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SeND Hash Threat Analysis
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Status of this Memo

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Abstract

This document analysis the use of hashes in SeND, possible threats and the impact of recent attacks on hash functions used by SeND. Current SeND specification [[rfc3971](#)] uses SHA-1 [[sha-1](#)] hash algorithm and PKIX certificates [[rfc3280](#)] and does not provide support for the hash algorithm agility. The purpose of the document is to provide analysis of possible hash threats and to decide how to encode the hash agility support in SeND.

Table of Contents

1.	Introduction	3
2.	Terminology	4
3.	Impact of collision attacks on SeND	5
3.1.	Attacks against CGAs in stateless autoconfiguration	5
3.2.	Attacks against PKIX certificates in ADD process	5
3.3.	Attacks against Digital Signature in RSA Signature option	7
3.4.	Attacks against Key Hash in RSA Signature option	7
4.	Support for the hash agility in SeND	8
5.	Security Considerations	9
6.	IANA Considerations	10
7.	References	11
7.1.	Normative References	11
7.2.	Informative References	11
	Authors' Addresses	12
	Intellectual Property and Copyright Statements	13

1. Introduction

SEND [[rfc3971](#)] uses the SHA-1 hash algorithm to generate the contents of the Key Hash and the Digital Signature fields of the RSA signature. It also uses a hash algorithm (SHA-1, MD5 etc.) in the PKIX certificates [[rfc3280](#)] used for the router authorization in the ADD process. Recently there have been demonstrated attacks against the collision free property of such hash functions [[sha1-coll](#)]. There have also been attacks on the PKIX X.509 certificates that use the MD5 hash algorithm [[x509-coll](#)] This document analyzes the effects of such attacks and other hash attacks on the SEND protocol and proposes changes to make it resistant to such attacks.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [[rfc2119](#)].

3. Impact of collision attacks on SeND

Due to the hash attacks demonstrated on the aforesaid hash algorithms a study was performed to assess the threat of these attacks on the cryptographic hash usage in internet protocols [[rfc4270](#)]. This document analyzes the hash usage in SeND following the approach recommended by [[rfc4270](#)]. Following the approach recommended by [[rfc4270](#)] and [[new-hashes](#)], we will analyze the impact of these attacks on SeND case by case in this section. Through our analysis, whether we should support hash agility on SeND is also discussed.

Up to date, all demonstrated attacks are attacks against a collision-free property. An attacker produces two messages which result in the same hash. Attacks against the one-way property are not yet feasible [[rfc4270](#)]. There are two attacks against one property. In the first-preimage attack, based on the hash of the real message, an attacker finds a false message which results in the same hash. In the second-preimage attack an attacker based on the real message itself, finds the false message which results in the same hash.

3.1. Attacks against CGAs in stateless autoconfiguration

Hash functions are used in the stateless autoconfiguration process that is based on CGAs. Impacts of collision attacks on current uses of CGAs are analyzed in the update of CGA specification [[rfc4982](#)], which also enables CGAs to support hash agility. CGAs provide proof-of-ownership of the private key corresponding to the public key used to generate CGA, and they don't deal with the non-repudiation feature, while collision attacks are mainly about affecting non-repudiation feature. CGAs are not susceptible to the collision attacks. In the collision attack, an attacker finds two keys (and other CGA parameters) K and K' , where $CGA = hash(K, ..) = hash(K', ..)$. Since both keys have to be chosen by an attacker, CGAs are not vulnerable to the collision attack. So, as [[rfc4982](#)] points out CGA based protocols, including SeND, are not affected by the recent collision attacks. But, CGAs are vulnerable to the preimage attack in which an attacker could manage to find the false key K' based on node's $CGA = hash(K, ..)$, use key K' to produce the Key Hash field and to sign the SeND message afterwards. In that case, an attacker just has to break the CGA, and all other hashes are automatically broken, because an attacker can use the false key K' to produce all other hashes. But up to date, the preimage attacks are not yet feasible, but might be in the future.

3.2. Attacks against PKIX certificates in ADD process

The second use of hash functions is for the router authorization in ADD process. Router sends to host a certification path, which is a

path between a router and hosts's trust anchor and consists of PKIX certificates. Researchers demonstrated attacks against PKIX certificates with MD5 signature, in 2005 [[new-hashes](#)] and in 2007 [[x509-coll](#)].

In 2005 they succeeded to construct the original and the false certificate that had the same identity data and digital signature, but different public keys [[new-hashes](#)]. The problem for the attacker is that two certificates with the same identity are not very useful in real-world scenarios, while Certification Authority is not allowed to provide such two certificates. Generally, attacks against the human-readable fields demand much more effort than the attacks against non human-readable fields, such as a public key field. In case of the identity field, an attacker is faced with the problem of the prediction and the generation of the false but meaningful identity data, which at the end might be revealed by the Certification Authority. Thus, in practice, collision attacks do not affect non human-readable parts of the certificate.

In 2007 were demonstrated certificates which differ in the identity data and public key, but still result in the same signature value. In such attack, even if an attacker produces such two certificates in order to claim that he is someone else, he still needs to predict the content of all fields appearing before the public key, eg. serial number or validity periods. Although a relying party cannot verify the content of these fields (each certificate by itself is unsuspecting), the CA keeps track of those fields and during the fraud analysis, the false certificate can be revealed. Future attacks might affect other human-readable fields. Attacks against the validity period field and the IP address extension might have an implication to the current SeND protocol. An attack against the IP address extension might enable the router to advertize changed IP prefix range, although, not broader than the prefix range of the parent certificate in the ADD chain.

The certificate key in SeND is used both for the CGA generation and for message signing. In the future, CGA might not be used at all in SeND, just certificates. Thus, attacks against certificates are potentially very dangerous. Generally, the most dangerous are attacks against middle-certificates in the certification path, where for the cost of one false certificate, attacker launches attack on multiple routers. In such scenarios, we will be at least safe from attacks against Trust Anchor's certificate because it is not exchanged in SeND messages.

3.3. Attacks against Digital Signature in RSA Signature option

The digital signature in RSA Signature option is produced as the SHA-1 hash of IPv6 addresses, ICMPv6 header, ND message and other fields like Message Type Tag and ND options [[rfc3971](#)], and is signed with the sender's private key, which corresponds to the public key from the CGA parameters structure and is authorized usually through CGAs. The possible attack on such explicit digital signature is typical non-repudiation attack. The Digital Signature field is vulnerable to the collision attack. In such collision attack an attacker produces two messages M and M', where $\text{hash}(M) = \text{hash}(M')$, underlays one of the messages to be signed with authorized keys (through CGAs), but uses another message afterwards. However, the structure of at least one of two messages in collision attack is strictly predefined [[rfc4270](#)]. But we have to take into account that a variant of SHA-1 was already affected by recent collision attacks and we have to prepare for future improved attacks.

3.4. Attacks against Key Hash in RSA Signature option

Key Hash field in the RSA Signature option is a SHA-1 hash of the public key from the CGA parameters structure in the CGA option of SeND message. Key Hash field is potentially dangerous because it contains a non human-readable data. Since in the collision attack an attacker itself chooses both keys, K and K', where $\text{hash}(K) = \text{hash}(K')$, the Key Hash field is not suspectable to the collision attack. The preimage attack in which an attacker derives the key K' based on $\text{hash}(K)$ could be theoretically more useful. But even in that case, if an attacker signs the SeND message with the key K', he has to break also the CGA, since the Digital Signature is verified against the CGA and possibly against a certification path.

4. Support for the hash agility in SeND

While all of analyzed hash functions in SeND are theoretically affected by recent hash attacks, these attacks indicate the possibility of future real-world attacks. In order to increase the future security of SeND, we suggest the support for the hash and algorithm agility in SeND.

The most effective and secure would be to bind the hash function option with something that can not be changed at all, like [[rfc4982](#)] does for CGA - encoding the hash function information into addresses. But, there is no possibility to do that in SeND. We could decide to use by default the same hash function in SeND as in CGA. The security of all hashes in SeND depends on CGA, ie. if an attacker could break CGA, all other hashes are automatically broken. From the security point of view, at the moment, this solution is more reasonable then defining different hash algorithm for each hash. Additionally, if using the hash algorithm from the CGA, no bidding down attacks are possible.

Another solution is to incorporate the Hash algorithm option into SeND message, and use different hash algorithms for different hashes, or the same algorithm for all hashes. As already mentioned, from the security point of view, it is reasonable to define just one algorithm, because additional algorithms does not increase the security. If that algorithm is defined in the Hash algorithm option in SeND message, it is vulnerable to the bidding down attack. On the other hand, different algorithms provides additional flexibility, and in the future SeND might be used completely without CGAs.

5. Security Considerations

This document analyzes the impact of hash attacks in SeND and offeres a higher security level for SeND by providing solution for the hash agility support.

6. IANA Considerations

This document only analyzes the possible hash threats in SEND and introduces the possible mechanisms to support hash agility. The actual SEND extensions are defined in other documents. There are no IANA actions required by this document.

[7.](#) References

[7.1.](#) Normative References

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