SRP Compression for Constrained Networks

IEFT 121

Extensions for Scalable DNS Service Discovery (dnssd) WG

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Quick Intro - Abtin Keshavarzian

- Background
  - PhD from Stanford in EE
  - ~25 years of experience in research and development
    - Networking
    - Wireless
    - Embedded SW

- Work at Google (abtink@)
  - Thread protocol
  - OpenThread (Open source implementation Thread)

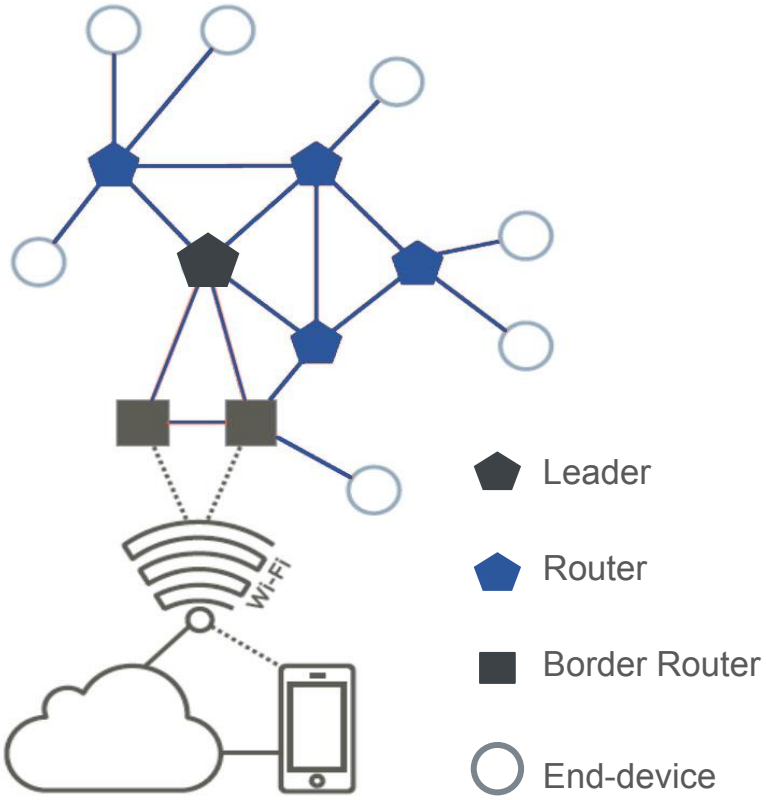
Background

- SRP - Service Registration Protocol
  - DNS-based Service Discovery using standard DNS Update with unicast packets
- Used by Thread
  - Thread devices use SRP to register services
  - Thread Border Routers act as SRP server
- Matter: Application layer protocol over Thread (and Wi-Fi)
  - Defines registered service names
  - Instance name, sub-types, host name, TXT data format, etc.

Thread

- Low-power Secure Mesh Network
- IPv6
  - 6LoWPAN
  - CoAP

- PHY: IEEE 802.15.4 (2.4GHz)
  - 250 Kbps data rate
  - PHY layer frame **127 bytes**



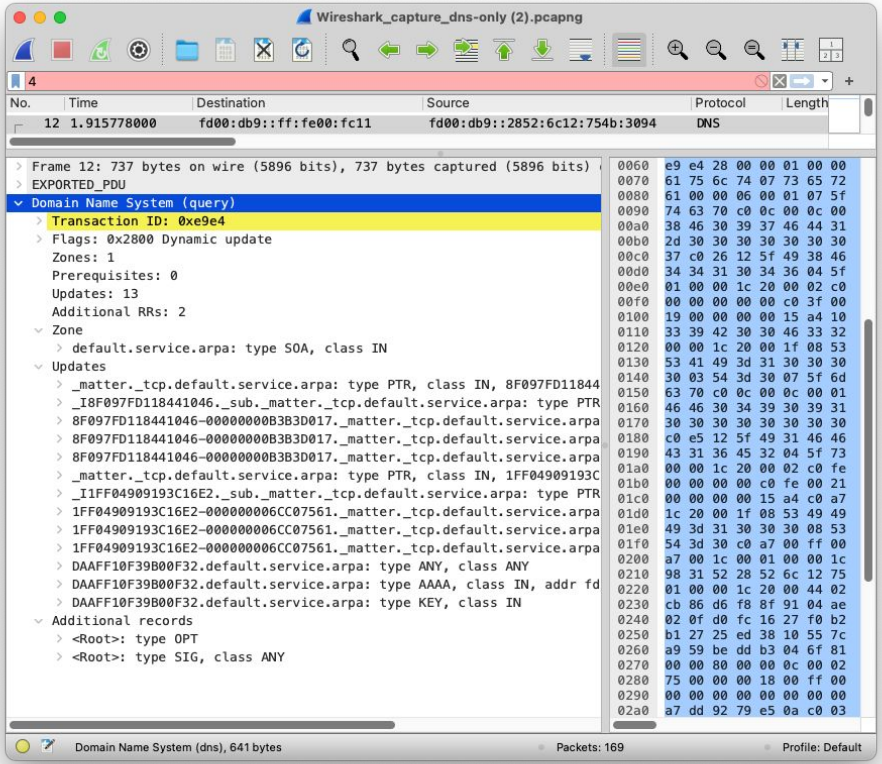
SRP Message Example (matter device)

Two services and one host address

8F097FD118441046-00000000B3B3D017
- type: _matter._tcp
- sub-type: _I8F097FD118441046
- port:5540, w:0, p:0, TXT data: 31 byte

1FF04909193C16E2-000000006CC07561
- type: _matter._tcp
- sub-type: _I1FF04909193C16E2
- port:5540, w:0, p:0, TXT data: 31 bytes

Host: DAAFF10F39B00F32
- fdc5:d08a:4e98:3152:2852:6c12:754b:3094

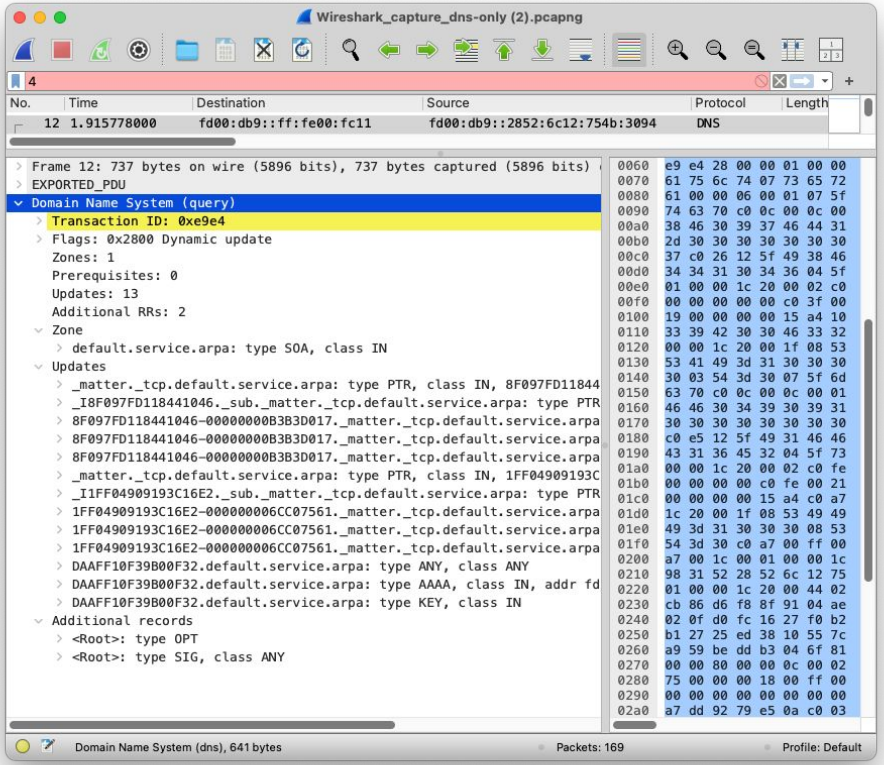


SRP Message Example (matter device)

641 bytes (UDP payload)

15 Records (13 in update, 2 in addtl)

DNS Header		**12**	bytes
Zone		**26**	bytes
1st service	(5 records)	**191**	bytes
2nd service	(5 records)	**174**	bytes
Host	(2 records)	**40**	bytes
Key	(1 record)	**80**	bytes
Lease Option	(1 record)	**23**	bytes
Signature	(1 record)	**95**	bytes



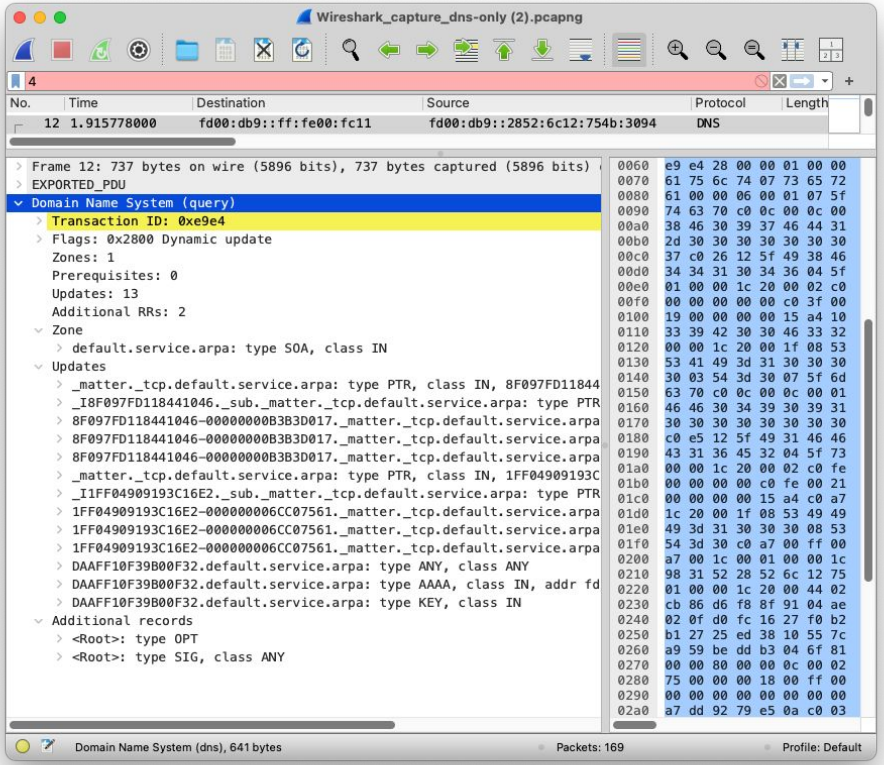
SRP Message Example (matter device)

641 bytes (UDP payload)

SRP message already uses:

DNS Name Compression
(use pointer labels to refer to previously encoded names in the message)

KEY Record Optimization
(include KEY record for host name only, omitting it in service descriptions).



Typical SRP Update Message Size

- SRP's adherence to the DNS Update general format introduces overhead and can lead to larger SRP message sizes

- Devices may register more services and/or addresses increasing msg size
  - Matter multi-fabric (separate service per fabric/ecosystem)

- Typical SRP message size: **400-1200 bytes**

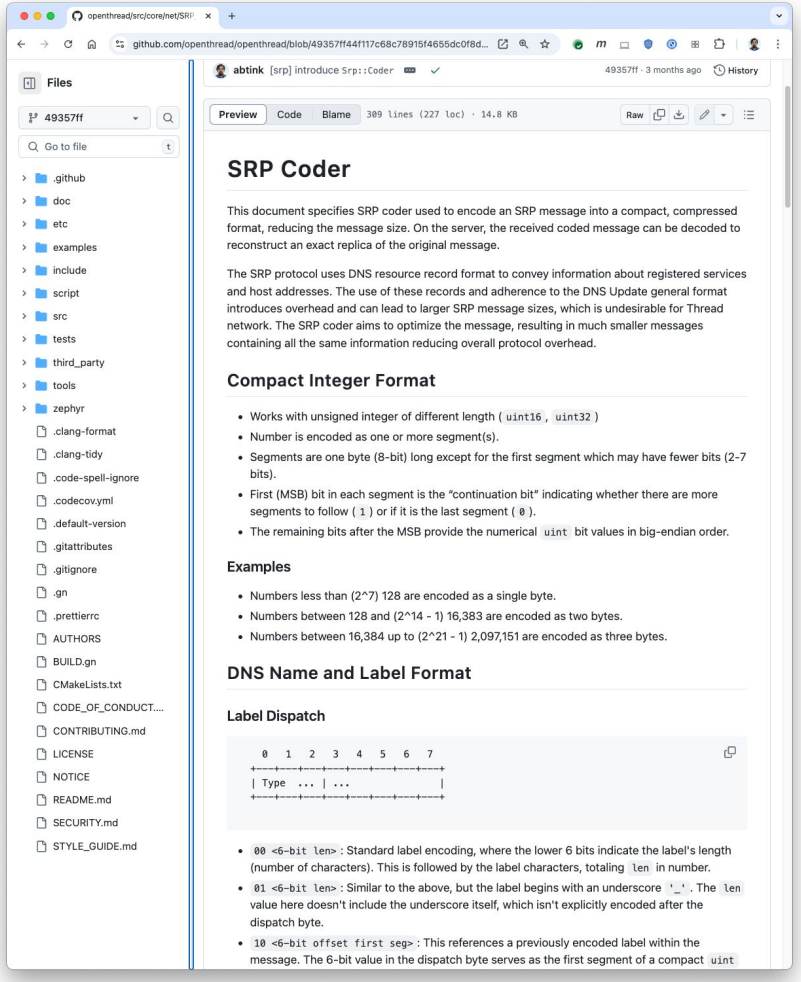
- Can lead to increased traffic over constrained networks
  - Registration by 10s or 100s of devices
  - Triggered by synchronous events (e.g. Border Router restart)

Can we compress the SRP message?

SRP Coder

- On the client, encode an SRP message into a **compact, compressed format,** reducing the message size

- On the server, the received coded message is decoded to reconstruct an **exact replica of the original message**



https://github.com/openthread/openthread/pull/10606

SRP Coder Example

Matter example: 2 services

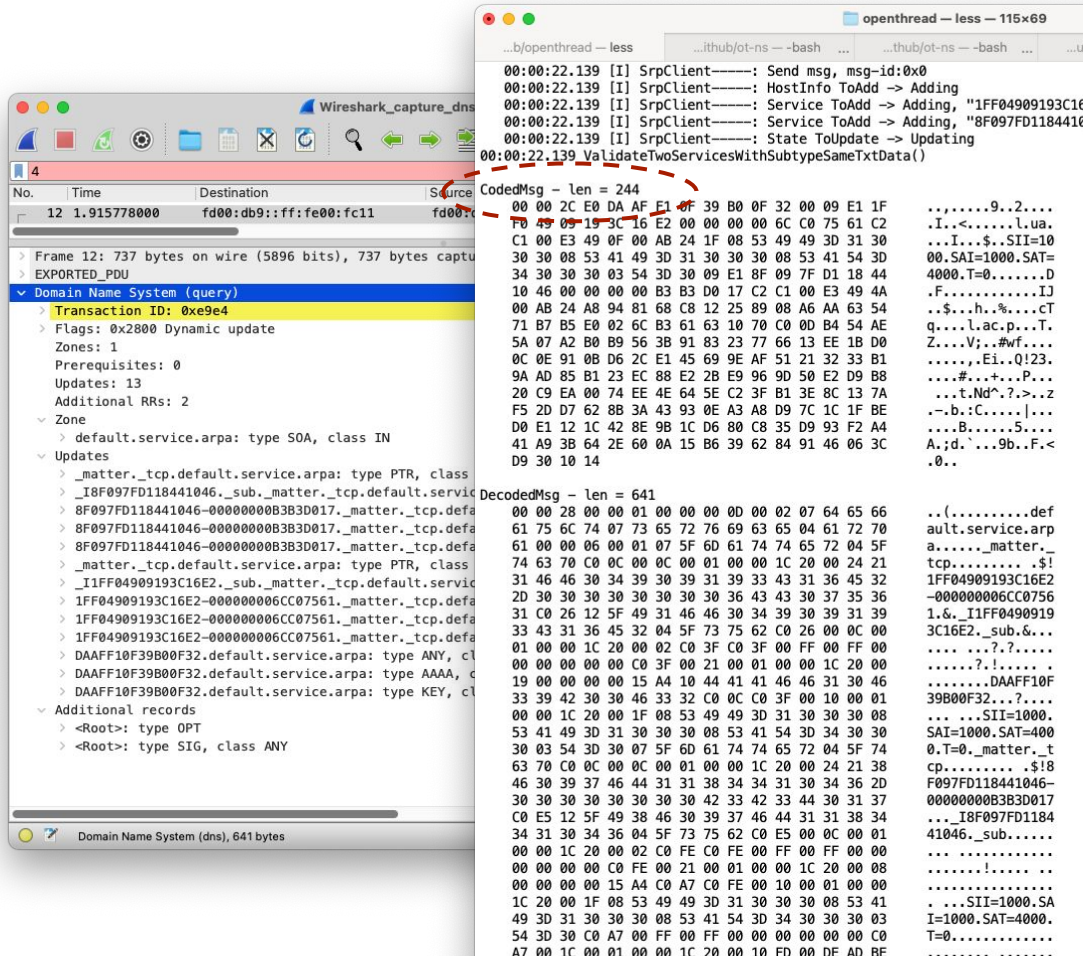
Original SRP message

641 bytes

Encoded message

244 bytes

2.4x smaller



SRP Coder Example

Matter example: 2 services

- To better highlight efficiency, it might make sense to exclude Key and Signature records, as they are not compressible.
- Recommend future extensions to SRP to allow shorter key and signature sizes.

Original SRP message

641 bytes = **175 bytes** (KEY/SIG) + **466 bytes**

Encoded message

244 bytes = **128 bytes** (KEY/SIG) + **116 bytes**

2.4x smaller

4x smaller

SRP Coded Format

Message Format

Header Block
Zero or more
Add/Remove Service Block(s)
Host Block
Footer Block

Each block begins with a “dispatch byte”

- ➢ Indicating the block type
- ➢ Bit flags to show which fields are elided
- ➢ Followed by encoded fields in the block

General Dispatch Byte Markers

Following the header, each subsequent block begins with a dispatch byte. The initial bits within a dispatch byte designate its type:

- `00` : Add service
- `01` : Remove service
- `10` : Host
- `110` : Footer

Any unused/reserved bits in dispatch bytes MUST be set to zero during encoding and its value MUST be ignored during decoding.

Add Service Block

Add Service Dispatch

```
  0     1     2     3     4     5     6     7
+-----+-----+-----+-----+-----+-----+-----+-----+
|  0  |  0  | PT  | ST  | SUB | PRI | WGT | TXT |
+-----+-----+-----+-----+-----+-----+-----+-----+
```

- `PT` flag (PTR TTL) - `0` : Elide PTR TTL (use default TTL from header), `1` : TTL encoded.
- `ST` flag (SRV/TXT TTL) - `0` : Elide SRV/TXT TLL (use default TTL from header), `1` : TTL encoded.
- `SUB` flag (sub-type) - `0` : No sub-types, `1` : Sub-types labels encoded.
- `PRI` flag (priority) - `0` : Elide priority (use zero), `1` : Priority encoded.
- `WGT` flag (weight) - `0` : Elide weight (use zero), `1` : Weight encoded.
- `TXT` flag (TXT data) - `0` : No TXT data (elided), `1` : TXT data encoded.

Add Service Block Format

- "Add Service Dispatch" byte
- PTR TTL (if not elided)
- SRV/TXT TTL (if not elided)
- Service instance label
- Service name labels (excluding the domain name).
- SubType labels (if not elided) - A list of labels, terminated by an empty label (single `0x00` byte).
- Port
- Priority (if not elided)
- Weight (if not elided)
- TXT Data block - if not elided.

TTLs, port, priority, and weight fields (when not elided) are encoded using the compact integer format.

https://github.com/openthread/openthread/pull/10606

SRP Coder - Encoding Labels

Can refer to a previously encoded label in the msg

Commonly used labels encoded as a single byte

`_udp, _tcp, _matter, …`

Generative patterns are encoded more efficiently

Host name

DAAFF10F39B00F32

16-char ASCII hex representation of a 64-bit value

Service Instance

8F097FD118441046-00000000B3B3D017

“<16-char ASCII hex>-<16-char ASCII hex>”

(two 64-bit hex values separated by hyphen)

DNS Name and Label Format

Label Dispatch

```
  0   1   2   3   4   5   6   7
+---+---+---+---+---+---+---+---+
| Type  ... | ...               |
+---+---+---+---+---+---+---+---+
```

- `00 <6-bit len>` : Standard label encoding, where the lower 6 bits indicate the label's length (number of characters). This is followed by the label characters, totaling `len` in number.
- `01 <6-bit len>` : Similar to the above, but the label begins with an underscore `'_'` . The `len` value here doesn't include the underscore itself, which isn't explicitly encoded after the dispatch byte.
- `10 <6-bit offset first seg>` : This references a previously encoded label within the message. The 6-bit value in the dispatch byte serves as the first segment of a compact `uint` representing the offset to that label. This offset must point to the label dispatch byte of the previous label.
  - Note: This mechanism applies to a single label only. Any subsequent labels are encoded directly after the current one. This differs from traditional DNS pointer name compression, where a pointer indicates that the remaining labels should be read from the specified offset.
- `110 <5-bit code>` : Commonly used constant labels. Codes are:
  - `0` : `_udp`
  - `1` : `_tcp`
  - `2` : `_matter`
  - `3` : `_matterc`
  - `4` : `_matterd`
  - `5` : `_hap`
- `111 <5-bit code>` : Commonly Used Generative Patterns
  - `0` : `<hex_value>` - 16-character uppercase hexadecimal 64-bit value.
    - Example: `DAAFF10F39B00F32`
    - Encoding: After the label dispatch byte, the 64-bit value is encoded as 8-byte binary format (big-endian order).
  - `1` : `<hex_value_1>-<hex_value_2>` - Two 16-character uppercase hexadecimals, separated by a hyphen `-`
    - Example `AABBCCDDEEFF0011-1122334455667788` .
    - Encoding: After the label dispatch byte, the two 64-bit values are encoded (each as 8-byte binary format big-endian).
  - `2` : Subtype label `_<char><hex_value>` - starting with an underscore `_` , followed by a single character `<char>` , ending with a 16-character uppercase hexadecimal 64-bit value `<hex_value>` .
    - Example: `_IAA557733CC00EE11`
    - Encoding: After the label dispatch byte, `<char>` is encoded as a single byte, followed by the 8-byte big-endian binary representation of the 64-bit value `<hex_value>` .
  - `3` : Subtype Label - same as the previous case.
    - Encoding: Instead of directly encoding the 8-byte value, an offset pointing to an earlier occurrence of the same byte sequence within the message is encoded. The offset is

OpenThread SRP Coder

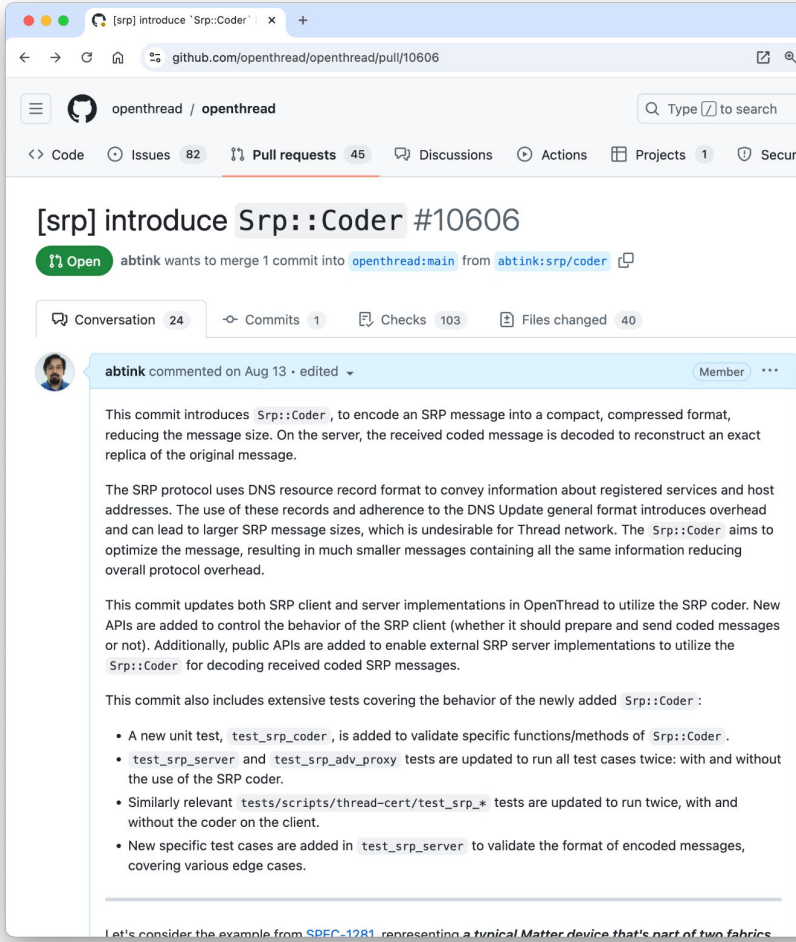
Implementation of SRP Coder (encoder/decoder)

- Integrated with OT SRP client and server
- Standalone decoder (use with external server impl)
- Documentation of the protocol
- Extensive set of tests

https://github.com/openthread/openthread/pull/10606

Next Steps

- Adopt the SRP Coder in the Thread specification (deploy and test)
- Open to a future IETF draft (assuming interest)



Backup Slides

```
> Flags: 0x2800 Dynamic update
  Zones: 1
  Prerequisites: 0
  Updates: 13
  Additional RRs: 2
v Zone
  > default.service.arpa: type SOA, class IN
v Updates
  > _matter._tcp.default.service.arpa: type PTR, class IN, 8F097FD118441046-00000000B3B3D017._matter._tcp.defa
  > _I8F097FD118441046._sub._matter._tcp.default.service.arpa: type PTR, class IN, 8F097FD118441046-00000000B3
  > 8F097FD118441046-00000000B3B3D017._matter._tcp.default.service.arpa: type ANY, class ANY
  > 8F097FD118441046-00000000B3B3D017._matter._tcp.default.service.arpa: type SRV, class IN, priority 0, weigh
  > 8F097FD118441046-00000000B3B3D017._matter._tcp.default.service.arpa: type TXT, class IN
  > _matter._tcp.default.service.arpa: type PTR, class IN, 1FF04909193C16E2-000000006CC07561._matter._tcp.defa
  > _I1FF04909193C16E2._sub._matter._tcp.default.service.arpa: type PTR, class IN, 1FF04909193C16E2-000000006C
  > 1FF04909193C16E2-000000006CC07561._matter._tcp.default.service.arpa: type ANY, class ANY
  > 1FF04909193C16E2-000000006CC07561._matter._tcp.default.service.arpa: type SRV, class IN, priority 0, weigh
  > 1FF04909193C16E2-000000006CC07561._matter._tcp.default.service.arpa: type TXT, class IN
  > DAAFF10F39B00F32.default.service.arpa: type ANY, class ANY
  > DAAFF10F39B00F32.default.service.arpa: type AAAA, class IN, addr fdc5:d08a:4e98:3152:2852:6c12:754b:3094
  > DAAFF10F39B00F32.default.service.arpa: type KEY, class IN
v Additional records
  > <Root>: type OPT
  > <Root>: type SIG, class ANY
```

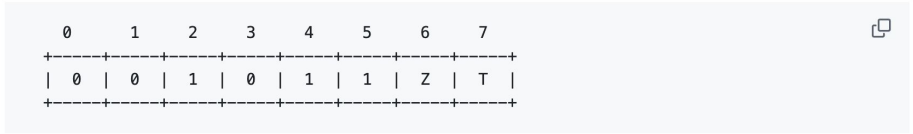
Distinguishing Coded Msg

The first 3 bytes (Header Block) can be used to differentiate a coded message from an SRP Update message:

- First two bytes encode message ID (same as general DNS header)
- Coded message uses fixed pattern as the 3rd byte to distinguish itself from an SRP update message

Header Block

Header Dispatch



- The initial bits in dispatch byte are fixed to differentiate it from the general DNS header used in SRP updates.
- `Z` flag (Zone)
  - `0` : Zone name is elided - use the default `default.service.arpa` .
  - `1` : Zone name is encoded within the message.
- `T` flag (Default TTL)
  - `0` : Default TTL is elided - use `7200` (2 hours).
  - `1` : Default TTL is encoded in the message using compact integer format.

Distinguishing from SRP Update Message

An SRP Update message uses the following DNS Update header format (RFC2136 section 2.2):

The first 3 bytes can be used to differentiate a coded message from an SRP Update message. In the coded message, the message ID is encoded in the first two bytes, similar to a general DNS header. The fixed initial bit pattern in the header dispatch byte, when mapped to the DNS header, corresponds to `QR = 0` , `Opcode = 0b0101 = 5` , with bit 5 also set. An SRP Update message also employs `Opcode = 5` but with zero flags (`Z`). Setting bit 5 to `1` is used to identify a coded message.