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
  - 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 2nd 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
  - $H_r(m_1 \mid \ldots \mid m_L) = H(\mathbf{r} \mid m_1 \oplus r \mid \ldots \mid m_L \oplus r)$
    - The new thing: 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
  - RMX(r, m_1 | … | m_L) = r | $m_1 \oplus r$ | … | $m_L \oplus r$
    - + 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
- 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

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

Feedback is Appreciated

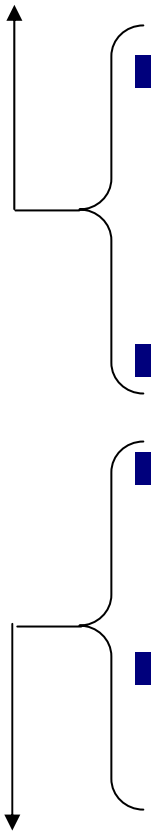
- Feedback/suggestions regarding using RMX in other applications

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_VeridyUpdate, EVP_VerifyFinal`

  - `Init/Update` just macros for `DigestInit/Udpate`
- 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