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Hierarchical HITs for HIPv2
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Abstract

This document describes using a hierarchical HIT to facilitate large deployments in mobile networks.

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1. Introduction

This document expands on HIPv2 [RFC7401] to describe the structure of a hierarchical HIT, the Registry services to support this hierarchy, and given a hierarchical HIT, how a device is found in the network.

Separate documents will further expand on the registry service and how a device can advertise its availability and services provided.

2. Terms and Definitions

2.1. Requirements 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].

2.2. Definitions

HDA (Hierarchical HIT Domain Authority): The 14 bit field identifying the HIT Domain Authority under a RAA.

HID (Hierarchy ID): The 32 bit field providing the HIT Hierarchy ID.

RAA (Registered Assigning Authority): The 18 bit field identifying the Hierarchical HIT Assigning Authority.

3. Problem Space

3.1. Meeting the future of Mobile Networking

The evolution of mobile networking to greater bandwidth and faster mobility will favor IP mobility technologies that optimize shortest routing paths for both mobile-to-stationary and mobile-to-mobile applications. For this, devices will need to use the IP address which provide the shortest path for where they are physically in the mobile network. The mobile device will need services that will discover the IP addresses for their peer mobile devices and keep them connected to those peers even when both devices move in the network at the same time (the double-jump problem). In order to support these services, there needs to be billable services to support the infrastructure. In some area close tracking of mobile devices will be mandatory. In other device obfuscation to protect privacy and/or safety will be the only life-enabling approach.

These conflicting requirements can be met with the Host Identity Protocol (HIP), provided its Rendezvous Server service is scaleable and manageable. Providers of RVS will need both a viable and scaleable business model.

3.2. Semi-permanency of Identities

A device Identity has some degree of permanency. A device creates its identity and registers it to some 3rd-party that will assert a level of trust for that identity. A device may have multiple identities to use in different contexts, and it may deprecate an identity for any number of reasons. The asserting 3rd-party may withdraw its assertion of an identity for any number of reasons. An identity system needs to facilitate all of this.

3.3. Managing a large flat address space

For HIP to be successfully used in large mobile networks, it must support an Identity per device, or at least 10 billion Identities. Perhaps a Distributed Hash Table [I-D.irtf-hiprg-dht] can scale this large. There is still the operational challenges in establishing such a world-wide DHT implementation and how RVS [RFC8004] works with such a large population. There is also the challenge of how to turn this into a viable business for the Mobile Network Providers.

Even though the probability of collisions with 7B HITs (one HIT per person) in a 96 bit flat address space is 3.9E-10, it is still real. How are collisions managed? It is also possible that weak key uniqueness, as has been shown in deployed TLS certificates, results in a much greater probability of collisions. Thus resolution of collisions needs to be a feature in a globally mobile network.

3.4. Defense against fraudulent HITs

How can a host protect against a fraudulent HIT? That is, a second pre-image attack on the HI hash that produces the HIT. A strong defense would require every HIT/HI registered and openly verifiable. This would best be done as part of the R1 and I2 validation.

3.5. Desire for administrative control by RVS providers

An RVS provider may only be willing to provide discovery (RVS) services to HIP devices it knows and trusts. A flat HIT space does not provide any intrinsic functionality to support this. A hierarchical HIT space can be mapped to the RVS provider. DNS can effectively be used to provide the HIT to IP mapping without DHT.

A hierarchical HIT space also creates a type of a business labeling for the RVS provider. "These are my customers."

4. The Hierarchical Host Identity Tag (HIT)

The Hierarchical HIT is a small but important enhancement over the flat HIT space. It represents the HI in only a 64 bit hash and uses the other 32 bits to create a hierarchical administration organization for HIT domains. Hierarchical HITs are ORCHIDs [RFC7343]. The change in construction rules are in Section 4.1.4.

A Hierarchical HIT is built from the following fields:

- 28 bit IANA prefix
- 4 bit HIT Suite ID
- 32 bit Hierarchy ID (HID)
- 64 bit ORCHID hash

4.1. The Hierarchy ID (HID)

The Hierarchy ID (HID) provides the structure to organize HITs into administrative domains. HIDs are further divided into 2 fields:

- 14 bit Registered Assigning Authority (RAA)
- 18 bit Hierarchical HIT Domain Authority (HDA)

4.1.1. The Registered Assigning Authority (RAA)

An RAA is a business that manages a registry of HDAs.

The RAA is a 14 bit field (16,384 RAAs) assigned sequentially by a numbers management organization, perhaps ICANN's IANA service. An RAA must provide a set of services to allocate HDAs to organizations. It must have a public policy on what is necessary to obtain an HDA. The RAA need not maintain any HIP related services. It must maintain a DNS zone for discovering HID RVS servers.

This DNS zone may be a reverse PTR for its RAA. Assume that the RAA is 100. The PTR record is constructed at a 2 bit grouping:

```
0.1.2.1.0.0.0.hhit.arpa   IN PTR      raa.bar.com.
```

4.1.2. The Hierarchical HIT Domain Authority (HDA)

An HDA may be an ISP or any third party that takes on the business to provide RVS and other needed services for HIP enabled devices.

The HDA is an 18 bit field (262,144 HDAs per RAA) assigned sequentially by an RAA. An HDA should maintain a set of RVS servers that its client HIP-enabled customers use. How this is done and scales to the potentially millions of customers is outside the scope of this document. This service should be discoverable through the DNS zone maintained by the HDA's RAA.

An RAA may assign a block of values to an individual organization. This is completely up to the individual RAA's published policy for delegation.

4.1.3. Example of the HID DNS

HID related services should be discoverable via DNS. For example the RVS for a HID could be found via the following. Assume that the RAA is 100 and the HDA is 50. The PTR record is constructed at a 2 bit grouping:

```
2.0.3.0.0.0.0.0.0.1.3.1.0.0.0.0.hhit.arpa   IN PTR      rvs.foo.com.
```

The RAA is running its zone, 1.3.1.0.0.0.0.hhit.arpa under the hhit.arpa zone.

4.1.4. Changes to ORCHIDv2 to support Hierarchical HITs

ORCHIDv2 [RFC7343] has a number of inputs including a context, some header bits, the hash algorithm, and the public key. The output is a 96 bit value. Hierarchical HIT makes the following changes. The HID is added as part of the header bits and the output is a 64 bit value, derived the same way as the 96 bit hash.

```
Input      :=  HID | HOST_ID
OGA ID     :=  4-bit Orchid Generation Algorithm identifier
                         The HIT Suite ID = 0x40
Hash Input :=  Context ID | Input
                         Same Context ID as HIPv2
Prefix     :=  HIPv2 Prefix
HID        :=  Hierarchy ID
Hash       :=  Hash_function( Hash Input )
Encode_64  :=  Same as Encode_96, but only 64 bits
ORCHID     :=  Prefix | OGA ID | HID | Encode_64( Hash )
```

Hierarchical HIT uses the same context as all other HIPv2 HIT Suites as they are clearly separated by the distinct HIT Suite ID.

4.1.5. Collision risks with Hierarchical HITs

The 64 bit hash size does have an increased risk of collisions over the 96 bit hash size used for the other HIT Suites. There is a 0.01% probability of a collision in a population of 66 million. The probability goes up to 1% for a population of 663 million. See Appendix A for the collision probability formula.

However, this risk of collision is within a single HDA. Further, all HDAs are expected to provide a registration process for reverse lookup validation. This registration process would reject a collision, forcing the client to generate a new HI and thus hierarchical HIT and reapplying to the registration process.

5. HIP Parameters

The HIP parameters carry information that is necessary for establishing and maintaining a HIP association. For example, the device's public keys as well as the signaling for negotiating ciphers and payload handling are encapsulated in HIP parameters. Additional information, meaningful for end hosts or middleboxes, may also be included in HIP parameters. The specification of the HIP parameters and their mapping to HIP packets and packet types is flexible to allow HIP extensions to define new parameters and new protocol behavior.

5.1. HIT_SUITE_LIST

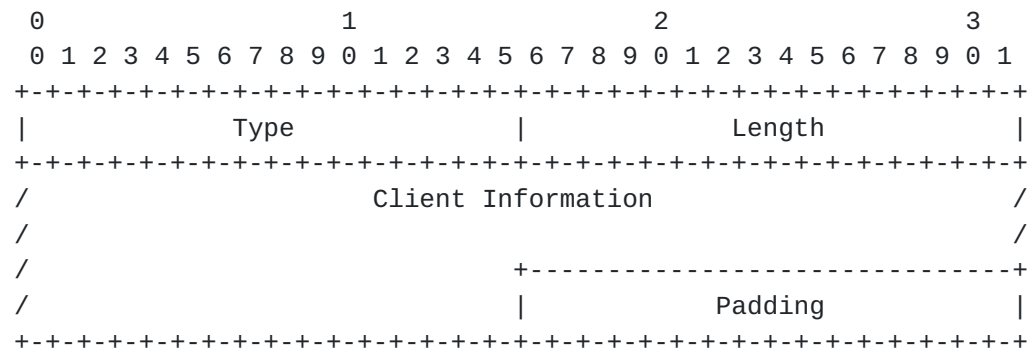
The HIT_SUITE_LIST parameter contains a list of the supported HIT suite IDs of the Responder. Based on the HIT_SUITE_LIST, the Initiator can determine which source HIT Suite IDs are supported by the Responder. The HIT_SUITE_LIST parameter is defined in Section 5.2.10 of [RFC7401].

The following HIT Suite IDs are defined for Hierarchical HITs, and the relationship between the four-bit ID value used in the OGA ID field and the eight-bit encoding within the HIT_SUITE_LIST ID field is clarified:

HIT Suite	Four-bit ID	Eight-bit encoding
ECDSA/hier/SHA-256	4	0x40

Note that the Hierarchical HIP HIT Suite ID allows the devices to use the hierarchical RVS discovery and authentication services to validate the peer and discover available services. The Responder SHOULD respond with a HIP hierarchical HIT suite ID when the HIT of the Initiator is a HIP hierarchical HIT.

5.2. CLIENT_INFO



Type	[TBD-IANA]
Length	length in octets, excluding Type, Length, and Padding
Client Information	The information required by the HDA in the format required by the HDA.

This parameter contains client information to include in the HIT registration. The specific content and format is set by the HDA.

6. HHIT Registry services to support hierarchical HITs

Hierarchical HIT registration SHOULD be performed using the HIP Registration Extension [RFC8003]. The client either uses an X.509 certificate [RFC8002], or use a PSK, as defined in Appendix A of HIP-DEX [I-D.ietf-hip-dex], to validate the registration.

The Registration should include additional client information. This information may be contained within the X.509 certificate and/or is carried in the CLIENT_INFO parameter, see Section 5.2. The Registrar can include its requirements in the R1 packet, and the client provide its information in the I2 packet. This parameter may be encrypted within the ENCRYPTED parameter. If the CLIENT_INFO contains Personal Identifying Information (PII), then it MUST be placed into the ENCRYPTED parameter.

The content and internal format of the CLIENT_INFO parameter is set by the HDA's policy and is outside the scope of this document. Examples of client information can by phone number, IMEI, and ICCID.

6.1. Hierarchical HIT Registration using X.509 Certificates

This requires the HIP client to possess a client certificate trusted by the HDA/Registrar. Registration will either succeed or fail.

6.2. Hierarchical HIT Registration using a PSK

This requires the HIP client and the HDA/Registrar to share a PSK. The PSK may already exist prior to starting the registration and just be used within the registration. A PSK out-of-band exchange may be triggered by performing the registration without any authentication.

If no client authentication is included in the I2 packet, the registration fails with "No Authentication provided". If the I2 packet included the proper HDA required client information, the HDA can use it to set up a side channel for an out-of-band delivery of a PSK. And example of this would be to send an SMS message with the PSK. Once the client possesses the PSK, it can rerun the registration at which point the HI and HIT duplicate checks are performed.

6.3. Hierarchical HIT Registration Type

The Registration Type used in the REG_REQUEST is:

Number	Registration Type
2	HIT Registration

6.4. Hierarchical HIT Registration Failure Type

The Registration may fail. In fact, with PSK, this may be the response to expect an SMS message with the PSK to use in a second registration request. Failure Types used in the REG_FAIL are:

Failure Type	Reason
[TBD-IANA]	Hierarchical HIT Already Registered
[TBD-IANA]	HI Already Registered
[TBD-IANA]	Previously Registered HI with different device information
[TBD-IANA]	No Authentication provided
[TBD-IANA]	Invalid Authentication
[TBD-IANA]	Invalid Authentication, new PSK sent via SMS

6.5. Registration failure behavior

If the failure type is "Hierarchical HIT Already Registered", the client's HI is hashing to an existing HIT and must generate a new HI and hierarchical HIT and reregister. If the failure is "HI Already Registered", the client should assume it is registered. If the failure is "Previously Registered HI with different device information", either the client managed to generate a duplicate HI, probably indicating a weak key generation algorithm, or the client

was previously registered on a different device. Resolving this conflict will be left to the HDA's policy.

6.5.1. Example of a simple HDA policy

A simple HDA policy would be to require the device to generate a new HI and thus HHIT and try registration again. The HDA policy may also provide a URL for "Previous Registration Resolution". This contact is primarily to assist a device that was registered, but had some local failure resulting in a new registration attempt.

7. Using hierarchical HITs

All HIP clients with hierarchical HITs maintain an RVS connection with their HDA's RVS server(s). How the HDA scales this service up to a potential population in the millions is out of scope of this document. Lifetime management of these connections is also out of scope.

One approach an HDA can use to address the scaling challenge is to add an internal level of hierarchy to assign a set number of devices per RVS server.

Peering agreements between HDAs would allow for geographically close RVS to a device. This may reduce the latency for use of a device's current RVS. This is a subject of another document.

7.1. Contacting a HIP client

A service Initiator uses some service to discover the HIT of the service Responder. The Initiator uses the hierarchical information in the HIT to find the Responder's RVS. A trusted RVS discover method could use the DNS PTR to RVS as shown in Section 4.1.3. An I1 is sent to that RVS which forwards it to the Responder.

The potential Responder uses the HIT in the I1 to query the Initiator's RVS about the Initiator. The nature of information, and method of communication are determined by the Initiator's HDA and the Responder's (and or HDA's) relationship with it. Based on the Responder's local policy, this information will be used to determine if the contact is to be accepted. If accepted, the Responder may proceed sending an R1 to the Initiator. It may alternatively initiate some non-HIP process.

It should be noted that this R1 may contain a REG_INFO list for the Initiator to validate that the Responder does offer the desired service.

7.2. Defense against fraudulent HITs

Both the Initiator and Responder MAY validate a peer host as a defense against a second pre-image attack on the HHIT. This may occur via a CERT [RFC8002] in R1 or I2. It may be through a back end process associated with the R1 or I2 validation to look up the HHIT and retrieve the registered HI.

8. IANA Considerations

IANA will need to make the following changes to the "Host Identity Protocol (HIP) Parameters" registries:

HIT Suite ID: This document defines the new HIT Suite "Hierarchy with ECDSA/SHA256" (see Section 5.1).

CLIENT_INFO: This document defines the new CLIENT_INFO parameter (see Section 5.2). The parameter value will be assigned by IANA.

Reg Type: This document defines the new Registration Type for the REG_REQUEST parameter "HIT Registration" (see Section 6.3).

Reg Fail: This document defines the new Failure Types for the REG_FAIL parameter (see Section 6.4).

9. RAA Management Organization Considerations

Introducing the RAA management organization may be the largest hurdle for hierarchical HITs. Thus it would be best if this were adopted by an organization already in the business of allocating numbers within either the Internet or the Mobile, cellular, infrastructure.

One consideration would be to reserve the first N RAA values to map to the existing DNS TLDs. For example, these TLDs can be organized in an ascending order and numbered accordingly. Thus the 2 character TLDs will be a lower number than the 3 character TLDs. After that, it could be a first come, first numbered assignment process.

10. Security Considerations

There are potential risks with the hierarchical HIT, the Registry service, and the discovery of potential peer hosts using its hierarchical HIT.

A 64 bit hash space presents a real risk of second pre-image attacks. The HHIT Registry services effectively block attempts to "take over" a HHIT. It does not stop a rogue attempting to impersonate a known HHIT. This attack can be mitigated by the Responder using DNS to

find the HI for the HHIT or the RVS for the HHIT that then provides the registered HI.

The two risks with hierarchical HITs are the use of an invalid HID and forced HIT collisions. The use of the "hhit.arpa." DNS zone is a strong protection against invalid HIDs. Querying an HDA's RVS for a HIT under the HDA protects against talking to unregistered clients. The Registry service has direct protection against forced or accidental HIT hash collisions.

By using the HIP Registration Extension, the Registry service is protected from direct attacks. This service does rely on either the integrity of a PKI service or an out-of-band PSK delivery process. Thus the risk to the Registry service is highly related to the trust in these authentication setup services. Further, the duplicate HI resolution process may require human interaction with related social engineering risks.

Finally the peer host discovery process relies on trusting the finding the proper HDA for the host and its forwarding the I1 to the proper Responder. A rogue RVS, impersonating the RVS for the HIT, could redirect the I1 to a client that has forced a collision with the HIT and the Initiator would be none the wiser. The only defense against this is if the Initiator has some other source for the Responder HI and validate the HI in the R1.

10.1. Privacy Concerns

Mobile-privacy-attack [I-D.moskowitz-mobile-privacy-attack] details how Eve can follow a communication between two mobile peers using the session Identifiers and deep knowledge about those Identifiers gained by hacking servers that log PII related to the Identifiers.

Hierarchical HITs not only does not mitigate this attack, it can actually aggravate it by supplying the HDA where the HHIT is registered.

A HIP Privacy Enhanced Base Exchange, to be defined in a separate draft, along with a Privacy Enhanced ESP tunnel, can be used to hide all the HIP and ESP Identifiers from Eve.

11. Acknowledgments

Sue Hares of Huawei contributed to the clarity in this document.

12. References

12.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

12.2. Informative References

[I-D.ietf-hip-dex] Moskowitz, R. and R. Hummen, "HIP Diet EXchange (DEX)", draft-ietf-hip-dex-06 (work in progress), December 2017.

[I-D.irtf-hiprg-dht] Ahrenholz, J., "Host Identity Protocol Distributed Hash Table Interface", draft-irtf-hiprg-dht-05 (work in progress), December 2011.

[I-D.moskowitz-mobile-privacy-attack] Moskowitz, R., "An Attack on Privacy in Mobile Devices", draft-moskowitz-mobile-privacy-attack-01 (work in progress), November 2017.

[RFC7343] Laganier, J. and F. Dupont, "An IPv6 Prefix for Overlay Routable Cryptographic Hash Identifiers Version 2 (ORCHIDv2)", RFC 7343, DOI 10.17487/RFC7343, September 2014, <https://www.rfc-editor.org/info/rfc7343>.

[RFC7401] Moskowitz, R., Ed., Heer, T., Jokela, P., and T. Henderson, "Host Identity Protocol Version 2 (HIPv2)", RFC 7401, DOI 10.17487/RFC7401, April 2015, <https://www.rfc-editor.org/info/rfc7401>.

[RFC8002] Heer, T. and S. Varjonen, "Host Identity Protocol Certificates", RFC 8002, DOI 10.17487/RFC8002, October 2016, <https://www.rfc-editor.org/info/rfc8002>.

[RFC8003] Laganier, J. and L. Eggert, "Host Identity Protocol (HIP) Registration Extension", RFC 8003, DOI 10.17487/RFC8003, October 2016, <https://www.rfc-editor.org/info/rfc8003>.

[RFC8004] Laganier, J. and L. Eggert, "Host Identity Protocol (HIP) Rendezvous Extension", RFC 8004, DOI 10.17487/RFC8004, October 2016, <https://www.rfc-editor.org/info/rfc8004>.

Appendix A. Calculating Collision Probabilities

The accepted formula for calculating the probability of a collision is:

$$p = 1 - e^{-k^2/(2n)}$$

P	Collision Probability
n	Total possible population
k	Actual population

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