Constrained Application Protocol (CoAP) over Bundle Protocol (BP)

draft-gomez-core-coap-bp-00

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1. Introduction

- DTN architecture:
  - Enables communication in challenged networks
    - Intermittent connectivity, high delays, high error rates…
    - Deep space, temporarily disconnected areas...
  - BP is the fundamental component of DTN
    - Store-carry-forward overlay
    - Application functionality runs atop BP

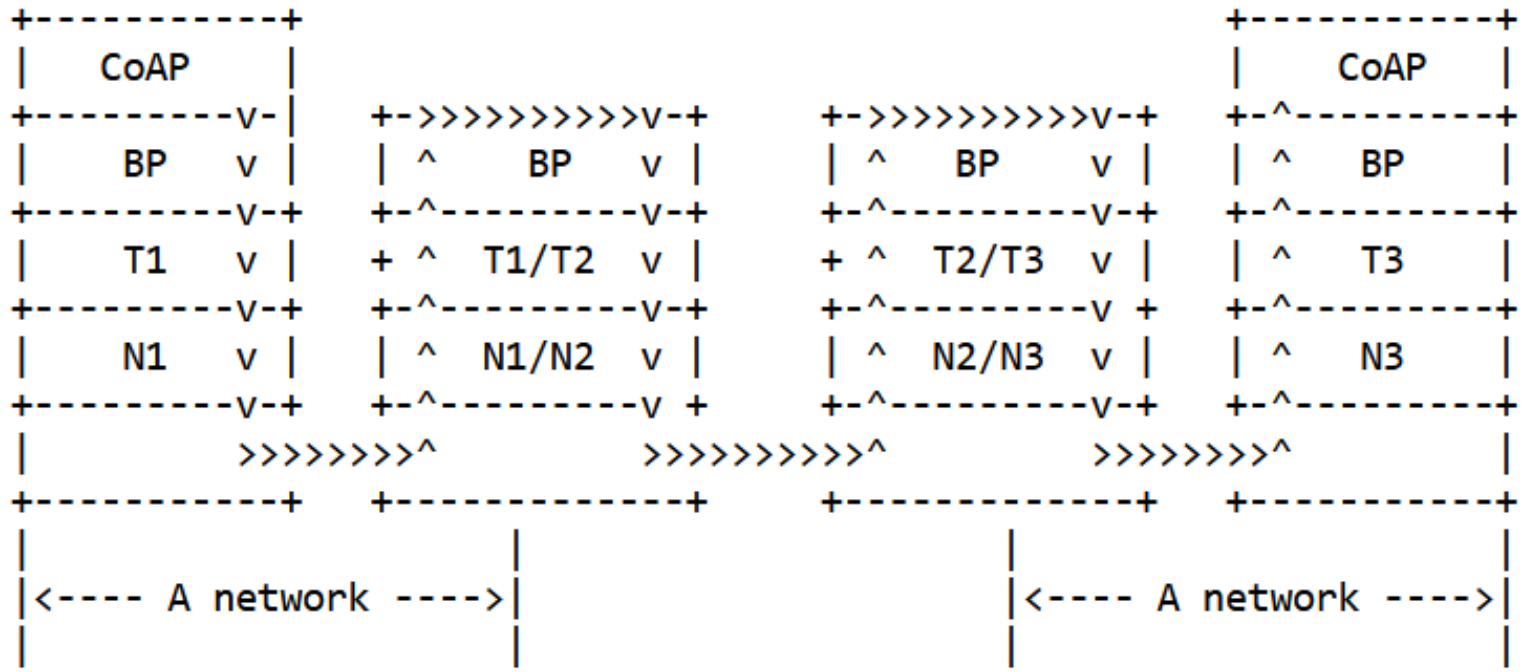
- CoAP:
  - Application-layer protocol designed for IoT environments
  - Typical IoT environment constraints:
    - Low energy (often leading to intermittent connectivity), high delays, low bandwidth, high error rates…
  - Features:
    - Lightweight operation, asynchronous message exchanges, flexibility, based on REST

Draft: main goal and status

- Main goal:
  - Specify how CoAP is carried over BP
- Initial draft version (-00)
  - Intended Status: Standards Track
- Explore interest, collect feedback
- Target WG?
  - CoRE WG
    - Specifies CoAP and related ecosystem
  - DTN WG
    - Specifies BP and related ecosystem
  - In any case, the aim is to keep both WGs in the loop

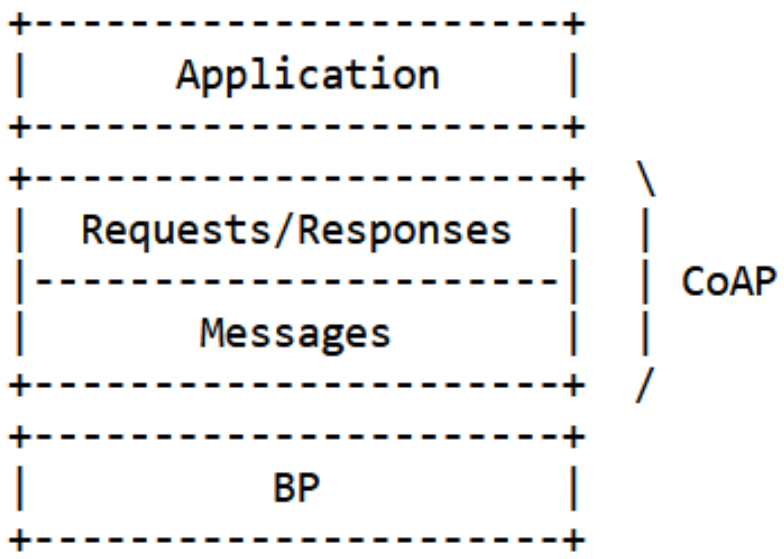
3. Architecture

- Protocol stack model:
  - Based on Fig. 1 of RFC 9171



4.1. Messaging model (I/III)

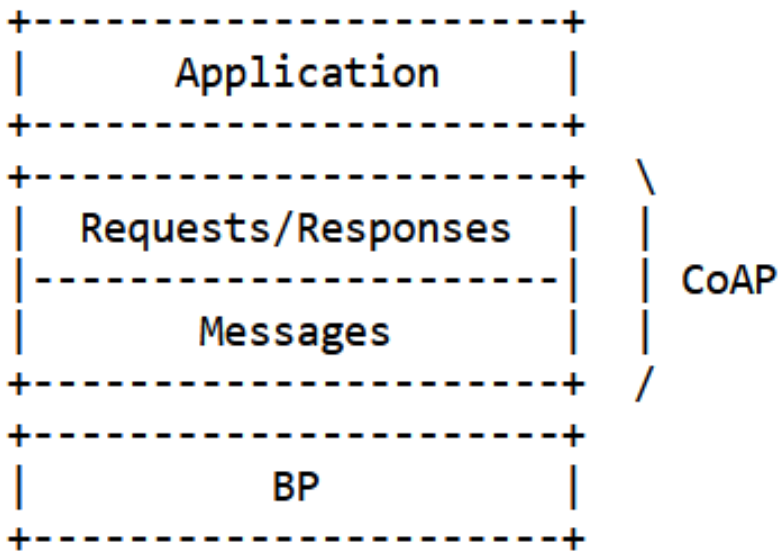
- Abstract layering for CoAP over BP:
  - CoAP was originally designed to operate over UDP
  - Same CoAP messaging model applies over BP:
    - UDP and BP are message-oriented protocols, no retransmission
    - CoAP over reliable transports: different model



4.1. Messaging model (II/III)

- Requests
  - Sent by clients
- Responses
  - Sent by servers

- Message types:
  - Confirmable (CON)
    - » Must be acknowledged
    - » Stop & wait
      - Default
    - » Timer-based retransmission, exponential back-off
  - Non-confirmable (NON)
  - Acknowledgment (ACK)
  - Reset (RST)



4.1. Messaging model (III/III)

- CoAP over BP:
  - A source bundle node MAY set the "request reporting of bundle delivery" flag in a bundle that encapsulates a CoAP CON message
  - The receiver MAY opt to only send the corresponding bundle delivery status report
    - Instead of sending a bundle encapsulating a CoAP ACK message
    - If and only if the CoAP ACK does not carry a payload
  - The status report sent in response to a bundle-encapsulated CON message serves as CoAP ACK for the CON message

  - Assumption: the status report size is shorter than the size of a bundle encapsulating a CoAP ACK message with no payload

4.2. Message format

- CoAP message over BP:
  - The CoAP message MUST be carried as the block-type-specific data field of the Bundle Payload Block (block type 1) of an encapsulating bundle
- CoAP message format over BP:
  - Extending the Message ID field size from 16 bits to 24 bits
  - Avoiding a severe limitation on the number of messages a sender can send per time unit:
    - RFC 7252: the same Message ID MUST NOT be reused within the EXCHANGE_LIFETIME (default: 247 s; deep space: ~10^3 s to ~10^4 s)
    - Maximum message rate (Appendix B):
      - » Default settings, Earth's Internet: ~265 message/s
      - » Default settings, Jupiter to Earth: ~3 message/s (1 retry)

5. CoAP parameter settings…

- NSTART
  - Max number of outstanding interactions
  - Default value: 1
    - Greater values possible when some mechanism ensures congestion safety
- ACK_TIMEOUT (AT), ACK_RANDOM_FACTOR (AF)
  - Initial RTO, randomly chosen from [AT, AT*AF]
  - Default values (respectively): 2 s, 1.5
    - ACK_TIMEOUT needs to be set to at least the RTT
    - ACK_RANDOM_FACTOR intended to avoid synchronization effects
- MAX_RETRANSMIT
  - Default value: 4
  - Due to exponential back-off, lower than default may be suitable
  - Congestion control: needed in BP environments?

5. … and related times

- MAX_LATENCY
  - Max time since a datagram is sent until it is received
  - Defined as 100 s
- EXCHANGE_LIFETIME
  - Max time since first transmission attempt of a CON until its ACK
  - Default value: 247 s
- NON_LIFETIME
  - Max time since a NON message is sent until it is received
  - Default value: MAX_LATENCY (i.e., 100 s)

At least 2 orders of magnitude greater over BP

- Note: CoAP implementations using 8-bit timers may need to be adapted to operate over BP

6. Observe

- Allows a server to send notifications carrying a representation of the current state of a resource to observers [RFC7641]
  - The latter need to initially register their interest
- The client does not have to send a request to receive each notification
  - Beneficial in high latency and/or low energy or bandwidth scenarios
- If time between the two last notifications received is > 128 seconds, the last one received is also the latest sent
  - 128 seconds: greater than the default MAX_LATENCY
  - When CoAP is used over BP, 128 seconds may be insufficient
  - The duration needs to be chosen as a value greater than the MAX_LATENCY of the scenario (see Appendix A)

7. Block-wise transfers

- CoAP supports functionality that allows carrying large payloads by means of block-wise transfers: RFC 7959, RFC 9177
- BP also supports fragmentation and reassembly functionality
- RFC 7959: "the fragmentation/reassembly process burdens the lower layers with conversation state that is better managed in the application layer"
  - Implicit assumption: details on the data unit sizes that can be carried over the different links of an end-to-end path are known in advance
- For CoAP over BP, CoAP block-wise transfers MAY be used if the source knows in advance the duration and type of expected contacts
  - This does not preclude the use of BP fragmentation and reassembly when deemed necessary
  - RFC 9177 is more suitable (RFC 7959 leads to stop & wait)
  - Many Block-specific parameters may need to be tuned

8. CoAP over BP URI

- Several CoAP URI schemes exist:
  - RFC 7252: "coap" and "coaps"
  - RFC 8323: "coap+tcp", "coaps+tcp", "coap+ws", "coaps+ws"

- For CoAP over BP:
  - New URI scheme: "coap+bp"
  - Syntax:
    - coap-bp-URI = "coap+bp:" "//" endpoint_ID path-abempty ["?" query]
    - Section 6.1 of RFC 7252 applies, except that a BP endpoint ID is used instead of the "host" and "port" authority subcomponents

9. IANA considerations

- IANA is requested to register the URI scheme "coap+bp"
  - Request structure conforms to RFC 7595
- Scheme name:
  - coap+bp
- Status:
  - Permanent
- Applications/protocols that use this scheme name:
  - CoAP endpoints to access CoAP resources using BP
- Contact:
  - IETF chair (chair@ietf.org)
- Change controller:
  - IESG (iesg@ietf.org)
- Reference:
  - Section 8.1 in [RFCthis]

Appendix A. Ref. parameter values for interplanetary communication

- Idealized scenarios: latency comprises propagation delay only

RTT, ACK_TIMEOUT (or EXCHANGE_LIFETIME, for MAX_RETRANSMIT=0)									
	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Sun	-	466	727	1,014	1,661	5,444	10,007	20,214	30,288
Mercury	-	-	1,181	1,448	1,968	5,751	10,340	20,548	30,554
Venus	-	-	-	1,735	2,382	6,158	10,741	20,948	30,955
Earth	-	-	-	-	2,642	6,424	11,008	21,215	31,222
Mars	-	-	-	-	-	6,805	11,408	21,615	31,622
Jupiter	-	-	-	-	-	-	14,944	25,151	35,425
Saturn	-	-	-	-	-	-	-	29,220	39,961
Uranus	-	-	-	-	-	-	-	-	50,168
Neptune	-	-	-	-	-	-	-	-	-

Appendix B. Max CoAP message rate

- Depending on
  - EXCHANGE_LIFETIME
  - Message ID
    - 16 bits (default)
    - 24 bits (suggested)

EXCHANGE_LIFETIME (s)	Message ID_16 bits	Message_ID 24 bits
247 (default)	265.3 (default)	67,924
500	131.1	33,554
1,000	65.5	16,777
1,500	43.7	11,184
2,000	32.8	8,388
2,500	26.2	6,710
3,000	21.8	5,592
3,500	18.7	4,793
4,000	16.4	4,194
4,500	14.6	3,728
5,000	13.1	3,355
5,500	11.9	3,050
6,000	10.9	2,796
6,500	10.1	2,581
7,000	9.4	2,396
7,500	8.7	2,237
10,000	6.6	1,677
20,000	3.3	838
30,000	2.2	559
40,000	1.6	419
50,000	1.3	335
60,000	1.1	279
70,000	0.9	239
80,000	0.8	209
90,000	0.7	186
100,000	0.7	167
110,000	0.6	152
120,000	0.5	139
130,000	0.5	129
140,000	0.5	119
150,000	0.4	111

Thanks!
Questions? Comments?

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