[JET-PROTO]:
JET Relay Protocol

Revision History

Revision summary			
Author	**Date**	**Revision history**	**Comments**
Marc-André Moreau	10/25/2018	0.1	Initial draft
Marc-André Moreau	07/17/2019	0.2	Major update
François Dubois	07/30/2021	0.3	Add “jet_rec” and “jet_flt” in JWT

Contents

1 Introduction

This document specifies the JET Relay Protocol.

1.1 Glossary

The following terms are specific to this document:

MAY, SHOULD, MUST, SHOULD NOT, MUST NOT: These terms (in all caps) are used as described in [RFC2119]. All statements of optional behavior use either MAY, SHOULD, or SHOULD NOT.

1.2 References

1.2.1 Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997, http://www.ietf.org/rfc/rfc2119.txt.

1.3 Overview

The JET protocol bears some similarities with the SOCKS proxy protocol and the routing token packets often used in remote desktop connections for load balancing and session selection. However, all of these protocols make connections in a forward manner: the client connects to the proxy, then the proxy connects to the server and then relays the traffic. The JET protocol is designed to relay TCP traffic between a TCP client and server using only outgoing TCP connections.

1.4 Prerequisites/Preconditions

The JET protocol requires a TCP transport.

1.5 Applicability Statement

The JET protocol is suitable for simple, efficient relaying TCP, TLS or WebSocket traffic.

2 Messages

2.1 Transport

The JET protocol is designed to provide a simple, efficient way to relay TCP traffic between two nodes that can only perform outgoing TCP connections to the same server, using a rendezvous connection style. Alternatively, a JET packet can be sent between a client and server as a way to discover a direct route.

2.2 Message Syntax

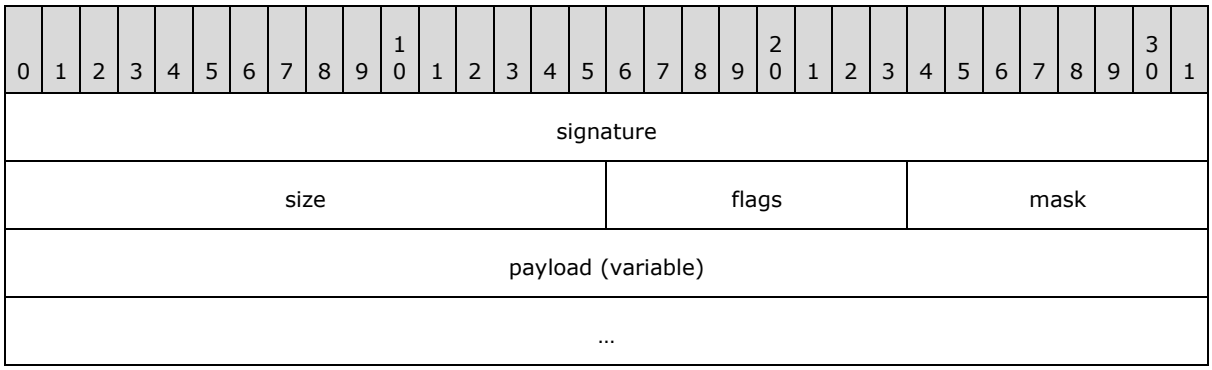
The following sections specify the JET protocol message syntax. All fields defined in this document use big endian byte ordering and are byte-aligned to their sizes (a field of 4 bytes starts at an offset that is a multiple of 4).

2.2.1 Protocol Messages

All JET binary protocol messages sent over TCP or TLS are contained within a JET_PACKET structure. The JET WebSocket protocol makes use of HTTP requests and the WebSocket handshake request path to achieve the same goal.

2.2.1.1 JET_PACKET

The JET_PACKET structure contains a routing token used to associate two indirect TCP connections.



signature (4 bytes): The packet signature. MUST be set to { 0x4A, 0x45, 0x54, 0x00 } ("JET").

size (2 bytes): The total size of the packet, including headers. The minimum size is 8.

flags (1 byte): This field is reserved for future use and MUST be set to zero.

mask (1 byte): This field contains a one-byte mask that MUST be applied to the payload.

payload (variable): This field contains a masked HTTP request or response using the value from the mask field.

2.2.2 REST API

The REST API is used to create Jet associations and optionally enforce authentication. It is optional for the JET binary protocol, but it is required for the JET WebSocket protocol.

2.2.2.1 Jet Association

The JET WebSocket protocol requires that the association be created with an HTTP request/response. While this call could be made by a backend server, it is recommended to make the call from endpoint that will act as a server, such that DNS load balancing can be implemented properly by selecting the closest Jet instance.

An association associates a client and a server independently from the underlying transport used. When a new association is created, a list of candidates is produced and sent to both peers to be tested for connectivity. A candidate is considered usable if both peers managed to connect using the same association id. Multiple usable candidates will normally be opened this way, but only one will be selected by the client, while all others will be closed without application traffic being sent.

The usage of an API key or authentication for this API endpoint is recommended but not required.

Jet association creation:

>> Request:

POST /jet/association/e6ec698c-5793-4c63-af79-bd644ccf022f HTTP/1.1

Host: jet.wayk.net

<< Response:

HTTP/1.1 200 OK

Jet association deletion:

>> Request:

DELETE /jet/association/e6ec698c-5793-4c63-af79-bd644ccf022f HTTP/1.1

Host: jet.wayk.net

<< Response:

HTTP/1.1 200 OK

Jet association info:

>> Request:

GET /jet/association/e6ec698c-5793-4c63-af79-bd644ccf022f HTTP/1.1

Host: jet.wayk.net

<< Response:

HTTP/1.1 200 OK

2.2.2.2 Jet Candidate Gathering

>> Request:

POST /jet/gather/e6ec698c-5793-4c63-af79-bd644ccf022f HTTP/1.1

Host: jet.wayk.net

<< Response:

HTTP/1.1 200 OK

```
{
  "id": "e6ec698c-5793-4c63-af79-bd644ccf022f",
  "candidates": [
    { "url": "tcp://jet101.wayk.net:8080",
      "id": "1ff84b5f-5a62-4124-bf61-381a5c55db89" },
    { "url": "tls://jet101.wayk.net:443",
      "id": "e9f4e1ea-0808-4e2a-8359-dd6e19c9148a" },
    { "url": "wss://jet101.wayk.net",
      "id": "b1cc4748-95a8-4064-9bd9-2e67b74a6fb9" }
  ]
}
```

The association id MUST be the same for all candidates, but each candidate MUST have a different id. A candidate id only needs to be unique within the same association. The association id can be the same across multiple distinct relay servers, as long as it is used to identify the same association.

If the signaling server policy allows direct connectivity (non-relay) between peers, this list of candidates will be enriched with direct connectivity candidates provided by the server endpoint. It is also possible to further enrich the list of relay candidates by using additional servers, such as a relay server available on the local network.

To avoid complicated management of global list of associations, each relay server SHOULD automatically delete inactive or unused ids after a defined period of time. An association is considered active on a given relay server if one of the candidates was selected, meaning there is a non-zero amount of bytes that were sent after the original JET handshake.

2.2.2.3 Jet Candidate Format

The JET candidate can be encoded in multiple ways, depending on how it is transmitted.

2.2.2.3.1 URL Format

A JET candidate is a URL representing a possible route that can be used for a connection.

If no scheme is specified, the "tcp://" scheme should be used. The default port can only be omitted for ws:// (80) and wss:// (443) schemes, otherwise it must be included in the URL.

tcp://jet101.wayk.net:8080

A TCP candidate using the JET binary protocol. This candidate is compatible with end-to-end TLS usage, where the JET exchange occurs prior to the TLS handshake.

tls://jet101.wayk.net:4343

A TLS candidate using the JET binary protocol. This candidate is not compatible with end-to-end TLS because the TLS handshake is performed with the Jet relay, followed by the JET exchange over TLS.

ws://jet101.wayk.net:8080

A WebSocket candidate without TLS. The WebSocket handshake request path contains the JET parameters.

wss://jet101.wayk.net:4343

A WebSocket candidate with TLS. The WebSocket handshake request path contains the JET parameters.

2.2.3 JWT Format

Starting with Jet V3, associations can be authorized using JWTs signed by a trusted authority external to the jet relays. Since JWTs can be passed as a string parameter, they can be embedded in Jet messages, but they can also be adapted to be encapsulated in other protocols, such as the Authorization header of a WebSocket handshake in a browser, or the token string of the RDP preconnection PDU.

2.2.3.1 Validity Period

The "iat" (issued at) claim or the "nbf" (not before) claim SHOULD be used to determine the beginning of the JWT validity period, where the "nbf" claim takes precedence over the "iat" claim if present. The "exp" (expiration time) claim SHOULD be used to determine the ending of the JWT validity period. The recommended JWT validity period SHOULD be two minutes with a leeway of a few minutes (10 minutes should be relatively safe for most system clocks). JWTs used outside of their validity period MUST be considered invalid and rejected by the Jet relay.

2.2.3.2 Token Signature

By default, Jet JWTs SHOULD use public key algorithms instead of symmetric algorithms, to reduce the number of places where the secret required to sign the JWTs is stored. With public-key cryptography, only the authorization server needs the private key to sign the JWTs, while the jet relays only need to be configured with the corresponding public key to validate the signatures.

Usage of the "none" algorithm (unsecured JWT) SHOULD be disabled by default. However, because the "none" algorithm can prove useful for development purposes, Jet relay implementations MAY offer an option to enable it, and effectively make it possible to craft JWTs without signing them.

2.2.3.3 Token Encryption

Because Jet JWTs can sometimes be sent over an unsecure communication channel, some implementations MAY use JSON Web Encryption (JWE) to encrypt the JWT instead of signing it. In most cases, the information contained in the JWT is not sensitive and meant to be used only once, so encryption should not be required. However, one should keep in mind that information confidentiality for all pre-TLS Jet messages, that occur in the following cases:

- TCP candidate packets
- RDP preconnection PDU

In the case of TCP candidate packets, the exchange occurs pre-TLS for the underlying application protocol. In the rendezvous connection mode, the association id and candidate ids are revealed, but these are not of a sensitive nature. In the RDP preconnection PDU, the "dst_hst" claim could reveal the internal hostname of the destination RDP server, which is still not very sensitive. For all these specific cases, JWT encryption SHOULD be considered optional and not a requirement.

The following JWT claims are considered sensitive and MUST only be used with JWT encryption:

- "dst_usr" (destination username) claim
- "dst_pwd" (destination password) claim

Since the Jet relay needs to decode the JWT contents, usage of JWT encryption requires that the private keys be configured in both the authorization server and the Jet relays. This is a limitation that defeats the purpose of public-key cryptography by sharing the private key in multiple locations, but it is the only way we can provide both signature and encryption capabilities.

2.2.3.4 "jet_cm" (Jet Connection Mode) Claim

The "jet_cm" (jet connection mode) claim identifies the connection mode used for the Jet association.

Value	Meaning
"rdv"	Rendezvous connection mode
"fwd"	Forward-only connection mode

If this claim is absent from the JWT, the "rdv" (Rendezvous) connection mode SHOULD be assumed.

2.2.3.5 "jet_ct" (Jet Connection Test) Claim

The "jet_ct" (jet connection test) claim identifies the connection test used for the Jet candidates.

Value	Meaning
"keep"	Keep connection open after test
"close"	Close connection after test

If this claim is absent from the JWT, the "keep" connection test value SHOULD be assumed.

2.2.3.6 "jet_ap" (Jet Application Protocol) Claim

The "ap" (application protocol) claim identifies the application protocol used over the Jet transport. If the jet relay is configured for protocol inspection, it SHOULD enforce usage of the advertised protocol. The known protocol values are:

Value	Meaning
"none"	Unidentified protocol
"wayk"	Wayk Now protocol
"rdp"	RDP protocol
"ssh"	SSH protocol
"vnc"	VNC protocol

All protocols except "none" should be identifiable by the relay server. Usage of "none" indicates to the relay server that the protocol is not identified, and therefore not inspectable according to a known protocol.

2.2.3.7 "jet_rec" (Jet Recording Policy) Claim

The "jet_rec" (jet recording policy) claim indicates if the session should be recorded or not. It is a boolean so possible values are true/false. If this claim is absent from the JWT, false SHOULD be used as default. If the Jet relay is unable to comply with the requested recording policy, it MUST reject the connection. For instance, if session recording is requested but the Jet relay is unable to perform session recording, the connection MUST be rejected.

2.2.3.8 "jet_flt" (Jet Filtering Policy) Claim

The "jet_flt" (jet filtering policy) claim indicate if the session should be filtered or not. It is a boolean so possible values are true/false. If this claim is absent from the JWT, false SHOULD be used as default. If the Jet relay is unable to comply with the requested filtering policy, it MUST reject the connection. For instance, if session recording is requested but the Jet relay is unable to perform session filtering, the connection MUST be rejected.

2.2.3.9 "dst_hst" (Destination Hostname) Claim

The "dst_hst" (destination hostname) claim indicates the destination or target server that the jet relay server should connect to. The "dst_hst" value is a destination host and port of the following format:

<host>:<port>

The "dst_hst" claim is meant to be used in forward-only connection modes, where a Jet client connects to a Jet relay, and the Jet relay connects to the destination server, similar to how a reverse proxy works, or how the Remote Desktop Gateway works. The "dst_hst" claim is not meant to be used in the rendezvous connection mode, where both the Jet client and Jet server connect to the Jet relay.

2.2.3.10 "dst_usr" (Destination Username) Claim

The "dst_usr" (destination username) claim is used to provide the username for the Jet relay destination. It is normally used with the "dst_hst" and "dst_pwd" claims in a forward-only connection.

2.2.3.11 "dst_pwd" (Destination Password) Claim

The "dst_pwd" (destination password) claim is used to provide the Jet relay with a sensitive password meant to connect to its destination. This claim SHOULD normally be used with the "dst_hst" claim in a forward-only connection.

2.2.4 Message Protocol

The Jet message protocol is the equivalent of the Session Description Protocol (SDP) used in WebRTC. It uses a series of JSON-formatted messages sent over the signaling server to perform the negotiation of the Jet candidates leading up to the selection of a final candidate, after which the signaling server is no longer required.

id: jet association id

role: jet role ("client" or "server")

version: jet version (2 or 3)

transports : comma-separated list of supported transports (optional, offer message only)

candidates : list of jet candidates (answer message only)

candidate: selected candidate (complete message only)

2.2.4.1 Offer Message

The offer message is produced by the Jet client and contains relatively little information, as we expect the Jet server to perform most of the work.

```
{
  "id": "4daeb814-cdb6-4779-a16b-6479064e8107",
  "role": "client",
  "transports": "tcp,wss",
  "version": 2
}
```

The “transports” field was introduced in Jet V3, but since it is optional, it remains backwards compatible with Jet V2. The absence of the “transports” field means the server should not filter candidate transport types.

Since the offer message is always sent by the Jet client, the “role” field MUST be set to “client”.

2.2.4.2 Answer Message

The answer message is produced by the Jet server as a response to the Jet client offer. It contains the host and relay candidates gathered by the server to be tested by the client.

```
{
  "id": "4daeb814-cdb6-4779-a16b-6479064e8107",
  "role": "server",
  "version": 2,
  "candidates": [
    { "id": "174a46de-7c56-30e0-e083-b6b03a2df15f",
      "url": "tcp://10.1.21.34:4489?ctype=host" },
    { "id": "fdc2726d-e228-59cd-3536-2c0919b509a3",
      "url": "tcp://192.168.25.1:4489?ctype=host" },
    { "id": "4fab2441-b8a5-4bd5-9831-fe7aa8cccb36",
      "url": "tcp://jet.wayk.net:8080?ctype=relay" },
    { "id": "b1b4db92-9cc0-49d6-a940-1846fc07cf05",
      "url": "wss://jet.wayk.net:7171?ctype=relay" }
  ]
}
```

If the client offer contained the “transports” field, the server SHOULD use it to filter out unsupported transport types from its list of candidates. This means that if “transports” is set to “wss”, the server SHOULD return only “wss” candidates and avoid wasting time opening “tcp” candidates.

Since the answer message is always sent by the server, the “role” field MUST be set to “server”.

2.2.4.3 Complete Message

The complete message is sent by the Jet client to the Jet server to tell which candidate it has selected, prompting all other unused tested candidates to be closed. Following this stage, only one candidate remains and becomes the actual transport used for the peer-to-peer session.

{"candidate":{"id":"4fab2441-b8a5-4bd5-9831-fe7aa8cccb36"}}

2.2.5 Binary Protocol

The JET binary protocol consists of a single request/response exchange at the beginning of the connection, either over TCP or over TLS. When done over TCP, a TLS handshake can follow. When done over TLS, the TLS handshake must be completed first, with the JET exchange done over TLS.

2.2.5.1 Binary Accept

>> Request:

GET /jet/accept/<association-id>/<candidate-id> HTTP/1.1

Host: jet101.wayk.net

Connection: Keep-Alive

Jet-Version: 2

<< Response:

HTTP/1.1 200 OK

Jet-Version: 2

After the response is sent by the server, the connection SHOULD remain open until a candidate is selected for the association.

2.2.5.2 Binary Connect

>> Request:

GET /jet/connect/<association-id>/<candidate-id> HTTP/1.1

Host: jet101.wayk.net

Connection: Keep-Alive

Jet-Version: 2

<< Response:

HTTP/1.1 200 OK

Jet-Version: 2

After the response is sent by the server, the connection SHOULD remain open until a candidate is selected for the association.

2.2.5.3 Binary Test

>> Request:

GET /jet/test/<association-id>/<candidate-id> HTTP/1.1

Host: jet101.wayk.net

Connection: Close

Jet-Version: 2

<< Response:

HTTP/1.1 200 OK

Jet-Version: 2

After the response is sent by the server, the connection MUST be closed by the server.

2.2.6 WebSocket Protocol

The JET WebSocket protocol consists of an HTTP request/response followed by a WebSocket handshake where the JET parameters are all encoded in the HTTP request path. The usage of the request path is necessary since it is not possible to add custom HTTP headers to a WebSocket handshake from a browser implementation.

2.2.6.1 WebSocket Accept

>> Request:

GET /jet/accept/<association-id>/<candidate-id> HTTP/1.1

Host: jet101.wayk.net

Upgrade: websocket

Connection: Upgrade

Sec-WebSocket-Version: 13

Sec-WebSocket-Key: B0mBaSTOZiC2RAkp3ScC8MA/gaI=

<< Response:

HTTP/1.1 101 Switching Protocols

Upgrade: websocket

Connection: Upgrade

Sec-WebSocket-Accept: B0mBaSTOZiC2RAkp3ScC8MA/gaI=

2.2.6.2 WebSocket Connect

>> Request:

GET /jet/connect/<association-id>/<candidate-id> HTTP/1.1

Host: jet101.wayk.net

Upgrade: websocket

Connection: Upgrade

Sec-WebSocket-Version: 13

Sec-WebSocket-Key: B0mBaSTOZiC2RAkp3ScC8MA/gaI=

<< Response:

HTTP/1.1 101 Switching Protocols

Upgrade: websocket

Connection: Upgrade

Sec-WebSocket-Accept: B0mBaSTOZiC2RAkp3ScC8MA/gaI=

2.2.6.3 WebSocket Test

The WebSocket connection test opens a WebSocket connection that is closed immediately upon success. The goal of opening this WebSocket connection is to make sure the WebSocket connection upgrade works and is not broken in by traffic inspection proxies.

>> Request:

GET /jet/test/<association-id>/<candidate-id> HTTP/1.1

Host: jet101.wayk.net

Upgrade: websocket

Connection: Upgrade

Sec-WebSocket-Version: 13

Sec-WebSocket-Key: B0mBaSTOZiC2RAkp3ScC8MA/gaI=

<< Response (success):

HTTP/1.1 101 Switching Protocols

Upgrade: websocket

Connection: Upgrade

Sec-WebSocket-Accept: B0mBaSTOZiC2RAkp3ScC8MA/gaI=

No data should be sent over this WebSocket, and it should be closed immediately after it has been successfully opened by the server. The closing of the WebSocket by the server is expected, and should not be considered an error as long as the WebSocket could be opened with success.

<< Response (failure):

HTTP/1.1 404 Not Found

If the association id and candidate id encoded in the request path are not recognized, the server should simply return an HTTP 404 not found error. As for the client, it should consider anything other than the success case to be a candidate test failure.

2.2.7 RDP Protocol

The RDP protocol can be adapted to work with a Jet relay server by injecting a Jet JWT inside the RDP preconnection PDU. This packet is sent pre-TLS in the regular RDP protocol, and the value can be set using the "loadbalanceinfo" .rdp file setting, making it possible to inject it inside a standard RDP client like mstsc. The RDP variant of the Jet protocol simply encodes the same information contained inside a Jet connect packet inside the RDP preconnection PDU.

2.3 Protocol details

The following section explain the abstract data model of the JET protocol, along with a detailed explanation of the sequence of events for different scenarios.

2.3.1 Abstract Data Model

This section provides definitions for abstract data model elements used in the JET protocol.

2.3.1.1 Association

An association uniquely represents the link between a client and a server, regardless of the underlying transport used. An association contains multiple candidates from which only one will be selected after a series of connectivity tests. Once a candidate is selected, the association is essentially the same as the selected candidate it contains, and the underlying transport can be passed to the application for usage as if it were a regular transport. An association is identified by a UUID string.

2.3.1.2 Candidate

A candidate is one of the possible transports that is part of an association. Candidate transports include TCP, TLS and WSS for both relay and direct connection types. To maximize chances of connectivity, multiple candidates are tested in parallel, creating a list of usable candidates from which one candidate deemed optimal will be selected. Usable candidates that do not get selected are simply disconnected. A candidate is identified by a UUID string, which needs to be unique only within the same association.

2.3.1.3 Usable Candidate

A usable candidate is a candidate for which the connectivity test was completed successfully. A connectivity test is considered successful if the client connect request was successful. Usable candidates are a subset of the total candidates.

2.3.1.4 Selected Candidate

The selected candidate is candidate chosen by the client from the usable candidates, based on adaptive logic. Even if the selected candidate SHOULD be the most optimal, a client can select any of the usable candidates.

2.3.1.5 Signaling Server

The signaling server is an external communication channel where two peers can exchange messages necessary to trigger the JET peer-to-peer connection process. The way this signaling server is implemented is outside the scope of the JET protocol.

2.3.2 Processing and Sequencing Rules

2.3.2.1 Connection Initiation

The connection initiation requires that both the client and server be connected have a usable external communication channel such as a signaling server. The client sends an SDP offer and waits for an SDP answer from the server. This SDP exchange should be able to include regular STUN/TURN candidates normally exchanged in WebRTC, but it does not need to include it.

2.3.2.2 Candidate Gathering

In the current version of the protocol, the client does not gather candidates prior to sending its SDP offer. Instead, it lets the server gather direct and relay candidates that will be sent back to the client in the SDP answer.

2.3.2.2.1 Relay Candidate Gathering

Relay candidate gathering begins with an initial list of relay candidates that can be obtained from the signaling server. This call to the signaling server creates the association id, and returns the information required to make JET accept requests.

The server endpoint MUST perform the accept requests on the original relay candidates to obtain the real list of relay candidates that will be sent to the client for connectivity testing. It is also important to properly parse the "Jet-Instance" response header of the JET accept request, since it corresponds to the correct relay server behind a potential load balancer.

2.3.2.2.2 Direct Candidate Gathering

Direct candidate gathering consists of obtaining the list of IP addresses and ports that the server is listening to on local network interfaces. Host candidate gathering is optional and can be disabled through a security policy since the list of IP addresses of a specific machine can be considered information disclosure.

The server must create the Association abstract data type and create candidate ids for each direct candidate. The result is a list of direct candidates that will be included in the SDP payload.