ALTO New Transport using HTTP/2

draft-schott-alto-new-transport-01

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Outline

- Motivation and requirements
- ALTO/H2 design
- Discussions and open issues

Motivation

- ALTO base protocol [RFC7285] is an HTTP/1.x client-pull protocol
- ALTO/SSE [RFC8895] adds incremental server push using Server-Sent-Event, but is based on HTTP/1.x
  - Need additional control connection
  - Updates must be serialized
- RFC8895 IESG review
  - Consider HTTP/2

```
 -------------------------------------------------------------------
|                          ALTO SSE Example                         |
|          +-------+         +-------+ 1. init request  +------+    |
|          |       |         |       | <-------------   |      |    |
|          |       |         |       | -------------->  |      |    |
| 3.add/   |       |         |       | 1'. control uri  |      |    |
| remove   |       |         |       |                  |      |    |
| resource |Stream |         |Update |                  |      |    |
 -------->|Control| private |Stream | 2a. data update  |Client| --
          |Server |<------->|Server | messages         |      |
 -------- |       |         |       | --------------->  |      | <-
| response |       |         |       | --------------->  |      |    |
|          |       |         |       | 2b.control update|      |    |
|          +-------+         +-------+ messages         +------+    |
|                                                                   |
 -------------------------------------------------------------------
```

ALTO/H2 Design Requirements

- From ALTO base protocol [RFC 7285]
  - R0: Client can request any ALTO resource using the connection, just as using ALTO base protocol using HTTP/1.x
- From ALTO SSE [RFC 8895]
  - R1: Client can request the addition (start) of incremental updates to a resource
  - R2: Client can request the deletion (stop) of incremental updates to a resource
  - R3: Server can signal to the client the start or stop of incremental updates to a resource
  - R4: Server can choose the type of each incremental update encoding, as long as the type is indicated to be acceptable by the client
- From ALTO base framework [RFC 7285]
  - R5: Design follows basic HTTP Representational State Transfer architecture if possible
    - Can use only a limited number of verbs (GET, POST, PUT, DELETE, HEAD)
  - R6: Design takes advantage of HTTP/2 design features such as parallel transfer and respects HTTP/2 semantics [PUSH_PROMISE]
- Allow flexible deployment
  - R7: Capability negotiation

ALTO/H2 Design Requirements addressed by daft

- From ALTO base protocol [RFC 7285]
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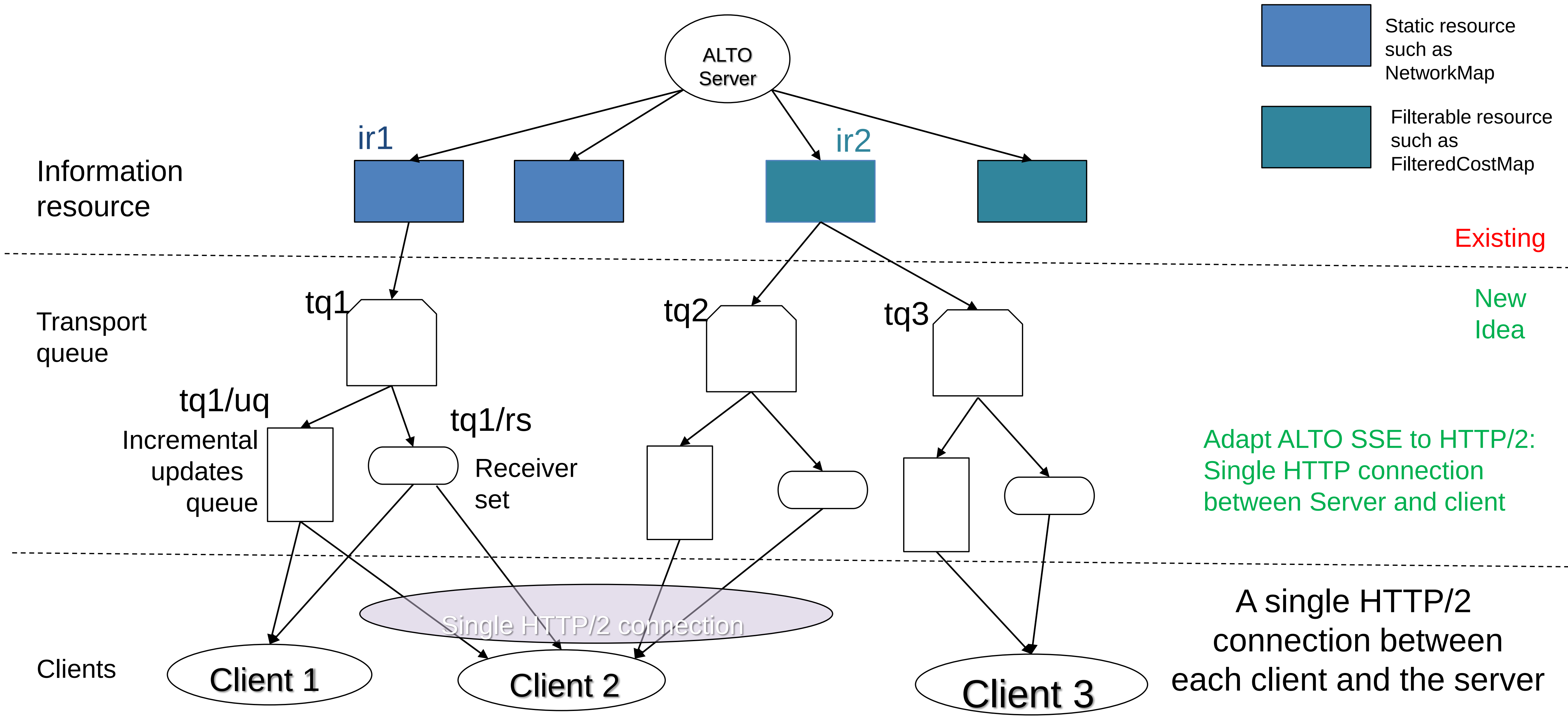
  - R1: Client can request the addition (start) of incremental updates to a resource
  - R2: Client can request the deletion (stop) of incremental updates to a resource
  - R3: Server can signal to the client the start or stop of incremental updates to a resource
  - R4: Server can choose the type of each incremental update encoding, as long as the type is indicated to be acceptable by the client
- From ALTO base framework [RFC 7285] ✓
  - R5: Design follows basic HTTP Representational State Transfer architecture if possible
    - Can use only a limited number of verbs (GET, POST, PUT, DELETE, HEAD)
  - R6: Design takes advantage of HTTP/2 design features such as parallel transfer and respects HTTP/2 semantics [PUSH_PROMISE]
- Allow flexible deployment ⊘
  - R7: Capability negotiation

Outline

- Motivation and requirements
- ALTO/H2 design
  - Overview

ALTO/H2 Transport Information Structure



ALTO/H2 Transport Information Structure

- Client opens a connection to the server
- Client opens/identifies a transport queue tq
  - Client requests transport queue status
  - Client requests an element in the message queue
  - Client becomes a receiver
  - Client receives push updates
- Client closes the transport queue
- Client closes connection

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  - Transport queue

Transport Queue

- Basic operations (CR~~U~~D): create, read (get status), delete
- Client creates transport queue
  - POST to transport queues path
    - Request reuses ALTO/SSE input
      - HTTP :method=post with AddUpdateReq [RFC8895]
    - Response
      - <transport-queue>

```
object {
    ResourceID   resource-id;
    [JSONString  tag;]
    [Boolean     incremental-changes;]
    [Object      input;]
 } AddUpdateReq;
```

Transport Queue Example (Create)

- Client -> Server request

```
HEADERS
  - END_STREAM
  + END_HEADERS
    :method = POST
    :scheme = https
    :path = /tqs
    host = alto.example.com
    accept = application/alto-error+json,
                 application/alto-transport+json
    content-type = application/alto-transport+json
    content-length = TBD

DATA
 - END_STREAM
 {
    "resource-id": "my-routingcost-map"
 }
```

- Server -> Client response

```
HEADERS
  - END_STREAM
  + END_HEADERS
    :status = 200
    content-type = application/alto-transport+json
    content-length = TBD

DATA
  - END_STREAM
   {"tq": "/tqs/2718281828459"}
```

Transport Queue

- Basic operations (CR~~U~~D): create, read (get status), delete
- Client creates transport queue
  - POST to transport queues path
    - Request reuses ALTO/SSE input
      - HTTP :method=post with AddUpdateReq [RFC8895]
    - Response
      - <transport-queue>

```
object {
    ResourceID    resource-id;
    [JSONString   tag;]
    [Boolean      incremental-changes;]
    [Object       input;]
 } AddUpdateReq;
```

- Client reads transport queue: GET <transport-queue>
- Client closes transport queue:
  - Explicit: DELETE <transport-queue>
    - Delete from local view (server may still maintain the transport queue for other client connections)
  - Implicit: Transport queue for a client is ephemeral: close of connection or stream deletes the transport queue from the client's view --- when the client reconnects, the client MUST NOT assume that the queue is still valid

Transport Queue Example (Read)

- Client -> Server request

```
HEADERS
  - END_STREAM
  + END_HEADERS
    :method = GET
    :scheme = https
    :path = /tqs/2718281828459
    host = alto.example.com
    accept = application/alto-error+json,
                application/alto-transport+json
```

- Server -> Client response

```
HEADERS
  - END_STREAM
  + END_HEADERS
    :status = 200
    content-type = application/alto-transport+json
    content-length = TBD

DATA
  - END_STREAM
 { "uq":
    [
      {"seq":        101,
       "media-type": "application/alto-costmap+json",
       "tag":        "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe" },
      {"seq":        102,
       "media-type": "application/merge-patch+json",
       "tag":        "cdf0222x59740b0b2e3f8eb1d4785acd42231bfe" },
      {"seq":        103,
       "media-type": "application/merge-patch+json",
       "tag":        "8eb1d4785acd42231bfecdf0222x59740b0b2e3f",
       "link":       "/tqs/2718281828459/snapshot/2e3f"}

    ],
  "rs": ["self"]
 }
```

„uq“ = incremental updates queue
„rs“ = receiver set

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  - Incremental updates queue

Incremental Updates Queue

- Incremental updates queue basic operations (~~C~~R~~UD~~): read (get status)
  - Client cannot create, update, or delete incremental updates queue directly---it is read only, and associated with transport queue automatically
  - Read:
    - Input: <tq>/uq
    - Response: updates queue state
    - Note
      - Server determines the state (window of history and type of each update) in the update queue [R4]
      - Read of updates queue status allows client to know
        - » backlog status
        - » workload to catch up (HEAD)
        - » potential direct link

Request

```
HEADERS
  - END_STREAM
  + END_HEADERS
    :method = GET
    :scheme = https
    :path = /tqs/2718281828459/uq
    host = alto.example.com
    accept = application/alto-error+json,
                application/alto-transport+json
```

Response data


```
DATA
  - END_STREAM
 {
   [
    {"seq":        101,
     "media-type": "application/alto-costmap+json",
     "tag":        "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe" },
    {"seq":        102,
     "media-type": "application/merge-patch+json",
     "tag":        "cdf0222x59740b0b2e3f8eb1d4785acd42231bfe" },
    {"seq":        103,
     "media-type": "application/merge-patch+json",
     "tag":        "8eb1d4785acd42231bfecdf0222x59740b0b2e3f",
     "link":       "/tqs/2718281828459/snapshot/2e3f"}
   ],
 }
```

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  - Incremental updates queue
  - Individual updates

Individual Incremental Updates

- Individual incremental updates operations (~~C~~R~~UD~~): pull read or push read
  - Client pull
    - GET <update-uri>

Client Pull Example

```
HEADERS
  + END_STREAM
  + END_HEADERS
    :method = GET
    :scheme = https
    :path = /tqs/2718281828459/uq/101
    host = alto.example.com
    accept = application/alto-error+json,
                 application/alto-costmap+json
```

```
HEADERS
  - END_STREAM
  + END_HEADERS
    :status = 200
    content-type = application/alto-costmap+json
    content-length = TBD

DATA
  + END_STREAM
 {
   "meta" : {
      "dependent-vtags" : [{
         "resource-id": "my-network-map",
         "tag": "da65eca2eb7a10ce8b059740b0b2e3f8eb1d4785"
       }],
      "cost-type" : {
        "cost-mode"  : "numerical",
        "cost-metric": "routingcost"
      },
      "vtag": {
        "resource-id" : "my-routingcost-map",
        "tag" : "3ee2cb7e8d63d9fab71b9b34cbf764436315542e"
      }
   },
   "cost-map" : {
     "PID1": { "PID1": 1,  "PID2": 5,  "PID3": 10 },
     "PID2": { "PID1": 5,  "PID2": 1,  "PID3": 15 },
     "PID3": { "PID1": 20, "PID2": 15  }
   }
}
```

Individual Incremental Updates

- Individual incremental updates operations (~~C~~R~~UD~~): pull read or push read
  - Client pull
    - GET <update-uri>
  - Server push
    - Initialization:
      - the first update pushed from the server to the client MUST be the later of the following two
        - » the last independent update in the incremental updates queue
        - » the following entry of the entry that matches the tag when the client creates the transport queue
      - The client MUST set SETTINGS_ENABLE_PUSH to be consistent
    - State: the server maintains the last entry pushed to the client and schedules next update push
      - Per client, connection state
    - Client MUST NOT cancel (RST_STREAM) a PUSH_PROMISE
      - To avoid complex server state management

Server Push Initialization Example

```
DATA
  + END_STREAM
 {
    [
      {"seq":        101,
       "media-type": "application/alto-costmap+json",
       "tag":        "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe" },
      {"seq":        102,
       "media-type": "application/merge-patch+json",
       "tag":        "cdf0222x59740b0b2e3f8eb1d4785acd42231bfe" },
      {"seq":        103,
       "media-type": "application/merge-patch+json",
       "tag":        "8eb1d4785acd42231bfecdf0222x59740b0b2e3f",
       "link":       "/tqs/2718281828459/snapshot/2e3f"}

    ],

 }
```

First push, if client has no matching tag

First push, if client has tag matching previous entry

Server Push Transport Example

- Each pushed update is indicated first in a PUSH_PROMISE

Server send PUSH_PROMISE

```
Server -> client PUSH_PROMISE in stream 3

PUSH_PROMISE
  - END_STREAM
    Promised Stream 4
    HEADER BLOCK
    :method = GET
    :scheme = https
    :pseudopath = /tqs/2718281828459/uq/101
    host = alto.example.com
    accept = application/alto-error+json,
                 application/alto-costmap+json
```

```
Server -> client content Stream 4

HEADERS
  + END_STREAM
  + END_HEADERS
    :status = 200
    content-type = application/alto-costmap+json
    content-length = TBD

DATA
  + END_STREAM
 {
   "meta" : {
      "dependent-vtags" : [{
         "resource-id": "my-network-map",
         "tag": "da65eca2eb7a10ce8b059740b0b2e3f8eb1d4785"
       }],
      "cost-type" : {
        "cost-mode"  : "numerical",
        "cost-metric": "routingcost"
      },
      "vtag": {
        "resource-id" : "my-routingcost-map",
        "tag" : "3ee2cb7e8d63d9fab71b9b34cbf764436315542e"
      }
   },
   "cost-map" : {
     "PID1": { "PID1": 1,  "PID2": 5,  "PID3": 10 },
     "PID2": { "PID1": 5,  "PID2": 1,  "PID3": 15 },
     "PID3": { "PID1": 20, "PID2": 15  }
   }
```

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  - Receiver set

Receiver Set

- Receiver set operations (~~C~~R~~U~~D): read (get status), delete (self only)
- By default, a client can see only itself in the receiver set
  - Appearance of self in the receiver set (read does not return “not exists”) is an indication that push starts
- A client can delete itself (stops receiving push):
  - Explicit: DELETE <transport-queue>/rs/self
  - Implicit: Transport queue is connection ephemeral: close of connection or stream for the transport queue deletes the transport queue (from the view) for the client

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  - Individual updates
  - Receiver set
  - Stream management

ALTO/H2 Stream Management: Objectives

- Objectives
  - Allow stream concurrency to reduce latency
  - Minimize the number of streams created
  - Enforce dependency among streams (so that if A depends on B, then A should be sent before B)
    - Encode dependency to enforce semantics (correctness)

ALTO/H2 Stream Management: Specification

- Client -> Server [Create transport queue]
  - Each request to create a transport queue (POST) MUST choose a new client selected stream ID (SID_tq)
    - Stream Identifier of the frame is a new client-selected stream ID; Stream Dependency in HEADERS is 0 (connection) for an independent resource, the other transport queue if the dependency is known
    - Invariant: Stream keeps open until close or error

```
+-----------------------------------------------+
|                 Length (24)                   |
+---------------+---------------+---------------+
|   Type (8)    |   Flags (8)   |
+-+-------------+---------------+-------------------------------+
|R|                 Stream Identifier (31)                      |
+=+=============================================================+
|                   Frame Payload (0...)                      ...
+---------------------------------------------------------------+
```

Figure 1: Frame Layout

```
+---------------+
|Pad Length? (8)|
+-+-------------+-----------------------------------------------+
|E|                 Stream Dependency? (31)                     |
+-+-------------+-----------------------------------------------+
|  Weight? (8)  |
+-+-------------+-----------------------------------------------+
|                   Header Block Fragment (*)                 ...
+---------------------------------------------------------------+
|                           Padding (*)                       ...
+---------------------------------------------------------------+
```

Figure 7: HEADERS Frame Payload

ALTO/H2 Stream Management: Specification

- Client -> Server [Close transport queue]
  - DELETE to close a transport queue (SID_tq) MUST be sent in SID_tq
    - Stream Identifier of the frame is SID_tq; Stream Dependency in HEADER is 0 (connection)
      - So that a client cannot close a different stream
      - Indicates END_STREAM; server response also close stream

```
+-----------------------------------------------+
|                 Length (24)                   |
+---------------+---------------+---------------+
|   Type (8)    |   Flags (8)   |
+-+-------------+---------------+-------------------------------+
|R|                 Stream Identifier (31)                      |
+=+=============================================================+
|                   Frame Payload (0...)                      ...
+---------------------------------------------------------------+
```

Figure 1: Frame Layout

```
+---------------+
|Pad Length? (8)|
+-+-------------+-----------------------------------------------+
|E|                 Stream Dependency? (31)                     |
+-+-------------+-----------------------------------------------+
|  Weight? (8)  |
+-+-------------+-----------------------------------------------+
|                   Header Block Fragment (*)                 ...
+---------------------------------------------------------------+
|                           Padding (*)                       ...
+---------------------------------------------------------------+
```

Figure 7: HEADERS Frame Payload

ALTO/H2 Stream Management: Specification

- Client -> Server [Request on data of a transport queue SID_tq, e.g., read message]
  - Stream Identifier of the frame is a new client-selected stream ID, Stream Dependency in HEADERs MUST be SID_tq
    - So that a client cannot issue request on a closed transport queue
    - Request indicates END_STREAM; response also indicates end of stream

```
+-----------------------------------------------+
|                 Length (24)                   |
+---------------+---------------+---------------+
|   Type (8)    |   Flags (8)   |
+-+-------------+---------------+-------------------------------+
|R|                 Stream Identifier (31)                      |
+=+=============================================================+
|                  Frame Payload (0...)                       ...
+---------------------------------------------------------------+
```

Figure 1: Frame Layout

```
+---------------+
|Pad Length? (8)|
+-+-------------+-----------------------------------------------+
|E|                 Stream Dependency? (31)                     |
+-+-------------+-----------------------------------------------+
|  Weight? (8)  |
+-+-------------+-----------------------------------------------+
|                   Header Block Fragment (*)                 ...
+---------------------------------------------------------------+
|                           Padding (*)                       ...
+---------------------------------------------------------------+
```

Figure 7: HEADERS Frame Payload

ALTO/H2 Stream Management: Specification

- Server -> Client PUSH_PROMISE for transport queue SID_tq
  - PUSH_PROMISE sent in stream SID_tq to serialize to allow the client to know the push order
  - Each PUSH_PROMISE chooses a new server-selected stream ID
    - Stream is closed after push

```
+-----------------------------------------------+
|                 Length (24)                   |
+---------------+---------------+---------------+
|   Type (8)    |   Flags (8)   |
+-+-------------+---------------+-------------------------------+
|R|                 Stream Identifier (31)                      |
+=+=============================================================+
|                   Frame Payload (0...)                      ...
+---------------------------------------------------------------+
```

Figure 1: Frame Layout

```
+---------------+
|Pad Length? (8)|
+-+-------------+-----------------------------------------------+
|R|                  Promised Stream ID (31)                    |
+-+-----------------------------+-------------------------------+
|                   Header Block Fragment (*)                 ...
+---------------------------------------------------------------+
|                           Padding (*)                       ...
+---------------------------------------------------------------+
```

Figure 11: PUSH_PROMISE Payload Format

Concurrent Streams Management

- Controlled by SETTINGS_MAX_CONCURRENT_STREAMS
- Client -> Server
  - There is one stream for each open transport queue
    - A client can always close a transport queue (it uses the open stream) and hence can open -> can close, without issue of deadlock
- Server -> Client push
  - Each push needs to open a new stream

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Transport and Pub/sub

- What is missing
  - The design does not allow creation of generic message queues
  - Only the server can be the publisher
    - Clients cannot publish info to be shared with other clients
  - The design does not have the capability of Exchange (message router)
- Way forward: Keep simple
  - Broker for further discussion

```
                                        Server
                      +-------------------------------+
                      |          Virtual host         |
                      |   +-----------------------+   |
                      |   |       Exchange        |   |
+-------------+       |   |      +-------+        |   |
|  Publisher  |  ----------->    |       |        |   |
| application |       |   |      +---+---+        |   |
+-------------+       |   |          |            |   |
                      |   |       Message         |   |
                      |   |        Queue          |   |
+-------------+       |   |      +-------+        |   |
|  Consumer   |  <-----------    +-------+        |   |
| application |       |   |      +-------+        |   |
+-------------+       |   |      +-------+        |   |
                      |   +-----------------------+   |
                      +-------------------------------+
```

https://www.rabbitmq.com/resources/specs/amqp0-9-1.pdf

Capability Negotiation

- Capability Negotiation is not fully specified
  - Instead of fix stream management, client server can negotiate

Additional Information about Transport Queue

- Calendar semantics
  - Tell the client ALTO information (e.g., cost) for a future time point
  - Tell the client when the next information will be released, it is the time that the info is released is distributed, not the value [support]

Thank you!

Questions?