



# Update on Randomized Hashing

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# Reminder: randomized hashing

- To hash a message  $m$ :
  - Choose random salt  $r$
  - Hash  $m$  and  $r$  together
  - $\text{hash-value} = H_r(m)$
- Useful for digital signatures
  - Signer chooses fresh salt for each signature
  - Protects against collision attacks
    - More on that later

# What we propose

- A randomized mode-of-operation
  - Applicable to iterated hash functions
  - No changes to underlying hash functions
- Resists off-line collision attacks
  - Provably: only need something close to 2<sup>nd</sup> pre-image resistance, not full collision-resistance [Crypto'06]
  - Attack is inherently on-line
- Use for signatures
  - No changes to sig algorithms (RSA, DSA)

# Why randomized hashing?

- **Safety net** in case our hash functions are not as strong as we think
  - Much like HMAC does for MAC/PRF
  - Prudent engineering: adds another major line of defense against cryptanalysis
- Complements search for better hash functions, doesn't replace it

# Why now?

- Changes in standards, implementations are coming our way
- Even moving to SHA-2 takes significant effort (cf. [Bellovin-Rescorla])
- Residual effort to also support RMX is small in comparison
  - Small overhead, significant returns

# New since last time

- Slightly modified the proposed mode
  - $H_r(m_1 \mid \dots \mid m_L) = H(\mathbf{r} \mid m_1 \oplus \mathbf{r} \mid \dots \mid m_L \oplus \mathbf{r})$ 
    - The new thing:  $\mathbf{r}$  at the beginning
- *Signatures don't need to "sign the salt" !*
  - Sufficient to sign only the hash value
    - Same as with deterministic hashing
  - Greatly simplifies implementations/deployment
    - No need to change encoding for signatures, etc.

# The RMX transform

- RMX: message-randomization transform
  - $\text{RMX}(r, m_1 \mid \dots \mid m_L) = r \mid m_1 \oplus r \mid \dots \mid m_L \oplus r$ 
    - + rules for padding, etc.
- Can be used with any hash function
  - This is a mode-of-operation
  - E.g., RMX-SHA1, RMX-SHA256, etc.
- Should be standardized on its own
  - separately from individual hash functions

# Analogous to CBC

- Mode-of-operation
- Can be used with any cipher
- Requires an additional input (the IV)
  - IV generation, transmission, etc. handled by the applications
  - Different applications handle the IV differently



# Implementing RMX: test cases

## ■ Modified `openssl`

- Support for RMX in signatures
- Use it for certificates

Less than 100 LOC due to the randomness, the rest would have to be done also for any new deterministic hashing

## ■ XML-signatures:

- RMX implemented by Michael McIntosh (IBM)
- Can work with XML-sig's "two-level hashing"

## ■ See additional slides for details

## ■ S/MIME, PGP, are next on our list



# Feedback is Appreciated

- Feedback/suggestions regarding using RMX in other applications

Thank you for your attention



Additional Slides

# Modifying openssl

This is needed also when adding  
a new deterministic hash function

- Hardest part: adding OIDs, changing config files to compile, link new functions
  - Changes in 10-15 files
- Implementing RMX: 2 new files (~360 LOC)
- Support for RMX signatures
  - ~40 LOC changed in evp/evp.h, evp/digest.c
- Use RMX for certificates
  - ~40 LOC changed in asn1/a\_sign.c, asn1/a\_verify.c

This is unique to RMX

# Support for RMX signatures

## ■ Signature interface in openssl:

```
EVP_SignInit,    EVP_SignUpdate,    EVP_SignFinal  
EVP_VerifyInit, EVP_VerifyUpdate, EVP_VerifyFinal
```

- Init/Update just macros for DigestInit/Update

## ■ New Init interfaces

- `EVP_DigestInit_ex2(ctx, MD-type, engine, new-param)`
- Macros `EVP_SignInit_ex2/VerifyInit_ex2`

## ■ New OIDs (types) for randomized hashing

# Inserting RMX to control-flow

- Added “transform-needed” flag to MD-type (and param field to MD context)
- `DigestInit/Update/Final` check flag
  - If set, call `RMX_Init/Update/Final` rather than the underlying MD functions
  - `RMX_` functions do transform (using param), then call underlying MD functions

# Using RMX for Certificates

## ■ Signing/verifying from ASN1 modules

```
ASN1_item_verify(ASN1_ITEM *it, X509_ALGOR *a,  
                ASN1_BIT_STRING *signature, void *asn,  
                EVP_PKEY *pkey)
```

- ASN1\_item\_sign is similar

## ■ The salt is passed inside X509\_ALGOR

- Parameter of the RMX-SHA1-RSA algorithm

## ■ ASN1\_item\_verify calls the new Init interface

```
EVP_VerifyInit_ex2(..., salt)
```

# XML Signatures

- Include transforms that are applied to data before hashing/signing
- Just add the RMX transform
  - Must be last transform before hashing
- Done by application, no change to signing code

```
// Do other transformations (envelope, canonicalize)
RMX = get_a_pointer_to_implementation("URI-of-RMX");
salt = call_your_favorite_RNG();
x.addTransform(RMX, salt);
// Proceed as usual
```



# XML Signatures: 2-level Hashing

- XML sigs use a 2-level hashing scheme
  1. Each document is hashed to get digest
  2. Digests concatenated and hashed again
  3. Result is signed
- Part 2 does not have transforms
  - But it has canonicalization
  - Can write new canonicalization method that includes RMX

# Aside: “first-party attacks”

- Can signer itself find collisions?
  - Only if hash is not collision-resistant
  - And even then non-repudiation is not effected
    - If signature is valid, signer is responsible
  - Most apps are not effected (e.g., certificates)
- Use RMX with a “strong hash function”  $H$ 
  - If  $H$  is strong then all is dandy
  - If  $H$  is weaker than we initially thought, most applications are still protected