Open Command and Control (OpenC2) Language Specification Version 1.0

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Abstract

Cyberattacks are increasingly sophisticated, less expensive to execute, dynamic and automated. The provision of cyberdefense via statically configured products operating in isolation is untenable. Standardized interfaces, protocols and data models will facilitate the integration of the functional blocks within a system and between systems. Open Command and Control (OpenC2) is a concise and extensible language to enable machine to machine communications

for purposes of command and control of cyber defense components, subsystems and/or systems in a manner that is agnostic of the underlying products, technologies, transport mechanisms or other aspects of the implementation. It should be understood that a language such as OpenC2 is necessary but insufficient to enable coordinated cyber responses that occur within cyber relevant time. Other aspects of coordinated cyber response such as sensing, analytics, and selecting appropriate courses of action are beyond the scope of OpenC2.

Status

This document was last revised or approved by the OASIS Open Command and Control (OpenC2) TC on the above date. The level of approval is also listed above. Check the "Latest version" location noted above for possible later revisions of this document. Any other numbered Versions and other technical work produced by the Technical Committee (TC) are listed at https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=openc2#technical.

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1 Introduction

OpenC2 is a suite of specifications that enables command and control of cyber defense systems and components. OpenC2 typically uses a request-response paradigm where a command is encoded by an OpenC2 producer (managing application) and transferred to an OpenC2 consumer (managed device or virtualized function) using a secure transfer protocol. The consumer can respond with status and any requested information. The contents of both the command and the response are fully defined in schemas, allowing both parties to recognize the syntax constraints imposed on the exchange.

OpenC2 allows the application producing the commands to discover the set of capabilities supported by the managed devices. These capabilities permit the managing application to adjust its behavior to take advantage of the features exposed by the managed device. The capability definitions can be easily extended in a noncentralized manner, allowing standard and non-standard capabilities to be defined with semantic and syntactic rigor.

1.1 IPR Policy

This specification is being developed under the Non-Assertion Mode of the OASIS IPR Policy, the mode chosen when the Technical Committee was established. For information on whether any patents have been disclosed that may be essential to implementing this specification, and any offers of patent licensing terms, please refer to the Intellectual Property Rights section of the TC's web page (https://www.oasis-open.org/committees/openc2/ipr.php).

1.2 Terminology

- **Action**: The task or activity to be performed.
- **Actuator**: The entity that performs the action.
- **Command**: A message defined by an action-target pair that is sent from a producer and received by a consumer.
- **Consumer**: A managed device / application that receives commands. Note that a single device / application can have both consumer and producer capabilities.
- **Producer**: A manager application that sends commands.
- **Response**: A message from a consumer to a producer acknowledging a command or returning the requested resources or status to a previously received request.
- **Target**: The object of the action, i.e., the action is performed on the target.

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 [RFC2119] and [RFC8174].

1.3 Normative References

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1.4 Non-Normative References

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1.5 Document Conventions

1.5.1 Naming Conventions

- RFC2119/RFC8174 key words (see section 1.4) are in all uppercase.
- All property names and literals are in lowercase, except when referencing canonical names defined in another standard (e.g., literal values from an IANA registry).
- All words in structure component names are capitalized and are separated with a hyphen, e.g., ACTION, TARGET, TARGET-SPECIFIER.
- Words in property names are separated with an underscore (_), while words in string enumerations and type names are separated with a hyphen (-).
- The term "hyphen" used here refers to the ASCII hyphen or minus character, which in Unicode is "hyphen-minus", U+002D.
- All type names, property names, object names, and vocabulary terms are between three and 40 characters long.

1.5.2 Font Colors and Style

The following color, font and font style conventions are used in this document:

- A fixed width font is used for all type names, property names, and literals.
- Property names are in bold style – **`created_at`**
- All examples in this document are expressed in JSON. They are in fixed width font, with straight quotes, black text and a light shaded background, and 4-space indentation. JSON examples in this document are representations of JSON Objects. They should not be interpreted as string literals. The ordering of object keys is insignificant. Whitespace before or after JSON structural characters in the examples are insignificant [RFC8259].
- Parts of the example may be omitted for conciseness and clarity. These omitted parts are denoted with the ellipses (...).

Example:

~~~
```javascript
{
    "action": "contain",
    "target": {
        "user_account": {
            "user_id": "fjbloggs",
            "account_type": "windows-local"
        }
    }
}
```
~~~

1.6 Overview

OpenC2 is a suite of specifications to command actuators that execute cyber defense functions in an unambiguous, standardized way. These specifications include the OpenC2 Language Specification, Actuator Profiles, and Transfer Specifications. The OpenC2 Language Specification and Actuator Profile specifications focus on the standard at the producer and consumer of the command and response while the transfer specifications focus on the protocols for their exchange.

- The OpenC2 Language Specification provides the semantics for the essential elements of the language, the structure for commands and responses, and the schema that defines the proper syntax for the language elements that represents the command or response.

- OpenC2 Actuator Profiles specify the subset of the OpenC2 language relevant in the context of specific actuator functions. Cyber defense components, devices, systems and/or instances may (in fact are likely) to implement multiple actuator profiles. Actuator profiles extend the language by defining specifiers that identify the actuator to the required level of precision and may define command arguments that are relevant and/or unique to those actuator functions.

- OpenC2 Transfer Specifications utilize existing protocols and standards to implement OpenC2 in specific environments. These standards are used for communications and security functions beyond the scope of the language, such as message transfer encoding, authentication, and end-to-end transfer of OpenC2 messages.

The OpenC2 Language Specification defines a language used to compose messages for command and control of cyber defense systems and components. A message consists of a header and a payload (*defined* as a message body in the OpenC2 Language Specification Version 1.0 and *specified* in one or more actuator profiles).

In general, there are two types of participants involved in the exchange of OpenC2 messages, as depicted in Figure 1-1:

1. **OpenC2 Producers**: An OpenC2 Producer is an entity that creates commands to provide instruction to one or more systems to act in accordance with the content of the command. An OpenC2 Producer may receive and process responses in conjunction with a command.
2. **OpenC2 Consumers**: An OpenC2 Consumer is an entity that receives and may act upon an OpenC2 command. An OpenC2 Consumer may create responses that provide any information captured or necessary to send back to the OpenC2 Producer.

The language defines two payload structures:

1. **Command**: An instruction from one system known as the OpenC2 "Producer", to one or more systems, the OpenC2 "Consumer(s)", to act on the content of the command.

2. **Response**: Any information captured or necessary to send back to the OpenC2 Producer that issued the Command, i.e., the OpenC2 Consumer's response to the OpenC2 Producer.

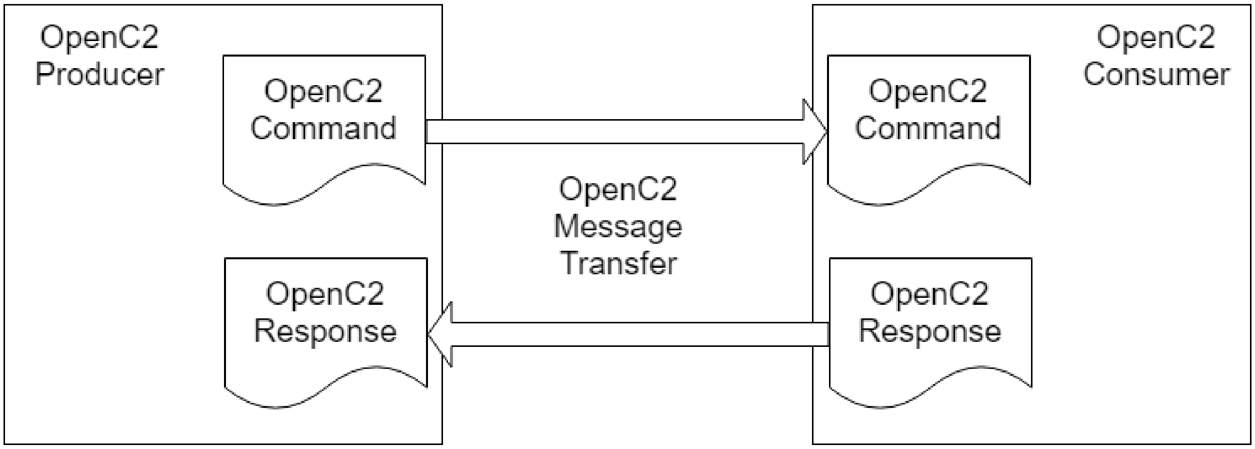
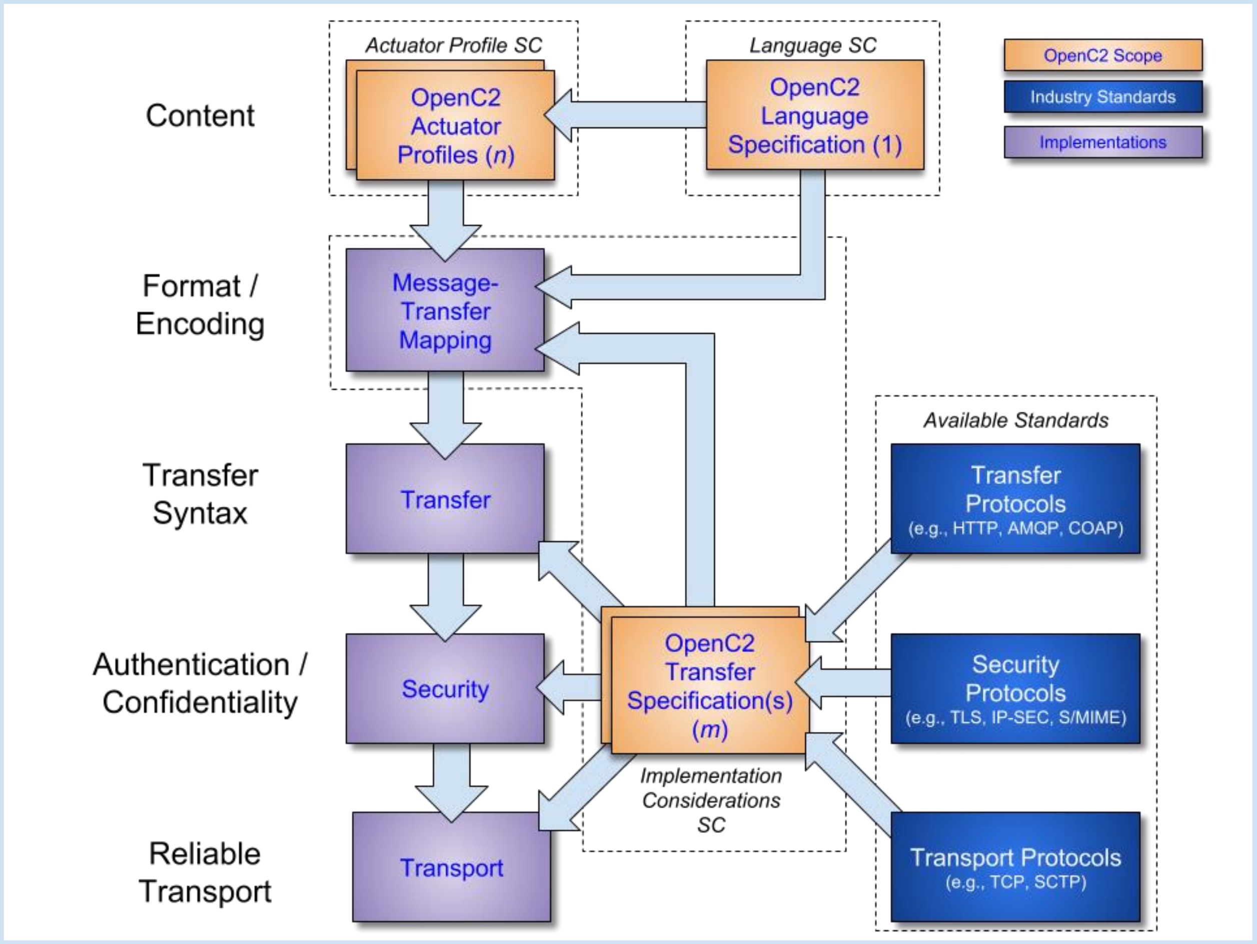


Figure 1-1. OpenC2 Message Exchange

OpenC2 implementations integrate the related OpenC2 specifications described above with related industry specifications, protocols, and standards. Figure 1 depicts the relationships among OpenC2 specifications, and their relationships to other industry standards and environment-specific implementations of OpenC2. Note that the layering of implementation aspects in the diagram is notional, and not intended to preclude the use of any particular protocol or standard.


Content
Format / Encoding
Transfer Syntax
Authentication / Confidentiality
Reliable Transport
Actuator Profile SC
OpenC2 Actuator Profiles (n)
Language SC
OpenC2 Language Specification (1)
OpenC2 Scope
Industry Standards
Implementations
Message-Transfer Mapping
Transfer
Security
Transport
OpenC2 Transfer Specification(s) (m)
Implementation Considerations SC
Available Standards
Transfer Protocols (e.g., HTTP, AMQP, COAP)
Security Protocols (e.g., TLS, IP-SEC, S/MIME)
Transport Protocols (e.g., TCP, SCTP)

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349 **Figure 1-2. OpenC2 Documentation and Layering Model**

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351 OpenC2 is conceptually partitioned into four layers as shown in Table 1-1.

352 **Table 1-1. OpenC2 Protocol Layers**

Layer	Examples
Function-Specific Content	Actuator Profiles (standard and extensions)
Common Content	Language Specification (this document)
Message	Transfer Specifications (OpenC2-over-HTTPS, OpenC2-over-CoAP, …)

Secure Transfer	HTTPS, CoAP, MQTT, OpenDXL, ...

- The **Secure Transfer** layer provides a communication path between the producer and the consumer. OpenC2 can be layered over any standard transfer protocol.

- The **Message** layer provides a transfer- and content-independent mechanism for conveying requests, responses, and notifications. A transfer specification maps transfer-specific protocol elements to a transfer-independent set of message elements consisting of content and associated metadata.

- The **Common Content** layer defines the structure of OpenC2 commands and responses and a set of common language elements used to construct them.

- The **Function-specific Content** layer defines the language elements used to support a particular cyber defense function. An actuator profile defines the implementation conformance requirements for that function. OpenC2 Producers and Consumers will support one or more profiles.

1.7 Goal

The goal of the OpenC2 Language Specification is to provide a language for interoperating between functional elements of cyber defense systems. This language used in conjunction with OpenC2 Actuator Profiles and OpenC2 Transfer Specifications allows for vendor-agnostic cybertime response to attacks.

The Integrated Adaptive Cyber Defense (IACD) framework defines a collection of activities, based on the traditional OODA (Observe–Orient–Decide–Act) Loop [IACD]:

- Sensing: gathering of data regarding system activities
- Sense Making: evaluating data using analytics to understand what's happening
- Decision Making: determining a course-of-action to respond to system events
- Acting: Executing the course-of-action

The goal of OpenC2 is to enable coordinated defense in cyber-relevant time between decoupled blocks that perform cyber defense functions. OpenC2 focuses on the Acting portion of the IACD framework; the assumption that underlies the design of OpenC2 is that the sensing/ analytics have been provisioned and the decision to act has been made. This goal and these assumptions guides the design of OpenC2:

- **Technology Agnostic:** The OpenC2 language defines a set of abstract atomic cyber defense actions in a platform and product agnostic manner
- **Concise:** An OpenC2 command is intended to convey only the essential information required to describe the action required and can be represented in a very compact form for communications-constrained environments

- **Abstract:** OpenC2 commands and responses are defined abstractly and can be encoded and transferred via multiple schemes as dictated by the needs of different implementation environments
- **Extensible:** While OpenC2 defines a core set of actions and targets for cyber defense, the language is expected to evolve with cyber defense technologies, and permits extensions to accommodate new cyber defense technologies.

1.8 Purpose and Scope

The OpenC2 Language Specification defines the set of components to assemble a complete command and control message and provides a framework so that the language can be extended. To achieve this purpose, the scope of this specification includes:

1. the set of actions and options that may be used in OpenC2 commands
2. the set of targets and target specifiers
3. a syntax that defines the structure of commands and responses
4. a JSON serialization of OpenC2 commands and responses
5. the procedures for extending the language

The OpenC2 language assumes that the event has been detected, a decision to act has been made, the act is warranted, and the initiator and recipient of the commands are authenticated and authorized. The OpenC2 language was designed to be agnostic of the other aspects of cyber defense implementations that realize these assumptions. The following items are beyond the scope of this specification:

1. Language extensions applicable to some actuators, which may be defined in individual actuator profiles.
2. Alternate serializations of OpenC2 commands and responses.
3. The enumeration of the protocols required for transport, information assurance, sensing, analytics and other external dependencies.

2 OpenC2 Language Description

The OpenC2 language has two distinct content types: command and response. The command is sent from a producer to a consumer and describes an action to be performed by an actuator on a target. The response is sent from a consumer, usually back to the producer, and is a means to provide information (such as acknowledgement, status, etc.) as a result of a command.

2.1 OpenC2 Command

The command describes an action to be performed on a target and may include information identifying the actuator or actuators that are to execute the command.

A command has four main components: ACTION, TARGET, ARGUMENTS, and ACTUATOR. The following list summarizes the components of a command.

- **ACTION** (required): The task or activity to be performed.
- **TARGET** (required): The object of the action. The ACTION is performed on the target.
  - **TARGET-NAME** (required): The name of the object of the action.
  - **TARGET-SPECIFIERS** (optional): The specifier further identifies the target to some level of precision, such as a specific target, a list of targets, or a class of targets.
- **ARGUMENTS** (optional): Provide additional information on how the command is to be performed, such as date/time, periodicity, duration etc.
- **ACTUATOR** (optional): The ACTUATOR executes the command (the ACTION and TARGET). The ACTUATOR type will be defined within the context of an Actuator Profile.
  - **ACTUATOR-NAME** (required): The name of the set of functions (e.g., "slpf") performed by the actuator, and the name of the profile defining commands applicable to those functions.
  - **ACTUATOR-SPECIFIERS** (optional): The specifier identifies the actuator to some level of precision, such as a specific actuator, a list of actuators, or a group of actuators.

The ACTION and TARGET components are required and are populated by one of the actions in Section 3.3.1.1 and the targets in Section 3.3.1.2. A particular target may be further refined by one or more TARGET-SPECIFIERS. Procedures to extend the targets are described in Section 3.3.4.

TARGET-SPECIFIERS provide additional precision to identify the target (e.g., 10.1.2.3) and may include a method of identifying multiple targets of the same type (e.g., 10.1.0.0/16).

The ARGUMENTS component, if present, is populated by one or more 'command arguments' that determine how the command is executed. ARGUMENTS influence the command by providing information such as time, periodicity, duration, or other details on what is to be executed. They can also be used to convey the need for acknowledgement or additional status information about the execution of a command. The valid ARGUMENTS defined in this specification are in Section 3.3.1.4.

An ACTUATOR is an implementation of a cyber defense function that executes the command. An Actuator Profile is a specification that identifies the subset of ACTIONS, TARGETS and other aspects of this language specification that are mandatory to implement or optional in the context of a particular ACTUATOR. An Actuator Profile may extend the language by defining additional ARGUMENTS, ACTUATOR-SPECIFIERS, and/or TARGETS that are meaningful and possibly unique to the actuator.

The ACTUATOR optionally identifies the entity or entities that are tasked to execute the command. Specifiers for actuators refine the command so that a particular function, system, class of devices, or specific device can be identified.

The ACTUATOR component may be omitted from a command and typically will not be included in implementations where the identities of the endpoints are unambiguous or when a high-level effects-based command is desired and the tactical decisions on how the effect is achieved is left to the recipient.

2.2 OpenC2 Response

The OpenC2 Response is a message sent from the recipient of a command. Response messages provide acknowledgement, status, results from a query, or other information.

The following list summarizes the fields and subfields of an OpenC2 Response.

- **STATUS** (required): An integer containing a numerical status code
- **STATUS_TEXT** (optional): A free-form string containing human-readable description of the response status. The string can contain more detail than is represented by the status code, but does not affect the meaning of the response.
- **RESULTS** (optional): Contains the data or extended status code that was requested from an OpenC2 Command.

3 OpenC2 Language Definition

3.1 Base Components and Structures

3.1.1 Data Types

The syntax of valid OpenC2 messages is defined using an information model constructed from the data types presented here:

Type	Description
Primitive Types	
Binary	A sequence of octets. Length is the number of octets.
Boolean	A logical entity that can have two values: `true` and `false`.
Integer	A whole number.
Number	A real number.
Null	Nothing, used to designate fields with no value.
String	A sequence of characters. Each character must have a valid Unicode codepoint. Length is the number of characters.
Structures	
Array	An ordered list of unnamed fields. Each field has an ordinal position and type.
ArrayOf	An ordered list of unnamed fields of the same type. Each field has an ordinal position and the specified type.
Choice	One field selected from a set of named fields. The value has a name and type.
Enumerated	A set of id:name pairs where id is an integer. The Enumerated.ID subtype is a set of ids only.
Map	An unordered set of named fields. Each field has an id, name and type.
Record	An ordered list of named fields, e.g. a message, record, structure, or row in a table. Each field has an ordinal position, name, and type.

3.1.2 Derived Data Types

The following types are defined as value constraints applied to String (text string), Binary (octet string) or Integer values. The serialized representation of the base types is specified in Section

3.1.5, but there are no restrictions on how derived types are represented internally by an implementation.

Type	Base	Description
Domain-Name	String	RFC 1034 Section 3.5
Date-Time	Integer	Milliseconds since 00:00:00 UTC, 1 January 1970.
Duration	Integer	Milliseconds.
Email-Addr	String	RFC 5322 Section 3.4.1
Identifier	String	(TBD rules, e.g., initial alpha followed by alphanumeric or underscore)
IP-Addr	Binary	32 bit IPv4 address or 128 bit IPv6 address
MAC-Addr	Binary	Media Access Control / Extended Unique Identifier address - EUI-48 or EUI-64.
Port	Integer	16 bit RFC 6335 Transport Protocol Port Number
Request-Id	Binary	A value of up to 128 bits
URI	String	RFC 3986
UUID	Binary	128 bit Universal Unique Identifier, RFC 4122 Section 4

3.1.3 Cardinality

Property tables for types based on Array, Choice, Map and Record include a cardinality column (#) that specifies the minimum and maximum number of values of a field. The most commonly used cardinalities are:

- 1 Required and not repeatable
- 0..1 Optional and not repeatable
- 1..n Required and repeatable
- 0..n Optional and repeatable

The cardinality column may also specify a range of sizes, e.g.,:

- 3..5 Required and repeatable with a minimum of 3 and maximum of 5 values

3.1.4 Derived Enumerations

An Enumerated field may be derived ("auto-generated") from the fields of a Choice, Map or Record type by appending ".*" to the type name.

Type: Example-sel (Record)

ID	Name	Type	#	Description
1	targets	Target.*	1..n	Enumeration auto-generated from a Choice

3.1.5 Serialization

OpenC2 is agnostic of any particular serialization; however, implementations MUST support JSON serialization in accordance with RFC 7493 and additional requirements specified in the following table.

JSON Serialization Requirements:

OpenC2 Data Type	JSON Serialization Requirement
Binary	JSON **string** containing Base64url encoding of the binary value as defined in Section 5 of RFC 4648.
Boolean	JSON **true** or **false**
Integer	JSON **number**
Number	JSON **number**
Null	JSON **null**
String	JSON **string**
Array	JSON **array**
ArrayOf	JSON **array**
Choice	JSON **object** with one member. Member key is the field name.
Choice.ID	JSON object with one member. Member key is the integer field id converted to string.
Enumerated	JSON **string**
Enumerated.ID	JSON **integer**
Map	JSON **object**. Member keys are field names.
Map.ID	JSON object. Member keys are integer field ids converted to strings.
Record	JSON **object**. Member keys are field names.

3.1.5.1 ID and Name Serialization

Instances of Enumerated types and keys for Choice and Map types are serialized as ID values except when using serialization formats intended for human consumption, where Name strings are used instead. Defining a type using ".ID" appended to the base type (e.g., Enumerated.ID, Map.ID) indicates that:

1. Type definitions and application values use only the ID. There is no corresponding name except as an optional part of the description.

2. Instances of Enumerated values and Choice/Map keys are serialized as IDs regardless of serialization format.

3.1.5.2 Integer Serialization

For machine-to-machine serialization formats, integers are represented as binary data, e.g., 32 bits, 128 bits.   But for human-readable serialization formats (XML and JSON), integers are converted to strings. For example, the JSON "number" type represents integers and real numbers as decimal strings without quotes, e.g., { "height": 68.2 }, and as noted in RFC 7493 Section 2.2, a sender cannot expect a receiver to treat an integer with an absolute value greater than 2^^53 as an exact value.

The default representation of Integer types in text serializations is the native integer type for that format, e.g., "number" for JSON.   Integer fields with a range larger than the IEEE 754 exact range (e.g., 64, 128, 2048 bit values) are indicated by appending ".<bit-size>" or ".*" to the type, e.g. Integer.64 or Integer.*. All serializations ensure that large Integer types are transferred exactly, for example in the same manner as Binary types. Integer values support arithmetic operations; Binary values are not intended for that purpose.

3.2 Message

As described in Section 1.1, this language specification and one or more actuator profiles define the content of OpenC2 commands and responses, while transfer specifications define the on-the-wire format of a message over specific secure transport protocols. Transfer specifications are agnostic with regard to content, and content is agnostic with regard to transfer protocol. This decoupling is accomplished by defining a standard message interface used to transfer any type of content over any transfer protocol.

A message is a content- and transport-independent set of elements conveyed between consumers and producers. To ensure interoperability all transfer specifications must unambiguously define how the message elements in Table 3-1 are represented within the secure transport protocol. This does not imply that all message elements must be used in all messages. Content, content_type, and msg_type are required, while other message elements are not required by this specification but may be required by other documents.

Table 3-1. Common Message Elements

Name	Description
content	Message body as specified by content_type and msg_type.
content_type	String. Media Type that identifies the format of the content, including major version. Incompatible content formats must have different content_types. Content_type **application/openc2** identifies content defined by OpenC2

	language specification versions 1.x, i.e., all versions that are compatible with version 1.0.
msg_type	Message-Type. One of **request**, **response**, or **notification**. For the **application/openc2** content_type the request content is an OpenC2-Command and the response content is an OpenC2-Response. OpenC2 does not currently define any notification content.
status	Status-Code. Populated with a numeric status code in response messages. Not present in request or notification messages.
request_id	Request-Id. A unique identifier value of up to 128 bits that is attached to request and response messages. This value is assigned by the sender and is copied unmodified into all responses to support reference to a particular command, transaction or event chain.
created	Date-Time. Creation date/time of the content, the number of milliseconds since 00:00:00 UTC, 1 January 1970.
from	String. Authenticated identifier of the creator of or authority for execution of a message.
to	ArrayOf(String). Authenticated identifier(s) of the authorized recipient(s) of a message.

Implementations may use environment variables, private APIs, data structures, class instances, pointers, or other mechanisms to represent messages within the local environment. However the internal representation of a message does not affect interoperability and is therefore beyond the scope of OpenC2. This means that the message content is a data structure in whatever form is used within an implementation, not a serialized representation of that structure. Content is the input provided to a serializer or the output of a de-serializer. Msg_type is a three-element enumeration whose protocol representation is defined in each transfer spec, for example as a string, an integer, or a two-bit field. The internal form of enumerations, like content, does not affect interoperability and is therefore unspecified.

3.3 Content

The scope of this specification is to define the ACTION and TARGET portions of an OpenC2 command and the common portions of an OpenC2 response. The properties of the OpenC2 command are defined in Section 3.3.1 and the properties of the response are defined in Section 3.3.2.

In addition to the ACTION and TARGET, an OpenC2 command has an optional ACTUATOR. Other than identification of namespace identifier, the semantics associated with the ACTUATOR specifiers are beyond the scope of this specification. The actuators and actuator-specific results contained in a response are specified in ‘Actuator Profile Specifications’ such as StateLess Packet Filtering Profile, Routing Profile etc.

3.3.1 OpenC2 Command

The OpenC2 Command describes an action performed on a target.

Type: OpenC2-Command (Record)

ID	Name	Type	#	Description
1	**action**	Action	1	The task or activity to be performed (i.e., the 'verb').
2	**target**	Target	1	The object of the action. The action is performed on the target.
3	**args**	Args	0..1	Additional information that applies to the command.
4	**actuator**	Actuator	0..1	The subject of the action. The actuator executes the action on the target.

3.3.1.1 Action

Type: Action (Enumerated)

ID	Name	Description
1	**scan**	Systematic examination of some aspect of the entity or its environment.
2	**locate**	Find an object physically, logically, functionally, or by organization.
3	**query**	Initiate a request for information.
6	**deny**	Prevent a certain event or action from completion, such as preventing a flow from reaching a destination or preventing access.
7	**contain**	Isolate a file, process, or entity so that it cannot modify or access assets or processes.
8	**allow**	Permit access to or execution of a target.
9	**start**	Initiate a process, application, system, or activity.
10	**stop**	Halt a system or end an activity.
11	**restart**	Stop then start a system or an activity.
14	**cancel**	Invalidate a previously issued action.
15	**set**	Change a value, configuration, or state of a managed entity.

16	**update**	Instruct a component to retrieve, install, process, and operate in accordance with a software update, reconfiguration, or other update.
18	**redirect**	Change the flow of traffic to a destination other than its original destination.
19	**create**	Add a new entity of a known type (e.g., data, files, directories).
20	**delete**	Remove an entity (e.g., data, files, flows).
22	**detonate**	Execute and observe the behavior of a target (e.g., file, hyperlink) in an isolated environment.
23	**restore**	Return a system to a previously known state.
28	**copy**	Duplicate an object, file, data flow or artifact.
30	**investigate**	Task the recipient to aggregate and report information as it pertains to a security event or incident.
32	**remediate**	Task the recipient to eliminate a vulnerability or attack point.

The following actions are under consideration for use in future versions of the Language Specification. Implementers may use these actions with the understanding that they may not be in future versions of the language.

- **report** - Task an entity to provide information to a designated recipient
- **pause** - Cease operation of a system or activity while maintaining state.
- **resume** - Start a system or activity from a paused state
- **move** - Change the location of a file, subnet, network, or process
- **snapshot** - Record and store the state of a target at an instant in time
- **save** - Commit data or system state to memory
- **throttle** - Adjust the rate of a process, function, or activity
- **delay** - Stop or hold up an activity or data transmittal
- **substitute** - Replace all or part of the payload
- **sync** - Synchronize a sensor or actuator with other system components
- **mitigate** - Task the recipient to circumvent a problem without necessarily eliminating the vulnerability or attack point

Usage Requirements:

- Each command MUST contain exactly one action.
- All commands MUST only use actions from this section (either the table or the list)
- Actions defined external to this section SHALL NOT be used.

3.3.1.2 Target

Type: Target (Choice)

ID	Name	Type	#	Description

1	**artifact**	Artifact	1	An array of bytes representing a file-like object or a link to that object.
2	**command**	Request-Id	1	A reference to a previously issued OpenC2 Command.
3	**device**	Device	1	The properties of a hardware device.
7	**domain_name**	Domain-Name	1	A network domain name.
8	**email_addr**	Email-Addr	1	A single email address.
16	**features**	Features	1	A set of items used with the query action to determine an actuator's capabilities.
10	**file**	File	1	Properties of a file.
11	**ip_addr**	IP-Addr	1	An IP address (either version 4 or version 6).
15	**ip_connection**	IP-Connection	1	A network connection that originates from a source and is addressed to a destination. Source and destination addresses may be either IPv4 or IPv6; both should be the same version
13	**mac_addr**	MAC-Addr	1	A Media Access Control (MAC) address - EUI-48 or EUI-64
17	**process**	Process	1	Common properties of an instance of a computer program as executed on an operating system.
25	**properties**	Properties	1	Data attribute associated with an actuator
19	**uri**	URI	1	A uniform resource identifier(URI).
1000	**extension**	PE-Target	1	Targets defined in a Private Enterprise extension profile.
1001	**extension_unr**	Unr-Target	1	Targets defined in an Unregistered extension profile
1024	**slpf**	slpf:Target	1	**Example Target Extension**: Targets defined in the Stateless Packet Filter profile

The following targets are under consideration for use in future versions of the Language Specification. Implementers may use these targets with the understanding that they may not be in future versions of the language.

- directory

- disk
- disk_partition
- email_message
- memory
- software
- user_account
- user_session
- volume
- windows_registry_key
- x509_certificate

Usage Requirements:

- The TARGET field in an OpenC2 Command MUST contain exactly one type of target (e.g. ip_addr).

3.3.1.3 Actuator

Type: Actuator (Choice)

ID	Name	Type	#	Description
1000	**extension**	PE-Specifiers	0..1	Specifiers defined in a Private Enterprise extension profile.
1001	**extension_unr**	Unr-Specifiers	0..1	Specifiers defined in an Unregistered extension profile

3.3.1.4 Command Arguments

Type: Args (Map)

ID	Name	Type	#	Description
1	**start_time**	Date-Time	0..1	The specific date/time to initiate the action
2	**stop_time**	Date-Time	0..1	The specific date/time to terminate the action
3	**duration**	Duration	0..1	The length of time for an action to be in effect
4	**response_requested**	Response-Type	0..1	The type of response required for the action: `none`, `ack`, `status`, `complete`.
1000	**extension**	PE-Args	0..1	Command arguments defined in a Private Enterprise extension profile
1001	**extension_unr**	Unr-Args	0..1	Command arguments defined in an

				Unregistered extension profile

Usage Requirements:

- When response_requested is not explicitly contained in an OpenC2 Command, a Consumer MUST respond in the same manner as {"response_requested": "complete"}.

3.3.2 OpenC2 Response

Type: OpenC2-Response (Record)

ID	Name	Type	#	Description
1	**status**	Status-Code	1	An integer status code
2	**status_text**	String	0..1	A free-form human-readable description of the response status
3	**strings**	String	0..n	Generic set of string values
4	**ints**	Integer	0..n	Generic set of integer values
5	**kvps**	KVP	0..n	Generic set of key:value pairs
6	**versions**	Version	0..n	List of OpenC2 language versions supported by this actuator
7	**profiles**	jadn:Uname	0..n	List of profiles supported by this actuator
8	**schema**	jadn:Schema	0..1	Syntax of the OpenC2 language elements supported by this actuator
9	**pairs**	Action-Targets	0..n	List of targets applicable to each supported action
10	**rate_limit**	Number	0..1	Maximum number of requests per minute supported by design or policy
1000	**extension**	PE-Results	0..1	Response data defined in a Private Enterprise extension profile
1001	**extension_unr**	Unr-Results	0..1	Response data defined in an unregistered extension profile

Example:

~~~~
```javascript
{
    "status": 200,
    "status_text": "All endpoints successfully updated",
    "strings": ["wd-394", "sx-2497"]
}
~~~~

` ` `

Usage Requirements:

- All Responses MUST contain a status.
- Responses MAY contain status_text and/or results.

3.3.2.1 OpenC2 Response Status Code

Type: Status-Code (Enumerated.ID)

ID	Description
102	**Processing** - an interim response used to inform the producer that the consumer has accepted the request but has not yet completed it.
200	**OK** - the request has succeeded.
301	**Moved Permanently** - the target resource has been assigned a new permanent URI.
400	**Bad Request** - the consumer cannot process the request due to something that is perceived to be a producer error (e.g., malformed request syntax).
401	**Unauthorized** - the request lacks valid authentication credentials for the target resource or authorization has been refused for the submitted credentials.
403	**Forbidden** - the consumer understood the request but refuses to authorize it.
404	**Not Found** - the consumer has not found anything matching the request.
500	**Internal Error** - the consumer encountered an unexpected condition that prevented it from fulfilling the request.
501	**Not Implemented** - the consumer does not support the functionality required to fulfill the request.
503	**Service Unavailable** - the consumer is currently unable to handle the request due to a temporary overloading or maintenance of the consumer.

3.3.3 Imported Data

In addition to the targets, actuators, arguments, and other language elements defined in this specification, OpenC2 messages may contain data objects imported from other specifications and/or custom data objects defined by the implementers. The details are specified in a data profile which contains:

1. a prefix indicating the origin of the imported data object is outside OpenC2:
    - `x_` (profile)
2. a unique name for the specification being imported, e.g.:
    - For shortname `x_kmipv2.0` the full name would be `oasis-open.org/openc2/profiles/kmip-v2.0,`

    - For shortname `x_sfslpf` the full name would be `sfractal.com/slpf/v1.1/x_slpf-profile-v1.1`
3. a namespace identifier (nsid) - a short reference, e.g., `kmipv2.0`, to the unique name of the specification
4. a list of object identifiers imported from that specification, e.g., `Credential`
5. a definition of each imported object, either referenced or contained in the profile
6. conformance requirements for implementations supporting the profile

The data profile itself can be the specification being imported or the data profile can reference an existing specification. In the example above, the data profile created by the OpenC2 TC to represent KMIP could have a unique name of `oasis-open.org/openc2/profiles/kmip-v2.0`. The data profile would note that it is derived from the original specification `oasis-open.org/kmip/spec/v2.0/kmip-spec-v2.0`. In the example for shortname `x_sfslpf`, the profile itself could be defined in a manner directly compatible with OpenC2 and would not reference any other specification.

An imported object is identified by namespace identifier and object identifier. While the data profile may offer a suggested nsid, the containing schema defines the nsids that it uses to refer to objects imported from other specifications:

```
import oasis-open.org/openc2/profiles/kmip-v2.0 as x_kmip_2.0
```

An element using an imported object identifies it using the nsid:

```
{
    "target": {
        "x_kmip_2.0": {
            {"kmip_type": "json"},
            {"operation": "RekeyKeyPair"},
            {"name": "publicWebKey11DEC2017"}
        }
    }
}
```

A data profile can define its own schema for imported objects, or it can reference content as defined in the specification being imported. Defining an abstract syntax allows imported objects to be represented in the same format as the containing object. Referencing content directly from an imported specification results in it being treated as an opaque blob if the imported and containing formats are not the same (e.g., an XML or TLV object imported into a JSON OpenC2 command, or a STIX JSON object imported into a CBOR OpenC2 command).

The OpenC2 Language MAY be extended using imported data objects for TARGET, TARGET_SPECIFIER, ACTUATOR, ACTUATOR_SPECIFIER, ARGUMENTS, and RESULTS. The list of ACTIONS in Section 3.2.1.2 SHALL NOT be extended.

3.3.4 Extensions

Organizations may extend the functionality of OpenC2 by defining organization-specific profiles. OpenC2 defines two methods for defining organization-specific profiles: using a registered namespace or an unregistered namespace. Organizations wishing to create non-standardized OpenC2 profiles SHOULD use a registered Private Enterprise Number namespace. Private Enterprise Numbers are managed by the Internet Assigned Numbers Authority (IANA) as described in RFC 5612, for example:

```
32473
  Example Enterprise Number for Documentation Use
    See [RFC5612]
      iana&iana.org
```

OpenC2 contains four predefined extension points to support registered private enterprise profiles: PE-Target, PE-Specifiers, PE-Args, and PE-Results. An organization can develop a profile that defines custom types, create an entry for their organization's namespace under each extension point used in the profile, and then use their custom types within OpenC2 commands and responses.

By convention ID values of 1000 and above within OpenC2-defined data types are namespace identifiers, although there is no restriction against assigning non-namespaced IDs in that range.

This is an example target from a registered profile containing a "lens" extension defined by the organization with IANA Private Enterprise Number 32473. This hypothetical target might be used with the "set" action to support an IoT camera pan-tilt-zoom use case. This example is for illustrative purposes only and MUST NOT use this in actual implementations.

~~~
```
{
    "target": {
        "extension": {
            "32473": {
                "lens": {"focal_length": 240, "aperture": "f/1.6"}
            }
        }
    }
}
```
~~~

This is an example of the same target from a profile defined by an organization that has not registered a Private Enterprise Number with IANA. This example is for illustrative purposes only and MUST NOT use this in actual implementations.

~~~
```
~~~

~~~
{
    "target": {
        "unregistered": {
            "x-foo.com": {
                "lens": {"focal_length": 240, "aperture": "f/1.6"}
            }
        }
    }
}
```
~~~

Using DNS names provides collision resistance for names used in x- namespaces, but the corresponding IDs are not coordinated through a registration process and are subject to collisions.

OpenC2 implementations MAY support registered and unregistered extension profiles regardless of whether those profiles are listed by OASIS. Implementations MUST NOT use the "Example" registered extension entries shown below, and MAY use one or more actual registered extensions by replacing the example entries.

3.3.4.1 Private Enterprise Target

Because target is a required element, implementations receiving an OpenC2 Command with an unsupported target type MUST reject the command as invalid.

Type: PE-Target (Choice.ID)

ID	Type	#	Description
32473	32473:Target	1	"Example": Targets defined in the Example Inc. extension profile

3.3.4.2 Private Enterprise Specifiers

The behavior of an implementation receiving an OpenC2 Command with an unsupported actuator type is undefined. It MAY ignore the actuator field or MAY reject the command as invalid.

Type: PE-Specifiers (Choice.ID)

ID	Type	#	Description
32473	32473:Specifiers	1	"Example": Actuator Specifiers defined in the Example Inc. extension profile

3.3.4.3 Private Enterprise Command Arguments

The behavior of an implementation receiving an OpenC2 Command with an unsupported arg type is undefined. It MAY ignore the unrecognized arg or MAY reject the command as invalid.

Type: PE-Args (Map.ID)

ID	Type	#	Description
32473	32473:Args	1	"Example": Command Arguments defined in the Example Inc. extension profile

3.3.4.4 Private Enterprise Results

The behavior of an implementation receiving an OpenC2 Response with an unsupported results type is undefined. An unrecognized response has no effect on the OpenC2 protocol but implementations SHOULD log it as an error.

Type: PE-Results (Map.ID)

ID	Type	#	Description
32473	32473:Results	1	"Example": Results defined in the Example Inc. extension profile

3.4 Type Definitions

3.4.1 Target Types

3.4.1.1 Artifact

Type: Artifact (Record)

ID	Name	Type	#	Description
1	**mime_type**	String	0..1	Permitted values specified in the IANA Media Types registry, RFC 6838
2	**payload**	Payload	0..1	Choice of literal content or URL
3	**hashes**	Hashes	0..1	Hashes of the payload content

3.4.1.3 Device

Type: Device (Map)

ID	Name	Type	#	Description
1	**hostname**	Hostname	1	A hostname that can be used to connect to this device over a network
2	**description**	String	0..1	A human-readable description of the purpose, relevance, and/or properties of this device
3	**device_id**	String	0..1	An identifier that refers to this device within an inventory or management system

3.4.1.4 Domain Name

Type Name	Base Type	Description
Domain-Name	String (hostname)	RFC 1034, section 3.5

3.4.1.5 Email Address

Type Name	Base Type	Description
Email-Addr	String (email)	Email address, RFC 5322, section 3.4.1

3.4.1.6 Features

Type Name	Base Type	Description
Features	ArrayOf(Feature)	An array of zero to ten names used to query an actuator for its supported capabilities.

3.4.1.7 File

Type: File (Map)

ID	Name	Type	#	Description
1	**name**	String	0..1	The name of the file as defined in the file system
2	**path**	String	0..1	The absolute path to the location of the file in the file system
3	**hashes**	Hashes	0..1	One or more cryptographic hash codes of the file contents

3.4.1.8 IP Address

Type Name	Base Type	Description
IP-Addr	Binary	32 bit IPv4 address or 128 bit IPv6 address

3.4.1.9 IP Connection

Type: IP-Connection (Record)

ID	Name	Type	#	Description
1	**src_addr**	IP-Addr	0..1	ip_addr of source, could be ipv4 or ipv6 - see ip_addr section
2	**src_port**	Port	0..1	source service per RFC 6335
3	**dst_addr**	IP-Addr	0..1	ip_addr of destination, could be ipv4 or ipv6 - see ip_addr section
4	**dst_port**	Port	0..1	destination service per RFC 6335
5	**protocol**	L4-Protocol	0..1	layer 4 protocol (e.g., TCP) - see l4_protocol section

Usage Requirements:

- src_addr and dst_addr MUST be the same version (ipv4 or ipv6) if both are present.

3.4.1.10 MACAddress

Type Name	Base Type	Description
MAC-Addr	Binary	Media Access Control / Extended Unique Identifier address - EUI-48 or EUI-64.

3.4.1.11 Process

Type: Process (Map)

ID	Name	Type	#	Description
1	**pid**	Integer	0..1	Process ID of the process

2	**name**	String	0..1	Name of the process
3	**cwd**	String	0..1	Current working directory of the process
4	**executable**	File	0..1	Executable that was executed to start the process
5	**parent**	Process	0..1	Process that spawned this one
6	**command_line**	String	0..1	The full command line invocation used to start this process, including all arguments

3.4.1.12 Properties

Type Name	Base Type	Description
Properties	ArrayOf(String)	A list of names that uniquely identify prope

3.4.1.13 URI

Type Name	Base Type	Description
URI	String	Uniform Resource Identifier

3.4.2 Data Types

3.4.2.1 Request Identifier

Type Name	Base Type	Description
Request-Id	Binary	A value of up to 128 bits that uniquely identifies a particular command

3.4.2.2 Date Time

Type Name	Base Type	Description
Date-Time	Integer	Milliseconds since 00:00:00 UTC, 1 January 1970

3.4.2.3 Duration

Type Name	Base Type	Description
Duration	Integer	Milliseconds

3.4.2.4 Hashes

Type: Hashes (Map)

ID	Name	Type	#	Description
1	**md5**	Binary	0..1	MD5 hash as defined in RFC 1321
2	**sha1**	Binary	0..1	SHA1 hash as defined in RFC 6234
3	**sha256**	Binary	0..1	SHA256 hash as defined in RFC 6234

3.4.2.5 Hostname

Type Name	Base Type	Description
Hostname	String	A legal Internet host name as specified in RFC 1123

3.4.2.7 L4 Protocol

Value of the protocol (IPv4) or next header (IPv6) field in an IP packet. Any IANA value, RFC 5237

Type: L4-Protocol (Enumerated)

ID	Name	Description
1	**icmp**	Internet Control Message Protocol - RFC 792
6	**tcp**	Transmission Control Protocol - RFC 793
17	**udp**	User Datagram Protocol - RFC 768
132	**sctp**	Stream Control Transmission Protocol - RFC 4960

3.4.2.8 Payload

Type: Payload (Choice)

ID	Name	Type	#	Description
1	**bin**	Binary	1	Specifies the data contained in the artifact
2	**url**	URI	1	MUST be a valid URL that resolves to the un-encoded content

3.4.2.9 Port

Type Name	Base Type	Description
Port	Integer	Transport Protocol Port Number, RFC 6335

3.4.2.10 Feature

Specifies the results to be returned from a query features command.

Type: Feature (Enumerated)

ID	Name	Description
1	**versions**	List of OpenC2 Language versions supported by this actuator
2	**profiles**	List of profiles supported by this actuator
3	**schema**	Definition of the command syntax supported by this actuator
4	**pairs**	List of supported actions and applicable targets
5	**rate_limit**	Maximum number of requests per minute supported by design or policy

3.4.2.11 Response-Type

Type: Response-Type (Enumerated)

ID	Name	Description
0	**none**	No response
1	**ack**	Respond when command received
2	**status**	Respond with progress toward command completion
3	**complete**	Respond when all aspects of command completed

3.4.2.12 Version

Type Name	Base Type	Description
Version	String	Major.Minor version number

3.4.2.14 Key-Value Pair

Type: KVP (Array)

ID	Type	#	Description
1	String	1	“key”: name of this item
2	String	1	“value”: string value of this item

3.4.2.15 Action-Targets Array

Type: Action-Targets (Array)

ID	Type	#	Description
1	Action	1	An action supported by this actuator.
2	Target.*	1..n	List of targets applicable to this action. The targets are enumerated values derived from the set of Target types.

3.4.3 Schema Syntax

3.4.3.1 Schema

Type: Schema (Record)

ID	Name	Type	#	Description
1	**meta**	Meta	1	Information about this schema module
2	**types**	Type	1..n	Types defined in this schema module

3.4.3.1 Meta

Meta-information about this schema

Type: Meta (Map)

ID	Name	Type	#	Description

1	**module**	Uname	1	Unique name
2	**title**	String	0..1	Title
3	**version**	String	0..1	Patch version (module includes major.minor version)
4	**description**	String	0..1	Description
5	**imports**	Import	0..n	Imported schema modules
6	**exports**	Identifier	0..n	Data types exported by this module
7	**bounds**	Bounds	0..1	Schema-wide upper bounds

3.4.3.2 Import

Type: Import (Array)

ID	Type	#	Description
1	Nsid	1	**nsid** - A short local identifier (namespace id) used within this module to refer to the imported module
2	Uname	1	**uname** - Unique name of the imported module

3.4.3.3 Bounds

Schema-wide default upper bounds.   If included in a schema, these values override codec default values but are limited to the codec hard upper bounds. Sizes provided in individual type definitions override these defaults.

Type: Bounds (Array)

ID	Type	#	Description
1	Integer	1	**max_msg** - Maximum serialized message size in octets or characters
2	Integer	1	**max_str** - Maximum text string length in characters
3	Integer	1	**max_bin** - Maximum binary string length in octets
4	Integer	1	**max_fields** - Maximum number of elements in ArrayOf

3.4.3.4 Type

Definition of a data type.

Type: Type (Array)

ID	Type	#	Description

1	Identifier	1	**tname** - Name of this data type
2	JADN-Type.*	1	**btype** - Base type. Enumerated value derived from the list of JADN data types.
3	Option	1..n	**topts** - Type options
4	String	1	**tdesc** - Description of this data type
5	JADN-Type.&2	1..n	**fields** - List of fields for compound types. Not present for primitive types.

3.4.3.5 JADN Type

Field definitions applicable to the built-in data types (primitive and compound) used to construct a schema.

Type: JADN-Type (Choice)

ID	Name	Type	#	Description
1	Binary	Null		Octet (binary) string
2	Boolean	Null		True or False
3	Integer	Null		Whole number
4	Number	Null		Real number
5	Null	Null		Nothing
6	String	Null		Character (text) string
7	Array	FullField		Ordered list of unnamed fields
8	ArrayOf	Null		Ordered list of fields of a specified type
9	Choice	FullField		One of a set of named fields
10	Enumerated	EnumField		One of a set of id:name pairs
11	Map	FullField		Unordered set of named fields
12	Record	FullField		Ordered list of named fields

3.4.3.6 Enum Field

Item definition for Enumerated types

Type: EnumField (Array)

ID	Type	#	Description
1	Integer	1	Item ID
2	Identifier	1	Item name

3	String	1	Item description

3.4.3.7 Full Field

Field definition for compound types Array, Choice, Map, Record

Type: FullField (Array)

ID	Type	#	Description
1	Integer	1	Field ID or ordinal position
2	Identifier	1	Field name
3	Identifier	1	Field type
4	Options	1	Field options. This field is an empty array (not omitted) if there are none.
5	String	1	Field description

3.4.3.8 Identifier

Type Name	Base Type	Description
Identifier	String	A string beginning with an alpha character followed by zero or more alphanumeric | underscore | dash characters, max length 32 characters

3.4.3.9 Nsid

Type Name	Base Type	Description
Nsid	String	Namespace ID - a short identifier, max length 8 characters

3.4.3.10 Uname

Type Name	Base Type	Description
Uname	String	Unique name (e.g., of a schema) - typically a set of Identifiers separated by forward slashes

3.4.3.11 Options

Type Name	Base Type	Description
Options	ArrayOf(Option)	An array of zero to ten option strings.

3.4.3.12 Option

Type Name	Base Type	Description
Option	String	An option string, minimum length = 1. The first character is the option id. Remaining characters if any are the option value.

4 Mandatory Commands/Responses

An OpenC2 command consists of an ACTION/TARGET pair and associated SPECIFIERS and ARGUMENTs. This section enumerates the allowed commands, identify which are required or optional to implement, and present the associated responses.

An OpenC2 Consumer MUST process an OpenC2 Command where "query" is specified for the ACTION and "features" is specified for the TARGET, hereafter, referred to as a 'query features' command".

Upon processing a 'query features' command, an OpenC2 Consumer MUST issue an OpenC2 Response to the OpenC2 Producer that issued the OpenC2 Command.

5 Conformance

5.1 OpenC2 Message Content

A conformant OpenC2 Command

A. MUST be structured in accordance with Section 3.4.1, and
B. MUST include exactly one ACTION specified in Section 3.4.1.1.

A conformant OpenC2 Response

A. MUST be structured in accordance with Section 3.4.2, and
B. MUST include exactly one STATUS specified in Section 3.4.2.1.

5.2 OpenC2 Producer

A conformant OpenC2 Producer

A. MUST issue OpenC2 Commands and process OpenC2 Responses specified in Section 4
B. MUST implement JSON serialization of generated OpenC2 Commands in accordance with RFC 7493

5.3 OpenC2 Consumer

A conformant OpenC2 Consumer

A. MUST process OpenC2 Commands and issue OpenC2 Responses specified in Section 4
B. MUST implement JSON serialization of generated OpenC2 Responses in accordance with RFC 7493

Annex A. Schemas

This annex defines the information model used by conforming OpenC2 implementations in JSON Abstract Data Notation (JADN) format. JADN is a structured textual representation of the tables shown in Section 3. Schema files referenced by the URLs include descriptive text shown in the tables. Descriptions are omitted from the figures in this section in order to: 1) illustrate that descriptive text is not part of the language syntax, 2) show what an actuator would return in response to a schema query, and 3) improve readability of the figures.

A.1 OpenC2 Language Syntax

Schema Files:

- https://github.com/oasis-tcs/openc2-oc2ls/tree/master/v1.0-wd08/openc2.jadn (authoritative)
- https://github.com/oasis-tcs/openc2-oc2ls/tree/master/v1.0-wd08/openc2.pdf (formatted)

Schema:

~~~
```
{
 "meta": {
  "module": "oasis-open.org/openc2/v1.0/openc2-lang",
  "patch": "wd09",
  "title": "OpenC2 Language Objects",
  "description": "Datatypes that define the content of OpenC2 commands and
responses.",
  "imports": [
   ["slpf", "oasis-open.org/openc2/v1.0/ap-slpf"],
   ["jadn", "oasis-open.org/openc2/v1.0/jadn"]
  ],
  "exports": ["OpenC2-Command", "OpenC2-Response", "Message-Type", "Status-
Code", "Request-Id", "Date-Time"]
 },
 "types": [
  ["Message", "Array", [], "", [
    [1, "msg_type", "Message-Type", [], ""],
    [2, "content_type", "String", [], ""],
    [3, "content", "Null", [], ""],
    [4, "status", "Status-Code", ["[0"], ""],
    [5, "request_id", "Request-Id", ["[0"], ""],
    [6, "to", "String", ["[0", "]0"], ""],
    [7, "from", "String", ["[0"], ""],
    [8, "created", "Date-Time", ["[0"], ""]
  ]],
  ["OpenC2-Command", "Record", [], "", [
    [1, "action", "Action", [], ""],
~~~

```
    [2, "target", "Target", [], ""],
    [3, "args", "Args", ["[0"], ""],
    [4, "actuator", "Actuator", ["[0"], ""]
  ]],
  ["Action", "Enumerated", [], "", [
    [1, "scan", ""],
    [2, "locate", ""],
    [3, "query", ""],
    [6, "deny", ""],
    [7, "contain", ""],
    [8, "allow", ""],
    [9, "start", ""],
    [10, "stop", ""],
    [11, "restart", ""],
    [14, "cancel", ""],
    [15, "set", ""],
    [16, "update", ""],
    [18, "redirect", ""],
    [19, "create", ""],
    [20, "delete", ""],
    [22, "detonate", ""],
    [23, "restore", ""],
    [28, "copy", ""],
    [30, "investigate", ""],
    [32, "remediate", ""]
  ]],
  ["Target", "Choice", [], "", [
    [1, "artifact", "Artifact", [], ""],
    [2, "command", "Request-Id", [], ""],
    [3, "device", "Device", [], ""],
    [7, "domain_name", "Domain-Name", [], ""],
    [8, "email_addr", "Email-Addr", [], ""],
    [16, "features", "Features", [], ""],
    [10, "file", "File", [], ""],
    [11, "ip_addr", "IP-Addr", [], ""],
    [15, "ip_connection", "IP-Connection", [], ""],
    [13, "mac_addr", "MAC-Addr", [], ""],
    [17, "process", "Process", [], ""],
    [25, "properties", "Properties", [], ""],
    [19, "uri", "URI", [], ""],
    [1000, "extension", "PE-Target", [], ""],
    [1001, "extension_unr", "Unr-Target", [], ""],
    [1024, "slpf", "slpf:Target", [], ""]
  ]],
  ["Actuator", "Choice", [], "", [
    [1000, "extension", "PE-Specifiers", [], ""],
    [1001, "extension_unr", "Unr-Specifiers", [], ""]
  ]],
  ["Args", "Map", [], "", [
    [1, "start_time", "Date-Time", ["[0"], ""],
    [2, "stop_time", "Date-Time", ["[0"], ""],
    [3, "duration", "Duration", ["[0"], ""],
    [4, "response_requested", "Response-Type", ["[0"], ""],
    [1000, "extension", "PE-Args", ["[0"], ""],
    [1001, "extension_unr", "Unr-Args", ["[0"], ""]
  ]],
  ["OpenC2-Response", "Map", [], "", [
    [1, "status", "Status-Code", ["[0"], ""],
    [2, "status_text", "String", ["[0"], ""],
    [3, "strings", "String", ["[0", "]0"], ""],
    [4, "ints", "Integer", ["[0", "]0"], ""],
    [5, "kvps", "KVP", ["[0", "]0"], ""],
    [6, "versions", "Version", ["[0", "]0"], ""],
    [7, "profiles", "jadn:Uname", ["[0", "]0"], ""],
    [8, "schema", "jadn:Schema", ["[0"], ""],
    [9, "pairs", "Action-Targets", ["[0", "]0"], ""],
    [10, "rate_limit", "Number", ["[0"], ""],
    [1000, "extension", "PE-Results", ["[0"], ""],
    [1001, "extension_unr", "Unr-Results", ["[0"], ""]
  ]],
  ["Status-Code", "Enumerated", ["="], "", [
    [102, "Processing", ""],
    [200, "OK", ""],
    [301, "Moved Permanently", ""],
    [400, "Bad Request", ""],
    [401, "Unauthorized", ""],
    [403, "Forbidden", ""],
    [404, "Not Found", ""],
    [500, "Internal Error", ""],
    [501, "Not Implemented", ""],
    [503, "Service Unavailable", ""]
  ]],
  ["PE-Target", "Choice", ["="], "", [
    [32473, "Example", "32473:Target", [], ""]
  ]],
  ["PE-Specifiers", "Choice", ["="], "", [
    [32473, "Example", "32473:Specifiers", [], ""]
  ]],
  ["PE-Args", "Map", ["="], "", [
    [32473, "Example", "32473:Args", [], ""]
  ]],
  ["PE-Results", "Map", ["="], "", [
    [32473, "Example", "32473:Results", [], ""]
  ]],
  ["Artifact", "Record", [], "", [
    [1, "mime_type", "String", ["[0"], ""],
    [2, "payload", "Payload", ["[0"], ""],
    [3, "hashes", "Hashes", ["[0"], ""]
  ]],
  ["Device", "Map", [], "", [
    [1, "hostname", "Hostname", [], ""],
    [2, "description", "String", ["[0"], ""],
    [3, "device_id", "String", ["[0"], ""]
  ]],
  ["Domain-Name", "String", ["@hostname"], ""],
  ["Email-Addr", "String", ["@email"], ""],
  ["Features", "ArrayOf", ["*Feature", "[0"], ""],
  ["File", "Map", [], "", [
    [1, "name", "String", ["[0"], ""],
    [2, "path", "String", ["[0"], ""],
    [3, "hashes", "Hashes", ["[0"], ""]
  ]],
  ["IP-Addr", "Binary", ["@ip-addr"], ""],
  ["IP-Connection", "Record", [], "", [
    [1, "src_addr", "IP-Addr", ["[0"], ""],
    [2, "src_port", "Port", ["[0"], ""],
    [3, "dst_addr", "IP-Addr", ["[0"], ""],
    [4, "dst_port", "Port", ["[0"], ""],
    [5, "protocol", "L4-Protocol", ["[0"], ""]
  ]],
  ["MAC-Addr", "Binary", [], ""],
  ["Process", "Map", [], "", [
    [1, "pid", "Integer", ["[0"], ""],
    [2, "name", "String", ["[0"], ""],
    [3, "cwd", "String", ["[0"], ""],
    [4, "executable", "File", ["[0"], ""],
    [5, "parent", "Process", ["[0"], ""],
    [6, "command_line", "String", ["[0"], ""]
  ]],
  ["Properties", "ArrayOf", ["*String"], ""],
  ["URI", "String", ["@uri"], ""],
  ["Message-Type", "Enumerated", [], "", [
    [0, "notification", ""],
    [1, "request", ""],
    [2, "response", ""]
  ]],
  ["Request-Id", "Binary", [], ""],
  ["Date-Time", "Integer", [], ""],
  ["Duration", "Integer", [], ""],
  ["Hashes", "Map", [], "", [
    [1, "md5", "Binary", ["[0"], ""],
    [4, "sha1", "Binary", ["[0"], ""],
    [6, "sha256", "Binary", ["[0"], ""]
  ]],
  ["Hostname", "String", [], ""],
  ["L4-Protocol", "Enumerated", [], "", [
    [1, "icmp", ""],
```

~~~
    [6, "tcp", ""],
    [17, "udp", ""],
    [132, "sctp", ""]
  ]],
  ["Payload", "Choice", [], "", [
    [1, "bin", "Binary", [], ""],
    [2, "url", "URI", [], ""]
  ]],
  ["Port", "Integer", ["[0", "]65535"], ""],
  ["Feature", "Enumerated", [], "", [
    [1, "versions", ""],
    [2, "profiles", ""],
    [3, "schema", ""],
    [4, "pairs", ""],
    [5, "rate_limit", ""]
  ]],
  ["Response-Type", "Enumerated", [], "", [
    [0, "none", ""],
    [1, "ack", ""],
    [2, "status", ""],
    [3, "complete", ""]
  ]],
  ["Version", "String", [], ""],
  ["KVP", "Array", [], "", [
    [1, "key", "String", [], ""],
    [2, "value", "String", [], ""]
  ]],
  ["Action-Targets", "Array", [], "", [
    [1, "action", "Action", [], ""],
    [2, "targets", "Target", ["]0", "*"], ""]
  ]]
 ]
}
```
~~~

A.2 JADN Syntax

Schema Files:

- https://github.com/oasis-tcs/openc2-oc2ls/tree/master/v1.0-wd08/jadn.jadn (authoritative)
- https://github.com/oasis-tcs/openc2-oc2ls/tree/master/v1.0-wd08/jadn.pdf (formatted)

Schema:

~~~
```
~~~

```
{
 "meta": {
  "module": "oasis-open.org/openc2/v1.0/jadn",
  "patch": "wd01",
  "title": "JADN Syntax",
  "description": "Syntax of a JSON Abstract Data Notation (JADN) module.",
  "exports": ["Schema", "Uname"]
 },

 "types": [
  ["Schema", "Record", [], "", [
    [1, "meta", "Meta", [], ""],
    [2, "types", "Type", ["]0"], ""]]
  ],

  ["Meta", "Map", [], "", [
    [1, "module", "Uname", [], ""],
    [2, "patch", "String", ["[0"], ""],
    [3, "title", "String", ["[0"], ""],
    [4, "description", "String", ["[0"], ""],
    [5, "imports", "Import", ["[0", "]0"], ""],
    [6, "exports", "Identifier", ["[0", "]0"], ""],
    [7, "bounds", "Bounds", ["[0"], ""]]
  ],

  ["Import", "Array", [], "", [
    [1, "nsid", "Nsid", [], ""],
    [2, "uname", "Uname", [], ""]]
  ],

  ["Bounds", "Array", [], "", [
    [1, "max_msg", "Integer", [], ""],
    [2, "max_str", "Integer", [], ""],
    [3, "max_bin", "Integer", [], ""],
    [4, "max_fields", "Integer", [], ""]]
  ],

  ["Type", "Array", [], "", [
    [1, "tname", "Identifier", [], ""],
    [2, "btype", "JADN-Type", ["*"], ""],
    [3, "opts", "Option", ["]0"], ""],
    [4, "desc", "String", [], ""],
    [5, "fields", "JADN-Type", ["&btype", "]0"], ""]]
  ],

  ["JADN-Type", "Choice", [], "", [
    [1, "Binary", "Null", [], ""],
    [2, "Boolean", "Null", [], ""],
    [3, "Integer", "Null", [], ""],
```

~~~
    [4, "Number", "Null", [], ""],
    [5, "Null", "Null", [], ""],
    [6, "String", "Null", [], ""],
    [7, "Array", "FullField", ["]0"], ""],
    [8, "ArrayOf", "Null", [], ""],
    [9, "Choice", "FullField", ["]0"], ""],
    [10, "Enumerated", "EnumField", ["]0"], ""],
    [11, "Map", "FullField", ["]0"], ""],
    [12, "Record", "FullField", ["]0"], ""]]
  ],

  ["EnumField", "Array", [], "", [
    [1, "", "Integer", [], ""],
    [2, "", "String", [], ""],
    [3, "", "String", [], ""]]
  ],

  ["FullField", "Array", [], "", [
    [1, "", "Integer", [], ""],
    [2, "", "Identifier", [], ""],
    [3, "", "Identifier", [], ""],
    [4, "", "Options", [], ""],
    [5, "", "String", [], ""]]
  ],

  ["Identifier", "String", ["$^[a-zA-Z][\\w-]*$", "[1", "]32"], ""],

  ["Nsid", "String", ["$^[a-zA-Z][\\w-]*$", "[1", "]8"], ""],

  ["Uname", "String", ["[1", "]100"], ""],

  ["Options", "ArrayOf", ["*Option", "[0", "]10"], ""],

  ["Option", "String", ["[1", "]100"], ""]]
}
```
~~~

Annex B. Examples

B.1 Example 1

This example shows the elements of an OpenC2 Message containing an OpenC2 Command. The content of the message is the de-serialized command structure in whatever format is used by the implementation, independent of the transfer protocol and serialization format used to transport the message.

The request_id in this example is a 64 bit binary value which can be displayed in many ways, including hex: `'d937 fca9 2b64 4e71'`, base64url: `'2Tf8qStkTnE'`, and Python byte string - ASCII characters with hex escapes (\xNN) for non-ASCII bytes: `b'\xd97\xfc\xa9+dNq'`. If OpenC2 producers generate numeric or alphanumeric request_ids, they are still binary values and are limited to 128 bits, e.g.,: hex: '6670 2d31 3932 352d 3337 3632 3864 3663', base64url: 'ZnAtMTkyNS0zNzYyOGQ2Yw', byte string: b'fp-1925-37628d6c'.

The created element is a Date-Time value of milliseconds since the epoch. The example `1539355895215` may be displayed as `'12 October 2018 14:51:35 UTC'`.

This example, illustrating an internal representation of a message, is non-normative. Other programming languages (e.g., Java, Javascript, C, Erlang) have different representations of literal values. There are no interoperability considerations or conformance requirements for how message elements are represented internally within an implementation. Only the serialized values of the message elements embedded within a protocol is relevant to interoperability.

B.1.1 Command Message

```
content-type: 'application/openc2'
msg_type: 'request'
request_id: b'\xd97\xfc\xa9+dNq'
from: 'nocc-3497'
to: ['#filter-devices']
created: 1539355895215
content: {'action': 'query', 'target': {'features': ['versions',
'profiles']}}
```

B.1.2 Response Message

The response message contains a status code, a content-type that is normally the same as the request content type, a msg_type of `'response'`, and the response content. The request_id from the command message, if present, is returned unchanged in the response message. The "to" element of the response normally echoes the "from" element of the command message, but the "from" element of the response is the actuator's identifier regardless of whether the command was sent to an individual actuator or a group. The "created" element, if present, contains the creation time of the response.

A responder could potentially return non-openc2 content, such as a PDF report or an HTML document, in response to an openc2 command. No actuator profiles currently define response content types other than openc2.

```
status: 200
content-type: 'application/openc2'
msg_type: 'response'
request_id: b'\xd97\xfc\xa9+dNq'
from: 'pf72394'
to: ['nocc-3497']
created: 1539355898000
content: {'status': 200, 'versions': ['1.3'], 'profiles': ['oasis-open.org/openc2/v1.0/ap-slpf']}
```

B.2 Example 2

This example shows the OpenC2 Command and Response for retrieving data from an actuator.

Command:

```
{
    "action": "query",
    "target": {
        "properties": ["battery_percentage"]
    },
    "actuator": {
        "esm": {
            "asset_id": "TGEadsasd"
        }
    }:
}
```

Response:

```
{
    "status": 200,
    "kvps": [["battery_percentage", "0.577216"]]
}
```

~~~
```
~~~

B.3 Example 3

Command:

~~~
```
{
  "action": "query",
  "target": {
    "features": ["versions", "profiles"]
  }
}
```
~~~

Response:

~~~
```
{
  "status_text": "ACME Corp Internet Toaster",
  "versions": ["1.0"],
  "profiles": []
}
```
~~~

Command:

This command queries the actuator for the syntax of its supported commands.

~~~
```
{
  "action": "query",
  "target": {
    "features": ["pairs", "schema"]
  }
}
```
~~~

Response:

This example illustrates how actuator developers tailor the OpenC2 schema to communicate the capabilities of their products to producers. This example actuator supports the mandatory requirements of the language specification plus a random subset of optional language elements (cancel, create, and delete actions, and the command, ip_addr, and properties targets). The example actuator supports a subset of the core OpenC2 language but no profile-defined targets, actuator specifiers, command arguments, or responses.

The example do-nothing actuator appears to support create and delete ip_addr commands, but without a profile there is no definition of what the actuator would do to "create" an IP address. The schema is used by producers to determine what commands are syntactically valid for an actuator, but it does not assign meaning to those commands.

~~~
```
{
  "pairs": [
    ["query", ["features", "properties"]],
    ["cancel", ["command"]],
    ["create", ["ip_addr"]],
    ["delete", ["ip_addr"]]
  ],
  "schema": {
     "meta": {
      "module": "oasis-open.org/openc2/v1.0/openc2-lang",
      "patch": "wd09_example",
      "title": "OpenC2 Language Objects",
      "description": "Example Actuator",
      "exports": ["OpenC2-Command", "OpenC2-Response", "Message-Type",
"Status-Code", "Request-Id", "Date-Time"]
     },
     "types": [
      ["OpenC2-Command", "Record", [], "", [
        [1, "action", "Action", [], ""],
        [2, "target", "Target", [], ""],
        [3, "args", "Args", ["[0"], ""]
      ]],
      ["Action", "Enumerated", [], "", [
        [3, "query", ""],
        [14, "cancel", ""],
        [19, "create", ""],
        [20, "delete", ""]
      ]],
      ["Target", "Choice", [], "", [
        [2, "command", "Request-Id", [], ""],
        [16, "features", "Features", [], ""],
        [11, "ip_addr", "IP-Addr", [], ""],
        [25, "properties", "Properties", [], ""]
      ]],
      ["Args", "Map", [], "", [
        [1, "start_time", "Date-Time", ["[0"], ""],
        [4, "response_requested", "Response-Type", ["[0"], ""]
      ]],
      ["OpenC2-Response", "Map", [], "", [
        [2, "status_text", "String", ["[0"], ""],
        [3, "strings", "String", ["[0", "]0"], ""],
        [4, "ints", "Integer", ["[0", "]0"], ""],
        [5, "kvps", "KVP", ["[0", "]0"], ""],
        [6, "versions", "Version", ["[0", "]0"], ""],
~~~

```
        [7, "profiles", "jadn:Uname", ["[0", "]0"], ""],
        [8, "schema", "jadn:Schema", ["[0"], ""],
        [9, "pairs", "Action-Targets", ["[0", "]0"], ""],
        [10, "rate_limit", "Number", ["[0"], ""]
      ]],
      ["Status-Code", "Enumerated", ["="], "", [
        [200, "OK", ""],
        [400, "Bad Request", ""],
        [404, "Not Found", ""],
        [500, "Internal Error", ""],
        [501, "Not Implemented", ""]
      ]],
      ["Features", "ArrayOf", ["*Feature", "[0"], ""],
      ["IP-Addr", "Binary", ["@ip-addr"], ""],
      ["Properties", "ArrayOf", ["*String"], ""],
      ["Message-Type", "Enumerated", [], "", [
        [1, "request", ""],
        [2, "response", ""]
      ]],
      ["Request-Id", "Binary", [], ""],
      ["Date-Time", "Integer", [], ""],
      ["Feature", "Enumerated", [], "", [
        [1, "versions", ""],
        [2, "profiles", ""],
        [3, "schema", ""],
        [4, "pairs", ""]
      ]],
      ["Response-Type", "Enumerated", [], "", [
        [0, "none", ""],
        [1, "ack", ""],
        [3, "complete", ""]
      ]],
      ["Version", "String", [], ""],
      ["KVP", "Array", [], "", [
        [1, "key", "String", [], ""],
        [2, "value", "String", [], ""]
      ]],
      ["Action-Targets", "Array", [], "", [
        [1, "action", "Action", [], ""],
        [2, "targets", "Target", ["]0", "*"], ""]
      ]],
      ["jadn:Schema", "Record", [], "", [
        [1, "meta", "jadn:Meta", [], ""],
        [2, "types", "jadn:Type", ["]0"], ""]
      ]],
      ["jadn:Meta", "Map", [], "", [
        [1, "module", "jadn:Uname", [], ""],
        [2, "patch", "String", ["[0"], ""],
        [3, "title", "String", ["[0"], ""],
        [4, "description", "String", ["[0"], ""],
        [5, "imports", "jadn:Import", ["[0", "]0"], ""],
        [6, "exports", "jadn:Identifier", ["[0", "]0"], ""],
        [7, "bounds", "jadn:Bounds", ["[0"], ""]
      ]],
      ["jadn:Import", "Array", [], "", [
        [1, "nsid", "jadn:Nsid", [], ""],
        [2, "uname", "jadn:Uname", [], ""]
      ]],
      ["jadn:Bounds", "Array", [], "", [
        [1, "max_msg", "Integer", [], ""],
        [2, "max_str", "Integer", [], ""],
        [3, "max_bin", "Integer", [], ""],
        [4, "max_fields", "Integer", [], ""]
      ]],
      ["jadn:Type", "Array", [], "", [
        [1, "tname", "jadn:Identifier", [], ""],
        [2, "btype", "jadn:JADN-Type", ["*"], ""],
        [3, "opts", "jadn:Option", ["]0"], ""],
        [4, "desc", "String", [], ""],
        [5, "fields", "jadn:JADN-Type", ["&btype", "]0"], ""]
      ]],
      ["jadn:JADN-Type", "Choice", [], "", [
        [1, "Binary", "Null", [], ""],
        [2, "Boolean", "Null", [], ""],
        [3, "Integer", "Null", [], ""],
        [4, "Number", "Null", [], ""],
        [5, "Null", "Null", [], ""],
        [6, "String", "Null", [], ""],
        [7, "Array", "jadn:FullField", ["]0"], ""],
        [8, "ArrayOf", "Null", [], ""],
        [9, "Choice", "jadn:FullField", ["]0"], ""],
        [10, "Enumerated", "jadn:EnumField", ["]0"], ""],
        [11, "Map", "jadn:FullField", ["]0"], ""],
        [12, "Record", "jadn:FullField", ["]0"], ""]
      ]],
      ["jadn:EnumField", "Array", [], "", [
        [1, "", "Integer", [], ""],
        [2, "", "String", [], ""],
        [3, "", "String", [], ""]
      ]],
      ["jadn:FullField", "Array", [], "", [
        [1, "", "Integer", [], ""],
        [2, "", "jadn:Identifier", [], ""],
        [3, "", "jadn:Identifier", [], ""],
        [4, "", "jadn:Options", [], ""],
        [5, "", "String", [], ""]
      ]],
      ["jadn:Identifier", "String", ["$^[a-zA-Z][\\w-]*$", "[1", "]32"], ""],
```

~~~~
      ["jadn:Nsid", "String", ["$^[a-zA-Z][\\w-]*$", "[1", "]8"], ""],
      ["jadn:Uname", "String", ["[1", "]100"], ""],
      ["jadn:Options", "ArrayOf", ["*jadn:Option", "[0", "]10"], ""],
      ["jadn:Option", "String", ["[1", "]100"], ""]
    ]
  }
}
```
~~~~

Annex C. Acronyms

> **Editor's Note** - TBSL - This section be included in the final version of the initial Committee Specification.

Annex D. Revision History

Revision	Date	Editor	Changes Made
v1.0-wd01	10/31/2017	Romano, Sparrell	Initial working draft
v1.0-csd01	11/14/2017	Romano, Sparrell	approved wd01
v1.0-wd02	01/12/2018	Romano, Sparrell	csd01 ballot comments targets
v1.0-wd03	01/31/2018	Romano, Sparrell	wd02 review comments
v1.0-csd02	02/14/2018	Romano, Sparrell	approved wd03
v1.0-wd04	03/02/2018	Romano, Sparrell	Property tables threads (cmd/resp) from use cases previous comments
v1.0-wd05	03/21/2018	Romano, Sparrell	wd04 review comments
v1.0-csd03	04/03/2018	Romano, Sparrell	approved wd05
v1.0-wd06	05/15/2018	Romano, Sparrell	Finalizing message structure message=header+body Review comments Using word ‘arguments’ instead of ‘options’
v1.0-csd04	5/31/2018	Romano, Sparrell	approved wd06
v1.0-wd07	7/11/2018	Romano, Sparrell	Continued refinement of details Review comments Moved some actions and targets to reserved lists
v1.0-wd08	10/05/2018	Romano, Sparrell	Continued refinement of details Review comments
v1.0-wd09	10/17/2018	Romano, Sparrell	Additional review comments to create wd09 for CSD approval and release for public review.

Annex E. Acknowledgments

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Participants:

> **Editor's Note** - TBSL - This section be included in the final version of the initial Committee Specification.