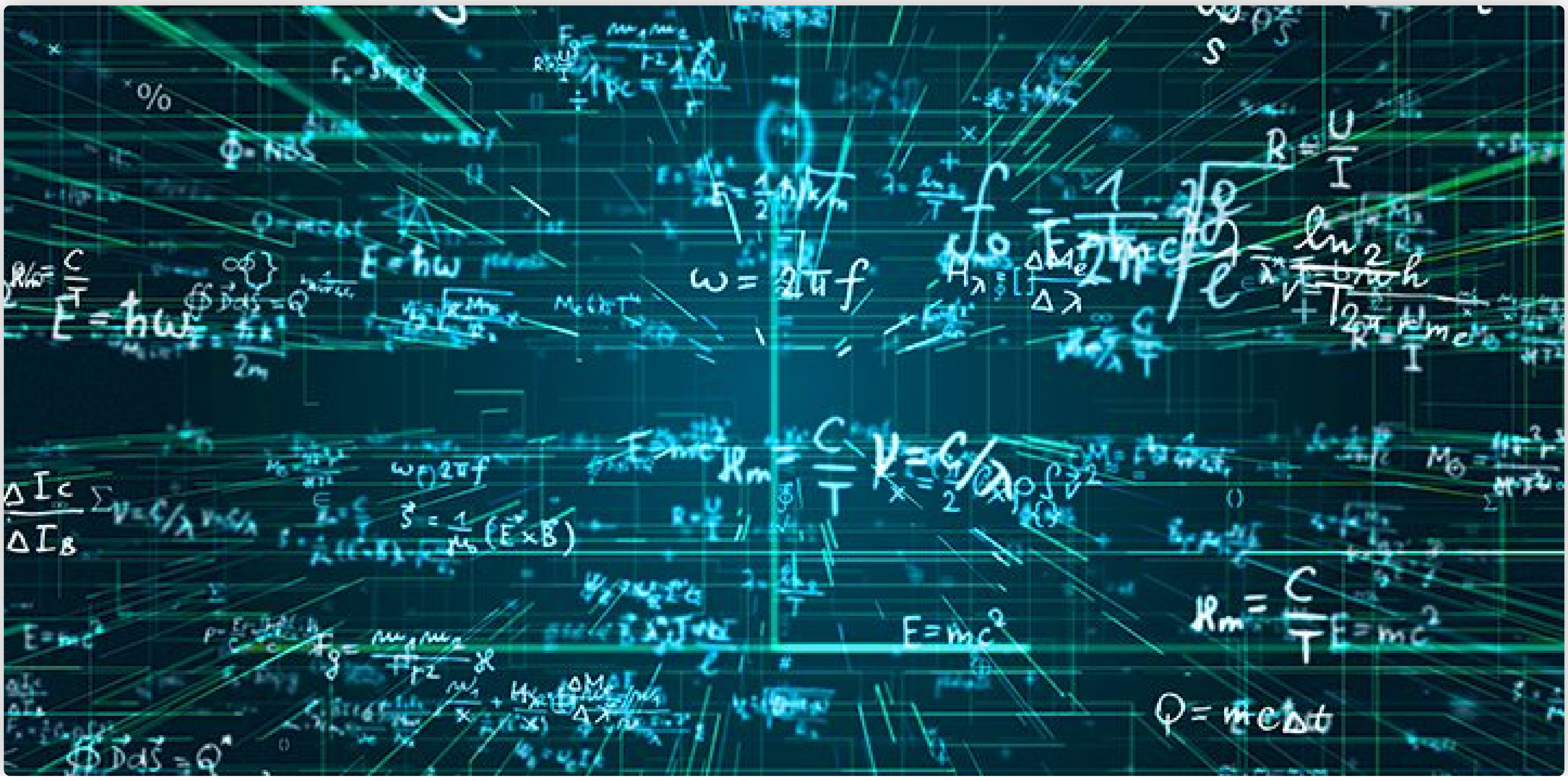
Security



Encryption is a critical part of modern computer security. Encryption algorithms like AES 256 and PGP are used to scramble data while in transit and unscramble it when it reaches the legitimate destination. But what happens when you need to scramble data in a way that's impossible to unscramble? That's where hashing comes in. This article will examine SHA-256, a widely used hash function, and its role in contemporary cybersecurity.

What is SHA-256?

The SHA-256 algorithm is one flavor of SHA-2 (Secure Hash Algorithm 2), which was created by the National Security Agency in 2001 as a successor to SHA-1. SHA-256 is a patented cryptographic hash function that outputs a value that is 256 bits long.

What is hashing? In encryption, data is transformed into a secure format that is unreadable unless the recipient has a key. In its encrypted form, the data may be of unlimited size, often just as long as when unencrypted. In hashing, by contrast, data of arbitrary size is mapped to data of fixed size. For example, a 512-bit string of data would be transformed into a 256-bit string through SHA-256 hashing.

In cryptographic hashing, the hashed data is modified in a way that makes it completely unreadable. It would be virtually impossible to convert the 256-bit hash mentioned above back to its original 512-bit form. So why would you want to create a scrambled message that can't be recovered? The most common reason is to verify the content of data that must be kept secret. For example, hashing is used to verify the integrity of secure messages and files. The hash code of a secure file can be posted publicly so users who download the file can confirm they have an authentic version without the contents of the file being revealed. Hashes are similarly used to verify digital signatures.

Password verification is a particularly important application for cryptographic hashing. Storing users' passwords in a plain-text document is a recipe for disaster; any hacker that manages to access the document would discover a treasure trove of unprotected passwords. That's why it's more secure to store the hash values of passwords instead. When a user enters a password, the hash value is calculated and then compared with the table. If it matches one of the saved hashes, it's a valid password and the user can be permitted access.

What role does SHA-256 hashing play in cybersecurity? SHA-256 is used in some of the most popular authentication and encryption protocols, including SSL, TLS, IPsec, SSH, and PGP. In Unix and Linux, SHA-256 is used for secure password hashing. Cryptocurrencies such as Bitcoin use SHA-256 for verifying transactions.

How secure is SHA-256?

SHA-256 is one of the most secure hashing functions on the market. The US government requires its agencies to protect certain sensitive information using SHA-256. While the exact details of how SHA-256 works are classified, we know that it is built with a Merkle-Damgård structure derived from a one-way compression function itself created with the Davies-Meyer structure from a specialized block cipher.

Three properties make SHA-256 this secure. First, it is almost impossible to reconstruct the initial data from the hash value. A brute-force attack would need to make 2^{256} attempts to generate the initial data. Second, having two messages with the same hash value (called a collision) is extremely unlikely. With 2^{256} possible hash values (more than the number of atoms in the known universe), the likelihood of two being the same is infinitesimally, unimaginably small. Finally, a minor change to the original data alters the hash value so much that it's not apparent the new hash value is derived from similar data; this is known as the avalanche effect.

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