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Digital Signature Records for the NFC Data Exchange Format

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NFC Research Lab Hagenberg

- Part of the R&D department of the
  Upper Austria University of Applied Sciences
- Research on NFC since 06/2005
- Our focus:
  - Hardware & software systems for NFC
  - Interoperability and performance testing for NFC systems
  - NFC applications and infrastructure
  - Security and user experience with NFC
- 1st Austrian NFC trial
- NFC Congress in Hagenberg

Outline

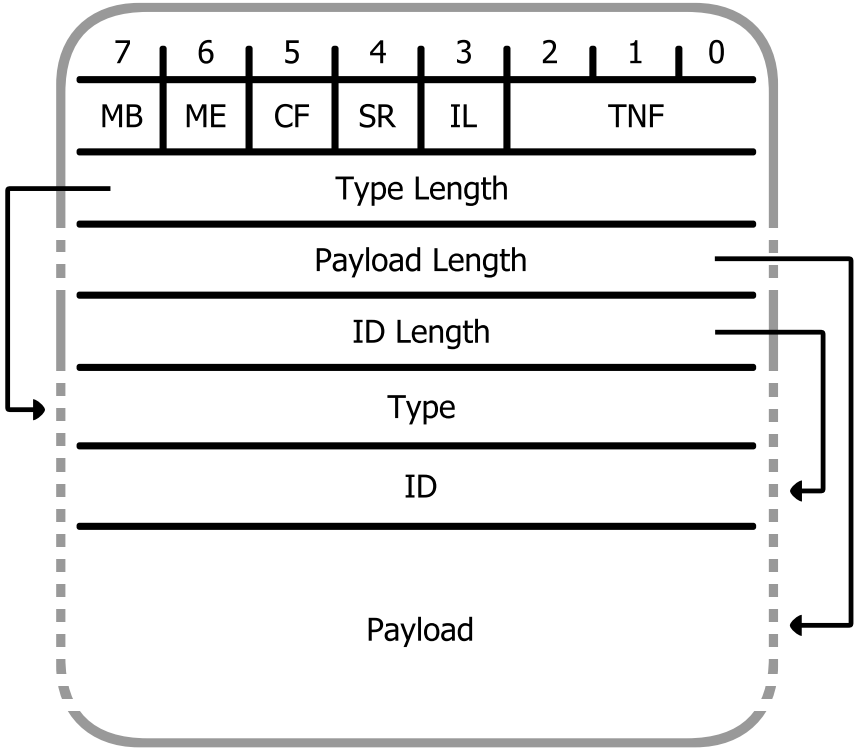
- Introduction and Motivation
  - What is the NFC Data Exchange Format?
  - What are potential attacks against NDEF applications?
  - How can digital signatures help?
- Signing NDEF Messages
  - How to add a signature to an NDEF message?
  - Are signatures backwards compatible?
  - Which parts of an NDEF record need to be signed?
- Conclusion

NFC Data Exchange Format (NDEF)

- Standardized data format for NFC applications
- Enables the “it’s all in a touch” principle:
  - Upon touching an NFC-enabled object with an NFC device NDEF messages are exchanged and an action is triggered.
- Applications are:
  - Business cards
  - Smart posters (i.e. posters with active content like a website‘s URL or instructions to send an SMS message)
  - Enabler for wireless technologies (i.e. Bluetooth or WiFi pairing)
  - …

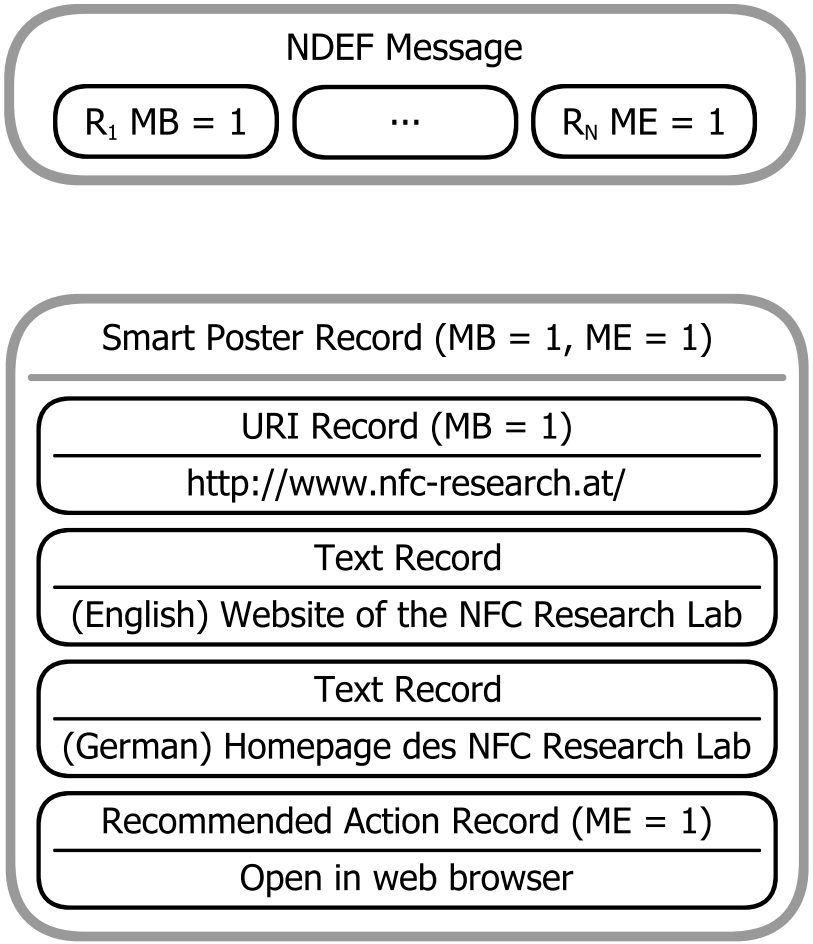
NDEF Record

- Header
  - Flags
    - Message Begin (MB)
    - Message End (ME)
    - Chunk Flag (CF)
    - Short Record (SR)
    - ID Length present (IL)
  - Type Name Format (TNF)
  - Length fields
  - Type
  - ID
- Payload



NDEF Message

- Sequence of one or more NDEF records
- First record has MB set
- Last record has ME set
- Records can contain NDEF messages as payload
  - Smart Poster Record



Vulnerabilities of NDEF applications

- Manipulation/replacement of NFC tags and their content
- The average user cannot distinguish forged from genuine tags!
- Flaws in current NDEF implementations:
  - E.g. it is possible to hide a smart poster‘s URI on the Nokia 6131 NFC
- Typical attack scenarios:
  - Replace a smart poster‘s URL (e.g. redirect to phishing site)
  - Replace a phone number (e.g. redirect to premium rate service)

Digital Signatures

- What is a signature?
  1. A hash value is generated from the data.
     - Assures integrity of the signed data
  2. The hash value is encrypted with the signers secret key.
     - Assures authenticity of the signed data
- Properties of a digital signature:
  (based on a trustworthy certification infrastructure)
  - Authentic: The signer‘s identity can be verified.
  - Unforgeable: Only the owner of the signing key can produce a certain signature.
  - Non-reusable: The signature is only valid for the signed data.

Digital Signatures

- Potentials:
  - Origin of data can be verified
  - Trustworthiness of data can be estimated based on its origin
- Dangers:
  - False sense of protection (due to bad implementations)
  - Not all types of attack can be avoided
    - E.g. valid signed tags could be misplaced within the system
    - Denial of service attacks

Signing NDEF messages

- NFC Forum‘s approach:
  - use a dedicated record type (“Signature Record Type”)
- Signature record is appended to a sequence of records
- Signature record signs every record between the previous signature record and itself (or the beginning of the NDEF message and itself)
- One NDEF message may contain more than one signature

Backwards compatibility

- 2 types of compatibility:
  - Compatibility to devices that do not support signature records
  - Compatibility to tag infrastructures that do not use signatures
- Signature Record Type is compatible to existing devices, as unknown record types will be ignored.
- Existing tag infrastructures that do not use signatures:
  - Disallowing NDEF records without signature would render current tag infrastructures unusable
  - BUT: NDEF records without signature must be treated with a different level of trust than signed records

Signing NDEF records

- Including certain fields of an NDEF record into the signature has advantages and disadvantages
- Advantages and disadvantages were evaluated

Message Begin (MB), Message End (ME)

- MB and ME mark the first and the last record in an NDEF message
- When the signature record is appended to the signed records, none of the signed records must have the ME flag enabled.
  - ME must not be included into the signature!
- When MB is signed, a signed sequence of records cannot be moved away from or to the beginning of a message.
  - Including MB is not useful!

Type, ID, Payload

- Payload contains the record‘s data
  - Must be included into the signature
- Type defines how the Payload field must be interpreted
  - Must be included into the signature
- ID contains a reference that allows linking from other records
  - Must be included into the signature
    - Otherwise links could be redirected to manipulated targets

Short Record Flag (SR)

- Controls the size of the Payload Length field:
  - SR = 0: Payload Length has 4 bytes
  - SR = 1: Payload Length has 1 byte
- When SR and Payload Length are not signed:
  - Repacking between short record format and standard record format possible
- When Length fields are signed but SR is not:
  - Bytes can be shifted from or to the Payload Length field, resulting in a (limited) manipulation of the length fields
  - Not signing SR has no advantage as repacking is not possible anyways

ID Length Present Flag (IL)

- Controls the presence of the ID Length (and the ID field):
  - IL = 0: no ID Length field available (no ID field)
  - IL = 1: ID Length field available (specifies the ID field's length)
- When IL and Length fields are not signed:
  - Attacker could add/remove an ID field
  - ID field could be used to hide a suffix of the Type field or a prefix of the Payload field
  - An existing ID field could be integrated into the Type or the Payload field
- When Length fields are signed but IL is not:
  - Attack is difficult as sizes cannot be arbitrarily chosen

Type Length, Payload Length, ID Length

- Length fields specify the length (in bytes) of corresponding the fields
- When Length fields are not signed:
  - Signed bytes can be moved between the field boundaries
    - E.g. ID field could be integrated into Payload or appended to Type field
  - Signed parts of subsequent records could be integrated into the preceeding record‘s Payload field
- When Length fields are signed:
  - Attacker can only change field sizes by modification of SR and IL (only very limited changes possible)

Chunk Flag (CF)

- Allows splitting the payload across multiple chained records
  - CF = 0: last record of a record chain
  - CF = 1: payload is continued in next record
- First record of a record chain contains the Type and ID fields, following records have Type Name Format (TNF) set to “continued payload” and have no Type and ID field
- When only Type, ID and Payload are signed:
  - Splitting and merging chunks is possible without invalidating the signature
- When CF is not signed:
  - Parts of a chunked NDEF record can be chopped off by clearing one CF flag
  - The chopped chunks are still part of the NDEF message, but the NDEF parser will drop them as invalid records
  - If TNF is not signed it could be set from “continued payload” to “unknown”, which makes the parser ignore the records without raising any error

Type Name Format (TNF)

- TNF specifies the interpretation of the Type field
  - Value can be:
    - Empty
    - NFC Forum well-known type
    - MIME media type
    - NFC Forum external type
    - Unknown
    - Continued from previous record
    - Reserved
- When TNF is changed, the meaning of the Type field changes (e.g. from well-known to external type)
  - Can be used to hide records from the receiving application

Contactless Communication API (JSR 257)

- Java API for encoding/decoding NDEF messages
- Has certain level of abstraction:
  - Record chunks are combined into one full record
- Consequence:
  - Header fields of all continued chunks are hidden from the user
  - These header fields cannot be used with signature implementations on top of JSR 257
  - On top of JSR 257 only Type, ID, Payload, Type Length and ID Length can be protected

Conclusion

- Some fields of an NDEF record must be signed:
  - Type, ID, Payload
- Some fields of an NDEF record should not be signed:
  - Message Begin (MB), Message End (ME)
- Signing the other fields has advantages and disadvantages

Conclusion

- Advantages:
  - Signatures can be used on top of current JSR 257 implementations
  - Records can be repacked (short records, chunked records)
- Disadvantages:
  - Vulnerable to attacks
    - Record hiding
    - Breaking ID field references

Field name	Signature useful	Possible on top of JSR 257
Message Begin	−−	−−
Message End	−−	−−
Chunk Flag	+	−−
Short Record Flag	+	−−
ID Length Present Flag	+	−−
Type Name Format	+	−−
Type Length	+	++
Payload Length	+	−−
ID Length	+	++
Type	++	++
ID	++	++
Payload	++	++

Thank You!

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