RFC5201-bis
Crypto Agility for HIP

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Crypto Agility

- No hard-coded ciphers/algorithms
- Negotiation of algorithms
- Possibility of extending set of used algorithms

- Goal of the changes in 5201-bis:
  - Keep changes minimal

Cryptographic Algorithms in HIP

1. HIT & HI
   a) Responder
   b) Initiator
2. Diffie Hellman (DH)
3. MAC / HMAC for control packets
4. Puzzle
5. Symmetric key derivation (keymat)

1.a Crypto Agility for the HIT

- HIT is exposed to the application
- Currently good legacy application support
  - Minimal changes to make applications HIP aware
  - Good support for DNS and referrals

→ We would like to keep it this way

Crypto Agility for the HIT (cont'd)

- Problem: Application binds to HIT before BEX
  - HIT algorithms cannot be negotiated during BEX
  - Invalid combinations of source and destination HIT are possible
- Solution: Only provide valid choices to application
  - Resolver filters results
  - All HITs the application sees are supported and usable
- Requirement: a-priori knowledge about HIT generation algorithms
  - Signature algorithm, hash function, truncation

Options for Transmitting HIT Alg. Information

- Pull from DNS
  - ✚ HIT can stay as it is
  - ✖ Referrals break – applications that pass on IPv6 addresses must be modified
    - HIT cannot be used alone
- Encode in HIT
  - ✚ Everything stays as it is
  - ✖ Slightly reduced security – only few bits to use
    - Proposal: sacrifice four bits
  - → Decision on ML to use this option

HIT Suites

- HIT is a product of
  - Family of signature algorithms (including groups, key lengths, …)
  - Hash function / compression function
  - Truncation
- Goal: Avoid picking the wrong destination HIT

- HIT suite defines a selection of these algorithms
- Suite ID encodes selection (in HIT)

How to Assign Suite IDs

- 16 values only
- Encode all suites that will ever be used
- Creating new suites
  - Be selective (do not use product of all possibilities)
  - Groups of algorithms if feasible
    ("RSA+DSA+SHA-256" vs. "RSA+SHA-256" and "DSA+SHA-256")
- Deprecate and reuse suite IDs
  - Goal: long time between deprecation and reuse
  - Worst case: more than 16 suites needed
    → use more bits (c.f. Appedix A,B)

1.b Initiator HIT Selection

- Responder must implement Initiator's HIT suite
- Two options:
  a) Initiator HIT = Responder HIT
  – Responder changes HIT – Initiator must change, too.
  – Breaks ACLs, certificates, etc.
  b) Negotiate during BEX
  – Must avoid downgrade attacks
  – Negotiation in signed part of the packet

- a) is problematic → we chose b)

HIT Suite List

- Responder sends list of supported HIT suites in signed part of R1
- Initiator can restart if currently chosen HIT is incompatible with HIT suite list
- List entries reflect HIT suite encoding
  - Four or more bits
  - Length field for bit-alignment: probably not
  - 8-bit HIT suite IDs in the list: 4 bits in reserve

Detect & Restart

- Downgrade attack: attacker forces Initiator and Responder to use weaker cipher than necessary
- Way of handling downgrade attacks: detect and restart BEX.
  - HIT suite list is signed, restart BEX if needed
- Replay attack: reuse old R1 with weak ciphers
  - Puzzle will not match
  - DH shared key will not match

  → No successful HIP association
- Performance of D&R: bad but it doesn't matter

2. Crypto Agility for DH

- Currently two DH public keys in DH parameter
- Do we need more flexibility?
  - More DH algorithms (ECDH, non-DH) at some point?
- If yes:
  - SIGMA compliance should be maintained
  - Start negotiation in I1 (DH algorithm list)
  - R1 pre-creation is tricky:
    → hashes or hash trees as solution (c.f. Appendix C)
  - Avoid downgrade attacks

3/4. Other Algorithms

- HMAC hash function for the control channel
  - Determined by Responder's HIT suite
- RHASH (puzzle, solution, keymat)
  - Determined by Responder's HIT suite
- Problem: future suites without hash function
  - Other message authentication code?
  - Puzzle replacement?
  - Different key material generation?
- Solution: Remove RHASH references
  - Reference HIT suite directly
  - No single algorithm for puzzle and keymat
  - Make main text of 5201-bis algorithm agnostic

5. Key Material

- Update key material generation to draft-krawczyk-hkdf-01.txt
- Problem: salt should be as long as output
- Current salt: puzzle I and J (each 64 bits)
  - I is random and determined by Responder
  - J is a solution to I but Initiator can influence J
- Proposed solution increase size for I and J to size of hash function used in key material generation.

Conclusion

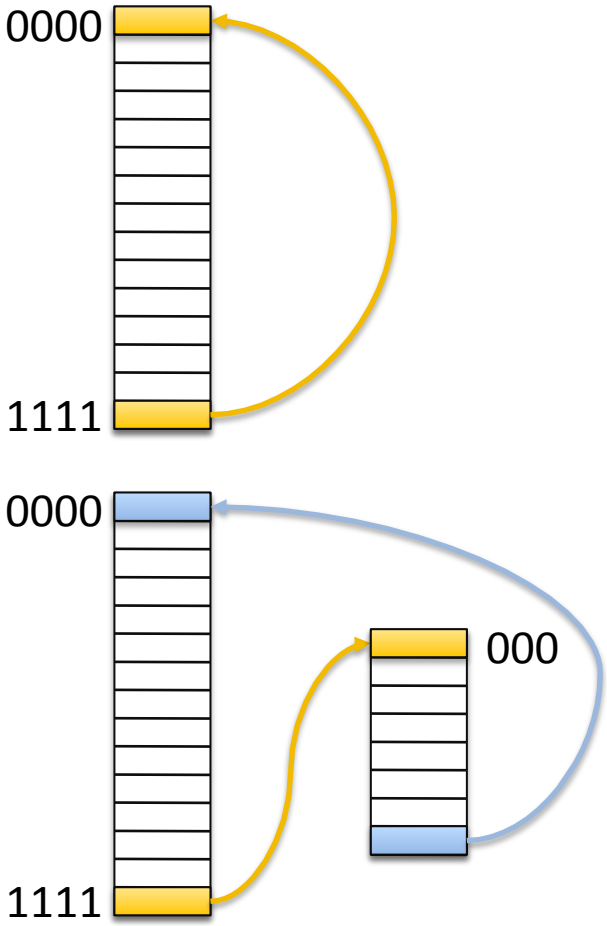
- Crypto agility for HIT & HI, DH, MAC / HMAC, puzzle, and symmetric key derivation
- Aim: keep changes small
- Enable future evolution of HIP
- Milestone for mentioned changes:
  - IETF 78 Maastricht

Appendix

- This is a set of additional slides that illustrate some of the mentioned problems in greater detail.

Appendix A: HIT Suite Lifecycle

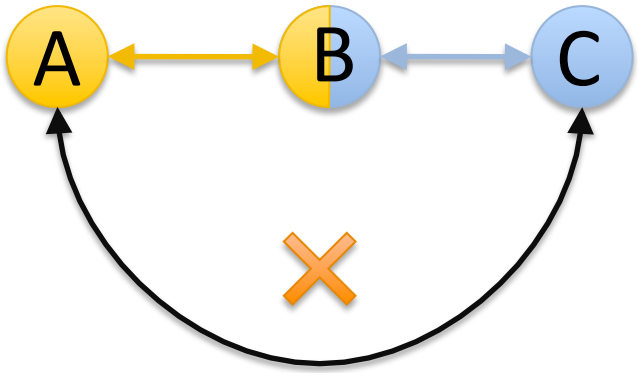
- How should the four bits in the ORCHID be reused?
  - Option a) 0000 has been deprecated long before rollover: reuse 0000
  - Option b) 0000 is still in use (worst case assumption): Use 1111 to indicate the use of more bits (e.g. 4+3+91 bits)



Appendix B:
Why we never want to use option b)

- Supporting too many HIT suites at the same time will lead to problems: Remember Babel

- Two alternatives:
  - Accept namespace segmentation
    - Transitivity problems in connectivity
    - Workarounds in other places



  - Implementation and maintenance pain
    - Everyone needs to support everything
    - Large code size, bad portability

→ Use only few suites

Appendix C.1: R1 Pre-creation for Many DH Keys

- Problem: space in R1 is limited
  - DH keys can be long
  - High number of algorithms (no need for limit)
  - → Many (long) DH public keys
- Trivial solution: pre-create a R1 for each key
  - Many R1s to pre-create (even if you do it smartly)
  - Problematic for Responders with many diverse Initiators

  → Not scalable

Appendix C.2: Candidate Solution

- Only include hashed DH key representations in signed part of R1
  1. Hashes of DH Keys: 128/256/… bits per DH key
  2. Create Merkle/hash tree over all DH keys and include root in signed part of R1, provide hash path to root in unsigned part
- Transmit actual DH key in unsigned part of R1
  - 0-ed spaceholder does not work (different key lengths)