

MILE
Internet-Draft
Intended status: Standards Track
Expires: October 3, 2019

T. Takahashi
NICT
R. Danyliw
CERT
M. Suzuki
NICT
April 1, 2019

CBOR/JSON binding of IODEF
draft-ietf-mile-jsoniodef-08

Abstract

[RFC7970](#) specified an information model and a corresponding XML data model for exchanging incident and indicator information. This draft provides an alternative data model implementation in CBOR/JSON.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on October 3, 2019.

Copyright Notice

Copyright (c) 2019 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in [Section 4](#).e of

the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1.	Introduction	2
1.1.	Requirements Language	3
2.	IODEF Data Types	3
2.1.	Abstract Data Type to JSON Data Type Mapping	3
2.2.	Complex JSON Types	5
2.2.1.	Multilingual Strings	5
2.2.2.	Software and Software Reference	6
2.2.3.	Structured Information	6
2.2.4.	EXTENSION	7
3.	IODEF JSON Data Model	7
3.1.	Classes and Elements	7
3.2.	Mapping between CBOR/JSON and XML IODEF	17
4.	Examples	18
4.1.	Minimal Example	18
4.2.	Indicators from a Campaign	20
5.	The IODEF Data Model (CDDL)	25
6.	IANA Considerations	40
7.	Security Considerations	40
8.	Acknowledgements	40
9.	References	40
9.1.	Normative References	40
9.2.	Informative References	41
Appendix A.	Data Types used in this document	41
Appendix B.	The IODEF Data Model (JSON Schema)	41
	Authors' Addresses	69

1. Introduction

[RFC7970] defines a data representation for security incident reports and indicators commonly exchanged by operational security teams. It facilitates the automated exchange of this information to enable mitigation and watch-and-warning. [Section 3 of \[RFC7970\]](#) defined an information model using Unified Modeling Language (UML) and a corresponding Extensible Markup Language (XML) schema data model in [Section 8](#). This UML-based information model and XML-based data model are referred to as IODEF UML and IODEF XML, respectively in this document.

This document defines an alternate implementation of the IODEF UML information model by specifying a JavaScript Object Notation (JSON) data model using CDDL and JSON Schema [[jsonschema](#)]. This JSON data model is referred to as IODEF JSON in this document.

IODEF JSON provides all of the expressivity of IODEF XML. It gives implementers and operators an alternative format to exchange the same information.

The normative IODEF JSON data model is found in [Section 5](#). [Section 2](#) and [Section 3](#) describe the data types and elements of this data model. [Section 4](#) provides examples.

[1.1](#). Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14](#) [[RFC2119](#)][[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

[2](#). IODEF Data Types

The abstract IODEF JSON implements the abstract data types specified in [Section 2 of \[RFC7970\]](#).

[2.1](#). Abstract Data Type to JSON Data Type Mapping

IODEF JSON uses native and derived JSON data types. Figure 1 describes the mapping between the abstract data types in [Section 2 of \[RFC7970\]](#) and their corresponding implementations in IODEF JSON.

IODEF Data Type	[RFC7970] Reference	JSON Data Type
INTEGER	Section 2.1	"integer" per [jsonschema]
REAL	Section 2.2	"number" per [jsonschema]
CHARACTER	Section 2.3	"string" per [jsonschema]
STRING	Section 2.3	"string" per [jsonschema]
ML_STRING	Section 2.4	see Section 2.2.1
BYTE	Section 2.5.1	"string" per [jsonschema]
BYTE[]	Section 2.5.1	"string" per [jsonschema]
HEXBIN	Section 2.5.2	"string" per [jsonschema]
HEXBIN[]	Section 2.5.2	"string" per [jsonschema]
ENUM	Section 2.6	"enum" array per [jsonschema]
DATETIME	Section 2.7	"string" per [jsonschema]
TIMEZONE	Section 2.8	"string" per [jsonschema]
PORTLIST	Section 2.9	"string" per [jsonschema]
POSTAL	Section 2.10	ML_STRING, Section 2.2.1
PHONE	Section 2.11	"string" per [jsonschema]
EMAIL	Section 2.12	"string" per [jsonschema]
URL	Section 2.13	"string" per [jsonschema]
ID	Section 2.14	"string" per [jsonschema]
IDREF	Section 2.14	"string" per [jsonschema]
SOFTWARE	Section 2.15	see Section 2.2.2
STRUCTUREDINFO	[RFC 7203]	see Section 2.2.3
EXTENSION	Section 2.16	see Section 2.2.4

Figure 1: JSON Data Types

IODEF Data Type	CBOR Data Type	CDDL prelude [draft-ietf-cbor-cddl-05]
INTEGER	0, 1, 6 tag 2, 6 tag 3	integer
REAL	7 bits 26	float32
CHARACTER	3	text
STRING	3	text
ML_STRING	5	Maps/Structs (Section 3.5.1)
BYTE	6 tag 22	eb64legacy
BYTE[]	6 tag 22	eb64legacy
HEXBIN	2	bytes
HEXBIN[]	2	bytes
ENUM	-	Choices (Section 2.2.2)
DATETIME	6 tag 0	tdate
TIMEZONE	3	text
PORTLIST	3	text
POSTAL	3	ML_STRING (Section 2.2.1)
PHONE	3	text
EMAIL	3	text
URL	6 tag 32	uri
ID	3	text
IDREF	3	text
SOFTWARE	5	Maps/Structs (Section 3.5.1)
STRUCTUREDINFO	5	Maps/Structs (Section 3.5.1)
EXTENSION	5	Maps/Structs (Section 3.5.1)

Figure 2: CBOR Data Types

2.2. Complex JSON Types

2.2.1. Multilingual Strings

A string that needs to be represented in a human-readable language different from the default encoding of the document is represented in the information model by the ML_STRING data type. This data type is implemented as either an object with "value", "lang", and "translation-id" elements or a text string as defined in [Section 5](#). Examples are shown below.

```
"MLStringType": {
  "value": "free-form text",           //STRING
  "lang": "en",                       //ENUM
  "translation-id": "jp2en0023"       //STRING
}
```


2.2.2. Software and Software Reference

A particular version of software is represented in the information model by the SOFTWARE data type. This software can be described by using a reference, a URL, or with free-form text. The SOFTWARE data type is implemented as an object with "SoftwareReference", "URL", and "Description" elements as defined in [Section 5](#). Examples are shown below.

```
"SoftwareType": {  
  "SoftwareReference": {...},           //SoftwareReference  
  "Description": ["MS Windows"]         //STRING  
}
```

SoftwareReference class is a reference to a particular version of software. Examples are shown below.

```
"SoftwareReference": {  
  "value": "cpe:/a:google:chrome:59.0.3071.115 ", //STRING  
  "spec-name": "cpe",                             //ENUM  
  "dtype": "string"                                //ENUM  
}
```

2.2.3. Structured Information

Information provided in a form of structured string, such as ID, or structured information, such as XML documents, is represented in the information model by the STRUCTUREDINFO data type. Note that this type was originally specified in [\[RFC7203\]](#). The STRUCTUREDINFO data type is implemented as an object with "SpecID", "ext-SpecID", "ContentID", "dtype", "RawData", "Reference" elements. An example for embedding a structured ID is shown below.

```
"StructuredInfo": {  
  "SpecID": "cve",                               //ENUM  
  "ContentID": "CVE-2007-5000"                    //STRING  
}
```

When embedding the raw data, base64 conversion should be used for encoding the data, as shown below.

```
"StructuredInfo": {  
  "SpecID": "oval",                               //ENUM  
  "RawData": "<<<strings encoded with base64>>>" //BYTE  
}
```


[2.2.4.](#) EXTENSION

Information not otherwise represented in the IODEF can be added using the EXTENSION data type. This data type is a generic extension mechanism. The EXTENSION data type is implemented as an ExtensionType object with "value", "name", "dtype", "ext-dtype", "meaning", "formatid", "restriction", "ext-restriction", and "observable-id" elements. An example for embedding a structured ID is shown below.

```
"ExtensionType": {
  "value": "xxxxxxx",           //STRING
  "name": "Syslog",            //STRING
  "dtype": "string",           //ENUM
  "meaning": "Syslog from the security appliance X" //STRING
}
```

[3.](#) IODEF JSON Data Model

[3.1.](#) Classes and Elements

The following table shows the list of IODEF Classes, their elements, and the corresponding section in [\[RFC7970\]](#). Note that the complete JSON schema is defined in [Section 5](#) using CDDL.

IODEF Class	Class Elements and Attribute	Corresponding Section in [RFC7970]
IODEF-Document	version lang? format-id? private-enum-name? private-enum-id? Incident+ AdditionalData*	3.1
Incident	purpose ext-purpose? status? ext-status? lang? restriction? ext-restriction? observable-id? IncidentID AlternativeID?	3.2

	RelatedActivity*	
	DetectTime?	
	StartTime?	
	EndTime?	
	RecoveryTime?	
	ReportTime?	
	GenerationTime	
	Description*	
	Discovery*	
	Assessment*	
	Method*	
	Contact+	
	EventData*	
	Indicator*	
	History?	
	AdditionalData*	
+-----+-----+-----+		
IncidentID	id	3.4
	name	
	instance?	
	restriction?	
	ext-restriction?	
+-----+-----+-----+		
AlternativeID	restriction?	3.5
	ext-restriction?	
	IncidentID+	
+-----+-----+-----+		
RelatedActivity	restriction?	3.6
	ext-restriction?	
	IncidentID*	
	URL *	
	ThreatActor*	
	Campaign*	
	IndicatorID*	
	Confidence?	
	Description*	
	AdditionalData*	
+-----+-----+-----+		
ThreatActor	restriction?	3.7
	ext-restriction?	
	ThreatActorID*	
	URL *	
	Description*	
	AdditionalData*	
+-----+-----+-----+		
Campaign	restriction?	
	ext-restriction?	
	CampaignID*	

	URL*	
	Description*	
	AdditionalData*	3.8
+-----+-----+-----+		
Contact	role	
	ext-role?	
	type	
	ext-type?	
	restriction?	
	ext-restriction?	
	ContactName*,	
	ContactTitle*	
	Description*	
	RegistryHandle*	
	PostalAddress*	
	Email*	
	Telephone*	
	Timezone?	
	Contact*	
	AdditionalData*	3.9
+-----+-----+-----+		
RegistryHandle	handle	
	registry	
	ext-registry?	3.9.1
+-----+-----+-----+		
PostalAddress	type?	
	ext-type?	
	PAddress	
	Description*	3.9.2
+-----+-----+-----+		
Email	type?	
	ext-type?	
	EmailTo	
	Description*	3.9.3
+-----+-----+-----+		
Telephone	type?	
	ext-type?	
	TelephoneNumber	
	Description*	3.9.4
+-----+-----+-----+		
Discovery	source?	
	ext-source?	
	restriction?	
	ext-restriction?	
	Description*	
	Contact*	
	DetectionPattern*	3.10
+-----+-----+-----+		

DetectionPattern	restriction?	3.10.1
	ext-restriction?	
	observable-id?	
	Application	
	Description*	
	DetectionConfiguration*	
+-----+-----+		
Method	restriction?	
	ext-restriction?	
	Reference*	
	Description*	
	AttackPattern*	
	Vulnerability*	
	Weakness*	
	AdditionalData*	3.11
+-----+-----+		
Reference	observable-id?	
	ReferenceName?	
	URL*	
	Description*	3.11.1
+-----+-----+		
Assessment	occurence?	
	restriction?	
	ext-restriction?	
	observable-id?	
	IncidentCategory*	
	SystemImpact*	
	BusinessImpact*	
	TimeImpact*	
	MonetaryImpact*	
	IntendedImpact*	
	Counter*	
	MitigatingFactor*	
	Cause*	
	Confidence?	
	AdditionalData*	3.12
+-----+-----+		
SystemImpact	severity?	
	completion?	
	type	
	ext-type?	
	Description*	3.12.1
+-----+-----+		
BusinessImpact	severity?	
	ext-severity?	
	type	
	ext-type?	
	Description*	3.12.2

TimeImpact	value	
	severity?	
	metric	
	ext-metric?	
	duration?	
	ext-duration?	3.12.3
MonetaryImpact	value	
	severity?	
	currency?	3.12.4
Confidence	value	
	rating	
	ext-rating?	3.12.5
History	restriction?	
	ext-restriction?	
	HistoryItem+	3.13
HistoryItem	action	
	ext-action?	
	restriction?	
	ext-restriction?	
	observable-id?	
	DateTime	
	IncidentID?	
	Contact?	
	Description*	
	DefinedCOA*	
	AdditionalData*	3.13.1
EventData	restriction?	
	ext-restriction?	
	observable-id?	
	Description*	
	DetectTime?	
	StartTime?	
	EndTime?	
	RecoveryTime?	
	ReportTime?	
	Contact*	
	Discovery*	
	Assessment?	
	Method*	
	System*	
	Expectation*	
	RecordData*	

	EventData*	
	AdditionalData*	3.14
+-----+-----+-----+		
Expectation	action?	
	ext-action?	
	severity?	
	restriction?	
	ext-restriction?	
	observable-id?	
	Description*	
	DefinedCOA*	
	StartTime?	
	EndTime?	
	Contact?	3.15
+-----+-----+-----+		
System	category?	
	ext-category?	
	interface?	
	spoofed?	
	virtual?	
	ownership?	
	ext-ownership?	
	restriction?	
	ext-restriction?	
	Node	
	NodeRole*	
	Service*	
	OperatingSystem*	
	Counter*	
	AssetID*	
	Description*	
	AdditionalData*	3.17
+-----+-----+-----+		
Node	DomainData*	
	Address*	
	PostalAddress?	
	Location*	
	Counter*	3.18
+-----+-----+-----+		
Address	value	
	category	
	ext-category?	
	vlan-name?	
	vlan-num?	
	observable-id?	3.18.1
+-----+-----+-----+		
NodeRole	category	
	ext-category?	

	Description*	3.18.2	
Counter	value		
	type		
	ext-type?		
	unit		
	ext-unit?		
	meaning?		
	duration?		
	ext-duration?	3.18.3	
DomainData	system-status		
	ext-system-status?		
	domain-status		
	ext-domain-status?		
	observable-id?		
	Name		
	DateDomainWasChecked?		
	RegistrationDate?		
	ExpirationDate?		
	RelatedDNS*		
	Nameservers*		
	DomainContacts?	3.19	
Nameserver	Server		
	Address*	3.19.1	
DomainContacts	SameDomainContact?		
	Contact+	3.19.2	
Service	ip-protocol?		
	observable-id?		
	ServiceName?		
	Port?		
	Portlist?		
	ProtoCode?		
	ProtoType?		
	ProtoField?		
	ApplicationHeaderField*		
	EmailData?		
	Application?	3.20	
ServiceName	IANAService?		
	URL*		
	Description*	3.20.1	
EmailData	observable-id?		
	EmailTo*		

	EmailFrom?		
	EmailSubject?		
	EmailX-Mailer?		
	EmailHeaderField*		
	EmailHeaders?		
	EmailBody?		
	EmailMessage?		
	HashData*		
	Signature*	3.21	
+-----+-----+-----+			
RecordData	restriction?		
	ext-restriction?		
	observable-id?		
	DateTime?		
	Description*		
	Application?		
	RecordPattern*		
	RecordItem*		
	URL*		
	FileData*		
	WindowsRegistryKeysModified*		
	CertificateData*		
	AdditionalData*	3.22.1	
+-----+-----+-----+			
RecordPattern	type		
	ext-type?		
	offset?		
	offsetunit?		
	ext-offsetunit?		
	instance?		
	value	3.22.2	
+-----+-----+-----+			
WindowsRegistryKeysModified	observable-id?	3.23	
	Key+		
+-----+-----+-----+			
Key	registryaction?		
	ext-registryaction?		
	observable-id?		
	KeyName		
	KeyValue?	3.23.1	
+-----+-----+-----+			
CertificateData	restriction?		
	ext-restriction?		
	observable-id?		
	Certificate+	3.24	
+-----+-----+-----+			
Certificate	observable-id?		
	X509Data		

	Description*	3.24.1	
FileData	restriction?		
	ext-restriction?		
	observable-id?		
	File+	3.25	
File	observable-id?		
	FileName?		
	FileSize?		
	FileType?		
	URL *		
	HashData?		
	Signature*		
	AssociatedSoftware?		
	FileProperties*	3.25.1	
HashData	scope		
	HashTargetID?		
	Hash*		
	FuzzyHash*	3.26	
Hash	DigestMethod		
	DigestValue		
	CanonicalizationMethod?		
	Application?	3.26.1	
FuzzyHash	FuzzyHashValue+		
	Application?		
	AdditionalData*	3.26.2	
Indicator	restriction?		
	ext-restriction?		
	IndicatorID		
	AlternativeIndicatorID*		
	Description*		
	StartTime?		
	EndTime?		
	Confidence?		
	Contact*		
	Observable?		
	uid-ref?		
	IndicatorExpression?		
	IndicatorReference?		
	NodeRole*		
	AttackPhase*		
	Reference*		
	AdditionalData*	3.29	

IndicatorID	id		
	name		
	version	3.29.1	
AlternativeIndicatorID	restriction?		
	ext-restriction?		
	IndicatorID+	3.29.2	
Observable	restriction?		
	ext-restriction?		
	System?		
	Address?		
	DomainData?		
	Service?		
	EmailData?		
	WindowsRegistryKeysModified?		
	FileData?		
	CertificateData?		
	RegistryHandle?		
	RecordData?		
	EventData?		
	Incident?		
	Expectation?		
	Reference?		
	Assessment?		
	DetectionPattern?		
	HistoryItem?		
	BulkObservable?		
	AdditionalData*	3.29.3	
BulkObservable	type?		
	ext-type?		
	BulkObservableFormat?		
	BulkObservableList		
	AdditionalData*	3.29.4	
BulkObservableFormat	Hash?		
	AdditionalData*	3.29.5	
IndicatorExpression	operator?		
	ext-operator?		
	IndicatorExpression*		
	Observable*		
	uid-ref*		
	IndicatorReference*		
	Confidence?		
	AdditionalData*	3.29.6	

IndicatorReference	uid-ref?		
	euid-ref?		
	version?	3.29.7	
AttackPhase	AttackPhaseID*		
	URL*		
	Description*		
	AdditionalData*	3.29.8	

Figure 3: IODEF Classes

3.2. Mapping between CBOR/JSON and XML IODEF

- o This document treats attributes and elements of each class defined in [RFC7970] equally and is agnostic on the order of their appearances.
- o Flow class is deleted, and classes with its instances now directly have instances of EventData class that used to belong to the Flow classes.
- o ApplicationHeader class is deleted, and classes with its instances now directly have instances of ApplicationHeaderField class that used to belong to the ApplicationHeader class.
- o SignatureData class is deleted, and classes with its instances now directly have instance of Signature class that used to belong to the SignatureData class.
- o IndicatorData class is deleted, and classes with its instances now directly have the instances of Indicator class that used to belong to the IndicatorData class.
- o ObservableReference class is deleted, and classes with its instances now directly have uid-ref as an element.
- o Record class is replaced by RecordData class, and RecordData class is renamed to Record class.
- o Record class is deleted, and classes with its instances now directly have the instances of RecordData class that used to belong to the Record class.
- o The MLStringType were modified to support simple string by allowing the type to have not only a predefined object type but

also text type, in order to allow simple descriptions of elements of the type.

- o The elements of ML_STRING type in XML IODEF document are presented as either STRING type or ML_STRING type in CBOR/JSON IODEF document.
- o Data models of the extension classes defined by [\[RFC7203\]](#) and referenced by [\[RFC7970\]](#) are represented by StructuredInfo class defined in this document.
- o Signature, X509Data, and RawData are encoded with base64 and are represented as string (BYTE type) in CBOR/JSON IODEF documents.

4. Examples

This section provides examples of IODEF documents. These examples do not represent the full capabilities of the data model or the only way to encode particular information.

4.1. Minimal Example

A document containing only the mandatory elements and attributes is shown below in JSON and CBOR, respectively.

```
{
  "version": "2.0",
  "lang": "en",
  "Incident": [{
    "purpose": "reporting",
    "restriction": "private",
    "IncidentID": {
      "id": "492382",
      "name": "csirt.example.com"
    },
    "GenerationTime": "2015-07-18T09:00:00-05:00",
    "Contact": [{
      "type": "organization",
      "role": "creator",
      "Email": [{"EmailTo": "contact@csirt.example.com"}]
    }]
  }]
}
```

Figure 4: A Minimal Example in JSON

```
A3                                     # map(3)
67                                     # text(7)
```



```
76657273696F6E      # "version"
63                    # text(3)
322E30                # "2.0"
64                    # text(4)
6C616E67              # "lang"
62                    # text(2)
656E                  # "en"
68                    # text(8)
496E636964656E74     # "Incident"
81                    # array(1)
A5                    # map(5)
67                    # text(7)
707572706F7365       # "purpose"
69                    # text(9)
7265706F7274696E67   # "reporting"
6B                    # text(11)
7265737472696374696F6E # "restriction"
67                    # text(7)
70726976617465       # "private"
6A                    # text(10)
496E636964656E744944 # "IncidentID"
A2                    # map(2)
62                    # text(2)
6964                  # "id"
66                    # text(6)
343932333832         # "492382"
64                    # text(4)
6E616D65             # "name"
71                    # text(17)
63736972742E6578616D706C652E636F6D # "csirt.example.com"
6E                    # text(14)
47656E65726174696F6E54696D65 # "GenerationTime"
C0                    # tag(0)
78 19                # text(25)
323031352D30372D31385430393A30303A30302D30353A3030
# "2015-07-18T09:00:00-05:00"
67                    # text(7)
436F6E74616374       # "Contact"
81                    # array(1)
A3                    # map(3)
64                    # text(4)
74797065             # "type"
6C                    # text(12)
6F7267616E697A6174696F6E # "organization"
64                    # text(4)
726F6C65             # "role"
67                    # text(7)
63726561746F72       # "creator"
```


65	# text(5)
456D61696C	# "Email"
81	# array(1)
A1	# map(1)
67	# text(7)
456D61696C546F	# "EmailTo"
78 19	# text(25)
636F6E746163744063736972742E6578616D706C652E636F6D	# "contact@csirt.example.com"

Figure 5: A Minimal Example in CBOR

4.2. Indicators from a Campaign

An example of C2 domains from a given campaign is shown below in JSON and CBOR, respectively.

```
{
  "version": "2.0",
  "lang": "en",
  "Incident": [{
    "purpose": "watch",
    "restriction": "green",
    "IncidentID": {
      "id": "897923",
      "name": "csirt.example.com"
    }
  },
  "RelatedActivity": [{
    "ThreatActor": [{
      "ThreatActorID": ["TA-12-AGGRESSIVE-BUTTERFLY"],
      "Description": ["Aggressive Butterfly"]}
    ],
    "Campaign": [{
      "CampaignID": ["C-2015-59405"],
      "Description": ["Orange Giraffe"]
    }
  ]
}],
  "GenerationTime": "2015-10-02T11:18:00-05:00",
  "Description": ["Summarizes the Indicators of Compromise for the
    Orange Giraffe campaign of the Aggressive Butterfly crime gang."],
  "Assessment": [{
    "Impact": [{"BusinessImpact": {"type": "breach-proprietary"}}]
  }],
  "Contact": [{
    "type": "organization",
    "role": "creator",
    "ContactName": ["CSIRT for example.com"],
    "Email": [{
```



```

    "EmailTo": "contact@csirt.example.com"
  }
},
"Indicator": [{
  "IndicatorID": {
    "id": "G90823490",
    "name": "csirt.example.com",
    "version": "1"
  },
  "Description": ["C2 domains"],
  "StartTime": "2014-12-02T11:18:00-05:00",
  "Observable": {
    "BulkObservable": {
      "type": "ipv6-addr",
      "BulkObservableList": "kj290023j09r34.example.com"
    }
  }
}]
}]
}

```

Figure 6: Indicators from a Campaign in JSON

A3	# map(3)
67	# text(7)
76657273696F6E	# "version"
63	# text(3)
322E30	# "2.0"
64	# text(4)
6C616E67	# "lang"
62	# text(2)
656E	# "en"
68	# text(8)
496E636964656E74	# "Incident"
81	# array(1)
A9	# map(9)
67	# text(7)
707572706F7365	# "purpose"
65	# text(5)
7761746368	# "watch"
6B	# text(11)
7265737472696374696F6E	# "restriction"
65	# text(5)
677265656E	# "green"
6A	# text(10)
496E636964656E744944	# "IncidentID"
A2	# map(2)
62	# text(2)
6964	# "id"


```
66                                     # text(6)
    383937393233                     # "897923"
64                                     # text(4)
    6E616D65                         # "name"
71                                     # text(17)
    63736972742E6578616D706C652E636F6D # "csirt.example.com"
6F                                     # text(15)
    52656C617465644163746976697479 # "RelatedActivity"
81                                     # array(1)
    A2                               # map(2)
    6B                               # text(11)
    5468726561744163746F72         # "ThreatActor"
    81                               # array(1)
    A2                               # map(2)
    6D                               # text(13)
    5468726561744163746F724944 # "ThreatActorID"
    81                               # array(1)
    78 1A                           # text(26)
    54412D31322D414747524553534956452D425554544552464
    C59                             # "TA-12-AGGRESSIVE-BUTTERFLY"
    6B                               # text(11)
    4465736372697074696F6E        # "Description"
    81                               # array(1)
    74                               # text(20)
    4167677265737369766520427574746572666C79
    # "Aggressive Butterfly"
68                                     # text(8)
    43616D706169676E              # "Campaign"
81                                     # array(1)
    A2                               # map(2)
    6A                               # text(10)
    43616D706169676E4944 # "CampaignID"
    81                               # array(1)
    6C                               # text(12)
    432D323031352D3539343035 # "C-2015-59405"
    6B                               # text(11)
    4465736372697074696F6E        # "Description"
    81                               # array(1)
    6E                               # text(14)
    4F72616E67652047697261666665 # "Orange Giraffe"
6E                                     # text(14)
    47656E65726174696F6E54696D65 # "GenerationTime"
C0                                     # tag(0)
    78 19                           # text(25)
    323031352D31302D30325431313A31383A30302D30353A3030
    # "2015-10-02T11:18:00-05:00"
6B                                     # text(11)
    4465736372697074696F6E        # "Description"
```



```
81                                # array(1)
  78 6F                          # text(111)
    53756D6D6172697A65732074686520496E64696361746F7273206F6620436
    F6D70726F6D69736520666F7220746865204F72616E676520476972616666
    652063616D706169676E206F6620746865204167677265737369766520427
    574746572666C79206372696D652067616E672E
    # "Summarizes the Indicators of Compromise for the Orange
    Giraffe campaign of the Aggressive Butterfly crime gang."
6A                                # text(10)
  4173736573736D656E74          # "Assessment"
81                                # array(1)
  A1                              # map(1)
    66                          # text(6)
      496D70616374            # "Impact"
    81                          # array(1)
      A1                       # map(1)
        6E                    # text(14)
          427573696E657373496D70616374 # "BusinessImpact"
        A1                     # map(1)
          64                   # text(4)
            74797065          # "type"
          72                   # text(18)
            6272656163682D70726F7072696574617279
                                # "breach-proprietary"
67                                # text(7)
  436F6E74616374              # "Contact"
81                                # array(1)
  A4                            # map(4)
    64                          # text(4)
      74797065                # "type"
    6C                          # text(12)
      6F7267616E697A6174696F6E # "organization"
    64                          # text(4)
      726F6C65                # "role"
    67                          # text(7)
      63726561746F72          # "creator"
    6B                          # text(11)
      436F6E746163744E616D65  # "ContactName"
    81                          # array(1)
      75                       # text(21)
        435349525420666F72206578616D706C652E636F6D
                                # "CSIRT for example.com"
    65                          # text(5)
      456D61696C              # "Email"
    81                          # array(1)
      A1                       # map(1)
        67                    # text(7)
          456D61696C546F      # "EmailTo"
```



```
78 19 # text(25)
636F6E746163744063736972742E6578616D706C652E636F6D
# "contact@csirt.example.com"
69 # text(9)
496E64696361746F72 # "Indicator"
81 # array(1)
A4 # map(4)
6B # text(11)
496E64696361746F724944 # "IndicatorID"
A3 # map(3)
62 # text(2)
6964 # "id"
69 # text(9)
473930383233343930 # "G90823490"
64 # text(4)
6E616D65 # "name"
71 # text(17)
63736972742E6578616D706C652E636F6D
# "csirt.example.com"
67 # text(7)
76657273696F6E # "version"
61 # text(1)
31 # "1"
6B # text(11)
4465736372697074696F6E # "Description"
81 # array(1)
6A # text(10)
433220646F6D61696E73 # "C2 domains"
69 # text(9)
537461727454696D65 # "StartTime"
C0 # tag(0)
78 19 # text(25)
323031342D31322D30325431313A31383A30302D30353A3030
# "2014-12-02T11:18:00-05:00"
6A # text(10)
4F627365727661626C65 # "Observable"
A1 # map(1)
6E # text(14)
42756C6B4F627365727661626C65 # "BulkObservable"
A2 # map(2)
64 # text(4)
74797065 # "type"
69 # text(9)
697076362D61646472 # "ipv6-addr"
72 # text(18)
42756C6B4F627365727661626C654C697374
# "BulkObservableList"
78 1A # text(26)
```



```

6B6A3239303032336A30397233342E6578616D706C652E636F6D
# "kj290023j09r34.example.com"

```

Figure 7: Indicators from a Campaign in CBOR

5. The IODEF Data Model (CDDL)

```

start = iodef

;;; iodef.json: IODEF-Document

iodef = {
  version: text
  ? lang: lang
  ? format-id: text
  ? private-enum-name: text
  ? private-enum-id: text
  Incident: [+ Incident]
  ? AdditionalData: [+ ExtensionType]
}

duration = "second" / "minute" / "hour" / "day" / "month" / "quarter" /
  "year" / "ext-value"
lang = "" / text .regexp "[a-zA-Z]{1,8}(-[a-zA-Z0-9]{1,8})*"

restriction = "public" / "partner" / "need-to-know" / "private" /
  "default" / "white" / "green" / "amber" / "red" /
  "ext-value"

SpecID = "urn:ietf:params:xml:ns:mile:mmdef:1.2" / "private"
IDtype = text .regexp "[a-zA-Z_][a-zA-Z0-9_.-]*"
IDREFType = IDtype
URLtype = uri
TimeZonetype = text .regexp "Z[\\+\\-](0[0-9]|1[0-4]):[0-5][0-9]"
PortlistType = text .regexp "\\d+(\\-\\d+)?(,\\d+(\\-\\d+)?)*"
action = "nothing" / "contact-source-site" / "contact-target-site" /
  "contact-sender" / "investigate" / "block-host" /
  "block-network" / "block-port" / "rate-limit-host" /
  "rate-limit-network" / "rate-limit-port" / "redirect-traffic" /
  "honeypot" / "upgrade-software" / "rebuild-asset" /
  "harden-asset" / "remediate-other" / "status-triage" /
  "status-new-info" / "watch-and-report" / "training" /
  "defined-coa" / "other" / "ext-value"

DATETIME = tdate

BYTE = eb64legacy

MLStringType = {

```



```
    value: text
    ? lang: lang
    ? translation-id: text
} / text
```

```
PositiveFloatType = float32 .gt 0
```

```
PAddressType = MLStringType
```

```
ExtensionType = {
  value: text
  ? name: text
  dtype: "boolean" / "byte" / "bytes" / "character" / "date-time" /
        "ntpstamp" / "integer" / "portlist" / "real" / "string" /
        "file" / "path" / "frame" / "packet" / "ipv4-packet" / "json"/
        "ipv6-packet" / "url" / "csv" / "winreg" / "xml" / "ext-value"
        .default "string"
  ? ext-dtype: text
  ? meaning: text
  ? formatid: text
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  ? observable-id: IDtype
}
```

```
SoftwareType = {
  ? SoftwareReference: SoftwareReference
  ? URL: [+ URLtype]
  ? Description: [+ MLStringType]
}
```

```
SoftwareReference = {
  ? value: text
  spec-name: "custom" / "cpe" / "swid" / "ext-value"
  ? ext-spec-name: text
  ? dtype: "bytes" / "integer" / "real" / "string" / "xml" / "ext-value"
        .default "string"
  ? ext-dtype: text
}
```

```
Incident = {
  purpose: "traceback" / "mitigation" / "reporting" / "watch" / "other" /
        "ext-value"
  ? ext-purpose: text
  ? status: "new" / "in-progress"/ "forwarded" / "resolved" / "future" /
        "ext-value"
  ? ext-status: text
  ? lang: lang
```



```
? restriction: restriction .default "private"
? ext-restriction: text
? observable-id: IDtype
IncidentID: IncidentID
? AlternativeID: AlternativeID
? RelatedActivity: [+ RelatedActivity]
? DetectTime: DATETIME
? StartTime: DATETIME
? EndTime: DATETIME
? RecoveryTime: DATETIME
? ReportTime: DATETIME
GenerationTime: DATETIME
? Description: [+ MLStringType]
? Discovery: [+ Discovery]
? Assessment: [+ Assessment]
? Method: [+ Method]
Contact: [+ Contact]
? EventData: [+ EventData]
? Indicator: [+ Indicator]
? History: History
? AdditionalData: [+ ExtensionType]
}
```

```
IncidentID = {
  id: text
  name: text
  ? instance: text
  ? restriction: restriction .default "private"
  ? ext-restriction: text
}
```

```
AlternativeID = {
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  IncidentID: [+ IncidentID]
}
```

```
RelatedActivity = {
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  ? IncidentID: [+ IncidentID]
  ? URL: [+ URLtype]
  ? ThreatActor: [+ ThreatActor]
  ? Campaign: [+ Campaign]
  ? IndicatorID: [+ IndicatorID]
  ? Confidence: Confidence
  ? Description: [+ text]
  ? AdditionalData: [+ ExtensionType]
```



```
}
```

```
ThreatActor = {  
  ? restriction: restriction .default "private"  
  ? ext-restriction: text  
  ? ThreatActorID: [+ text]  
  ? URL: [+ URLtype]  
  ? Description: [+ MLStringType]  
  ? AdditionalData: [+ ExtensionType]  
}
```

```
Campaign = {  
  ? restriction: restriction .default "private"  
  ? ext-restriction: text  
  ? CampaignID: [+ text]  
  ? URL: [+ URLtype]  
  ? Description: [+ MLStringType]  
  ? AdditionalData: [+ ExtensionType]  
}
```

```
Contact = {  
  role: "creator" / "reporter" / "admin" / "tech" / "provider" / "user" /  
    "billing" / "legal" / "irt" / "abuse" / "cc" / "cc-irt" / "leo" /  
    "vendor" / "vendor-support" / "victim" / "victim-notified" /  
    "ext-value"  
  ? ext-role: text  
  type: "person" / "organization" / "ext-value"  
  ? ext-type: text  
  ? restriction: restriction .default "private"  
  ? ext-restriction: text  
  ? ContactName: [+ MLStringType]  
  ? ContactTitle: [+ MLStringType]  
  ? Description: [+ MLStringType]  
  ? RegistryHandle: [+ RegistryHandle]  
  ? PostalAddress: [+ PostalAddress]  
  ? Email: [+ Email]  
  ? Telephone: [+ Telephone]  
  ? Timezone: TimeZonetype  
  ? Contact: [+ Contact]  
  ? AdditionalData: [+ ExtensionType]  
}
```

```
RegistryHandle = {  
  handle: text  
  registry: "internic" / "apnic" / "arin" / "lacnic" / "ripe" /  
    "afrinic" / "local" / "ext-value"  
  ? ext-registry: text  
}
```



```
PostalAddress = {  
  ? type: "street" / "mailing" / "ext-value"  
  ? ext-type: text  
  PAddress: PAddressType  
  ? Description: [+ MLStringType]  
}
```

```
Email = {  
  ? type: "direct" / "hotline" / "ext-value"  
  ? ext-type: text  
  EmailTo: text  
  ? Description: [+ MLStringType]  
}
```

```
Telephone = {  
  ? type: "wired" / "mobile" / "fax" / "hotline" / "ext-value"  
  ? ext-type: text  
  TelephoneNumber: text  
  ? Description: [+ MLStringType]  
}
```

```
Discovery = {  
  ? source: "nidsps" / "hips" / "siem" / "av" / "third-party-monitoring" /  
    "incident" / "os-log" / "application-log" / "device-log" /  
    "network-flow" / "passive-dns" / "investigation" / "audit" /  
    "internal-notification" / "external-notification" /  
    "leo" / "partner" / "actor" / "unknown" / "ext-value"  
  ? ext-source: text  
  ? restriction: restriction .default "private"  
  ? ext-restriction: text  
  ? Description: [+ MLStringType]  
  ? Contact: [+ Contact]  
  ? DetectionPattern: [+ DetectionPattern]  
}
```

```
DetectionPattern = {  
  ? restriction: restriction .default "private"  
  ? ext-restriction: text  
  ? observable-id: IDtype  
  (Description: [+ MLStringType] // DetectionConfiguration: [+ text])  
  Application: SoftwareType  
}
```

```
Method = {  
  ? restriction: restriction .default "private"  
  ? ext-restriction: text  
  ? Reference: [+ Reference]  
  ? Description: [+ MLStringType]
```



```
? AttackPattern: [+ StructuredInfo]
? Vulnerability: [+ StructuredInfo]
? Weakness: [+ StructuredInfo]
? AdditionalData: [+ ExtensionType]
```

```
}
```

```
StructuredInfo = {
  SpecID: SpecID
  ? ext-SpecID: text
  ? ContentID: text
  ? (RawData: [+ BYTE] // Reference:[+ Reference])
  ? Platform:[+ Platform]
  ? Scoring:[+ Scoring]
}
```

```
Platform = {
  SpecID: SpecID
  ? ext-SpecID: text
  ? ContentID: text
  ? RawData: [+ BYTE]
  ? Reference: [+ Reference]
}
```

```
Scoring = {
  SpecID: SpecID
  ? ext-SpecID: text
  ? ContentID: text
  ? RawData: [+ BYTE]
  ? Reference: [+ Reference]
}
```

```
Reference = {
  ? observable-id: IDtype
  ? ReferenceName: ReferenceName
  ? URL: [+ URLtype]
  ? Description: [+ MLStringType]
}
```

```
ReferenceName = {
  specIndex: integer
  ID: IDtype
}
```

```
Assessment = {
  ? occurrence: "actual" / "potential"
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  ? observable-id: IDtype
  ? IncidentCategory: [+ MLStringType]
  Impact: [+ {SystemImpact: SystemImpact} /
```



```
        {BusinessImpact: BusinessImpact} / {TimeImpact: TimeImpact} /
        {MonetaryImpact: MonetaryImpact} /
        {IntendedImpact: BusinessImpact}]
? Counter: [+ Counter]
? MitigatingFactor: [+ MLStringType]
? Cause: [+ MLStringType]
? Confidence: Confidence
? AdditionalData: [+ ExtensionType]
}
```

```
SystemImpact = {
? severity: "low" / "medium" / "high"
? completion: "failed" / "succeeded"
type: "takeover-account" / "takeover-service" / "takeover-system" /
      "cps-manipulation" / "cps-damage" / "availability-data" /
      "availability-account" / "availability-service" /
      "availability-system" / "damaged-system" / "damaged-data" /
      "breach-proprietary" / "breach-privacy" / "breach-credential" /
      "breach-configuration" / "integrity-data" /
      "integrity-configuration" / "integrity-hardware" /
      "traffic-redirection" / "monitoring-traffic" / "monitoring-host" /
      "policy" / "unknown" / "ext-value" .default "unknown"
? ext-type: text
? Description: [+ MLStringType]
}
```

```
BusinessImpact = {
? severity: "none" / "low" / "medium" / "high" / "unknown" / "ext-value"
      .default "unknown"
? ext-severity: text
type: "breach-proprietary" / "breach-privacy" / "breach-credential" /
      "loss-of-integrity" / "loss-of-service" / "theft-financial" /
      "theft-service" / "degraded-reputation" / "asset-damage" /
      "asset-manipulation" / "legal" / "extortion" / "unknown" /
      "ext-value" .default "unknown"
? ext-type: text
? Description: [+ MLStringType]
}
```

```
TimeImpact = {
value: PositiveFloatType
? severity: "low" / "medium" / "high"
metric: "labor" / "elapsed" / "downtime" / "ext-value"
? ext-metric: text
? duration: duration .default "hour"
? ext-duration: text
}
```



```
MonetaryImpact = {  
  value: PositiveFloatType  
  ? severity: "low" / "medium" / "high"  
  ? currency: text  
}
```

```
Confidence = {  
  value: float32  
  rating: "low" / "medium" / "high" / "numeric" / "unknown" / "ext-value"  
  ? ext-rating: text  
}
```

```
History = {  
  ? restriction: restriction .default "private"  
  ? ext-restriction: text  
  HistoryItem: [+ HistoryItem]  
}
```

```
HistoryItem = {  
  action: action .default "other"  
  ? ext-action: text  
  ? restriction: restriction .default "private"  
  ? ext-restriction: text  
  ? observable-id: IDtype  
  DateTime: DATETIME  
  ? IncidentID: IncidentID  
  ? Contact: Contact  
  ? Description: [+ MLStringType]  
  ? DefinedCOA: [+ text]  
  ? AdditionalData: [+ ExtensionType]  
}
```

```
EventData = {  
  ? restriction: restriction .default "default"  
  ? ext-restriction: text  
  ? observable-id: IDtype  
  ? Description: [+ MLStringType]  
  ? DetectTime: DATETIME  
  ? StartTime: DATETIME  
  ? EndTime: DATETIME  
  ? RecoveryTime: DATETIME  
  ? ReportTime: DATETIME  
  ? Contact: [+ Contact]  
  ? Discovery: [+ Discovery]  
  ? Assessment: Assessment  
  ? Method: [+ Method]  
  ? System: [+ System]  
  ? Expectation: [+ Expectation]
```



```
? RecordData: [+ RecordData]
? EventData: [+ EventData]
? AdditionalData: [+ ExtensionType]
}
```

```
Expectation = {
  ? action: action .default "other"
  ? ext-action: text
  ? severity: "low" / "medium" / "high"
  ? restriction: restriction .default "default"
  ? ext-restriction: text
  ? observable-id: IDtype
  ? Description: [+ MLStringType]
  ? DefinedCOA: [+ text]
  ? StartTime: DATETIME
  ? EndTime: DATETIME
  ? Contact: Contact
}
```

```
System = {
  ? category: "source" / "target" / "intermediate" / "sensor" /
    "infrastructure" / "ext-value"
  ? ext-category: text
  ? interface: text
  ? spoofed: "unknown" / "yes" / "no" .default "unknown"
  ? virtual: "yes" / "no" / "unknown" .default "unknown"
  ? ownership: "organization" / "personal" / "partner" / "customer" /
    "no-relationship" / "unknown" / "ext-value"
  ? ext-ownership: text
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  ? observable-id: IDtype
  Node: Node
  ? NodeRole: [+ NodeRole]
  ? Service: [+ Service]
  ? OperatingSystem: [+ SoftwareType]
  ? Counter: [+ Counter]
  ? AssetID: [+ text]
  ? Description: [+ MLStringType]
  ? AdditionalData: [+ ExtensionType]
}
```

```
Node = {
  (DomainData:[+ DomainData]
  ? Address:[+ Address] //
  ? DomainData:[+ DomainData]
  Address:[+ Address])
  ? PostalAddress: PostalAddress
```



```
? Location: [+ MLStringType]
? Counter: [+ Counter]
}
```

```
Address = {
  value: text
  category: "asn" / "atm" / "e-mail" / "ipv4-addr" / "ipv4-net" /
    "ipv4-net-masked" / "ipv4-net-mask" / "ipv6-addr" /
    "ipv6-net" / "ipv6-net-masked" / "mac" / "site-uri" /
    "ext-value" .default "ipv6-addr"
  ? ext-category: text
  ? vlan-name: text
  ? vlan-num: integer
  ? observable-id: IDtype
}
```

```
NodeRole = {
  category: "client" / "client-enterprise" / "client-partner" /
    "client-remote" / "client-kiosk" / "client-mobile" /
    "server-internal" / "server-public" / "www" / "mail" /
    "webmail" / "messaging" / "streaming" / "voice" / "file" /
    "ftp" / "p2p" / "name" / "directory" / "credential" /
    "print" / "application" / "database" / "backup" / "dhcp" /
    "assessment" / "source-control" / "config-management" /
    "monitoring" / "infra" / "infra-firewall" / "infra-router" /
    "infra-switch" / "camera" / "proxy" / "remote-access" /
    "log" / "virtualization" / "pos" / "scada" /
    "scada-supervisory" / "sinkhole" / "honeypot" /
    "anonymization" / "c2-server" / "malware-distribution" /
    "drop-server" / "hop-point" / "reflector" /
    "phishing-site" / "spear-phishing-site" / "recruiting-site" /
    "fraudulent-site" / "ext-value"
  ? ext-category: text
  ? Description: [+ MLStringType]
}
```

```
Counter = {
  value: float32
  type: "count" / "peak" / "average" / "ext-value"
  ? ext-type: text
  unit: "byte" / "mbit" / "packet" / "flow" / "session" / "alert" /
    "message" / "event" / "host" / "site" / "organization" /
    "ext-value"
  ? ext-unit: text
  ? meaning: text
  ? duration: duration .default "hour"
  ? ext-duration: text
}
```



```
DomainData = {
  system-status: "spoofed" / "fraudulent" / "innocent-hacked" /
    "innocent-hijacked" / "unknown" / "ext-value"
  ? ext-system-status: text
  domain-status: "reservedDelegation" / "assignedAndActive" /
    "assignedAndInactive" / "assignedAndOnHold" /
    "revoked" / "transferPending" / "registryLock" /
    "registrarLock" / "other" / "unknown" / "ext-value"
  ? ext-domain-status: text
  ? observable-id: IDtype
  Name: text
  ? DateDomainWasChecked: DATETIME
  ? RegistrationDate: DATETIME
  ? ExpirationDate: DATETIME
  ? RelatedDNS: [+ ExtensionType]
  ? NameServers: [+ NameServers]
  ? DomainContacts: DomainContacts
}
```

```
NameServers = {
  Server: text
  Address: [+ Address]
}
```

```
DomainContacts = {
  (SameDomainContact: text // Contact: [+ Contact])
}
```

```
Service = {
  ? ip-protocol: integer
  ? observable-id: IDtype
  ? ServiceName: ServiceName
  ? Port: integer
  ? Portlist: PortlistType
  ? ProtoCode: integer
  ? ProtoType: integer
  ? ProtoField: integer
  ? ApplicationHeaderField: [+ ExtensionType]
  ? EmailData: EmailData
  ? Application: SoftwareType
}
```

```
ServiceName = {
  ? IANAService: text
  ? URL: [+ URLtype]
  ? Description: [+ MLStringType]
}
```



```
EmailData = {  
  ? observable-id: IDtype  
  ? EmailTo: [+ text]  
  ? EmailFrom: text  
  ? EmailSubject: text  
  ? EmailX-Mailer: text  
  ? EmailHeaderField: [+ ExtensionType]  
  ? EmailHeaders: text  
  ? EmailBody: text  
  ? EmailMessage: text  
  ? HashData: [+ HashData]  
  ? Signature: [+ BYTE]  
}
```

```
RecordData = {  
  ? restriction: restriction .default "private"  
  ? ext-restriction: text  
  ? observable-id: IDtype  
  ? DateTime: DATETIME  
  ? Description: [+ MLStringType]  
  ? Application: SoftwareType  
  ? RecordPattern: [+ RecordPattern]  
  ? RecordItem: [+ ExtensionType]  
  ? URL: [+ URLtype]  
  ? FileData: [+ FileData]  
  ? WindowsRegistryKeysModified: [+ WindowsRegistryKeysModified]  
  ? CertificateData: [+ CertificateData]  
  ? AdditionalData: [+ ExtensionType]  
}
```

```
RecordPattern = {  
  value: text  
  type: "regex" / "binary" / "xpath" / "ext-value" .default "regex"  
  ? ext-type: text  
  ? offset: integer  
  ? offsetunit: "line" / "byte" / "ext-value" .default "line"  
  ? ext-offsetunit: text  
  ? instance: integer  
}
```

```
WindowsRegistryKeysModified = {  
  ? observable-id: IDtype  
  Key: [+ Key]  
}
```

```
Key = {  
  ? registryaction: "add-key" / "add-value" / "delete-key" /  
    "delete-value" / "modify-key" / "modify-value" /
```



```
        "ext-value"
    ? ext-registryaction: text
    ? observable-id: IDtype
    KeyName: text
    ? KeyValue: text
}

CertificateData = {
    ? restriction: restriction .default "private"
    ? ext-restriction: text
    ? observable-id: IDtype
    Certificate: [+ Certificate]
}

Certificate = {
    ? observable-id: IDtype
    X509Data: BYTE
    ? Description: [+ MLStringType]
}

FileData = {
    ? restriction: restriction .default "private"
    ? ext-restriction: text
    ? observable-id: IDtype
    File: [+ File]
}

File = {
    ? observable-id: IDtype
    ? FileName: text
    ? FileSize: integer
    ? FileType: text
    ? URL: [+ URLtype]
    ? HashData: HashData
    ? Signature: [+ BYTE]
    ? AssociatedSoftware: SoftwareType
    ? FileProperties: [+ ExtensionType]
}

HashData = {
    scope: "file-contents" / "file-pe-section" / "file-pe-iat" /
        "file-pe-resource" / "file-pdf-object" / "email-hash" /
        "email-headers-hash" / "email-body-hash" / "ext-value"
    ? HashTargetID: text
    ? Hash: [+ Hash]
    ? FuzzyHash: [+ FuzzyHash]
}
```



```
Hash = {
  DigestMethod: BYTE
  DigestValue: BYTE
  ? CanonicalizationMethod: BYTE
  ? Application: SoftwareType
}

FuzzyHash = {
  FuzzyHashValue: [+ ExtensionType]
  ? Application: SoftwareType
  ? AdditionalData: [+ ExtensionType]
}

Indicator = {
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  IndicatorID: IndicatorID
  ? AlternativeIndicatorID: [+ AlternativeIndicatorID]
  ? Description: [+ MLStringType]
  ? StartTime: DATETIME
  ? EndTime: DATETIME
  ? Confidence: Confidence
  ? Contact: [+ Contact]
  (Observable: Observable // uid-ref: IDREFTType //
   IndicatorExpression: IndicatorExpression //
   IndicatorReference: IndicatorReference)
  ? NodeRole: [+ NodeRole]
  ? AttackPhase: [+ AttackPhase]
  ? Reference: [+ Reference]
  ? AdditionalData: [+ ExtensionType]
}

IndicatorID = {
  id: IDtype
  name: text
  version: text
}

AlternativeIndicatorID = {
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  IndicatorID: [+ IndicatorID]
}

Observable = {
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  ? (System: System // Address: Address // DomainData: DomainData //
```



```
EmailData: EmailData // Service: Service //
WindowsRegistryKeysModified: WindowsRegistryKeysModified //
FileData: FileData // CertificateData: CertificateData //
RegistryHandle: RegistryHandle // RecordData: RecordData //
EventData: EventData // Incident: Incident //
Expectation: Expectation // Reference: Reference //
Assessment: Assessment // DetectionPattern: DetectionPattern //
HistoryItem: HistoryItem // BulkObservable: BulkObservable //
AdditionalData: [+ ExtensionType])
}

BulkObservable = {
  ? type: "asn" / "atm" / "e-mail" / "ipv4-addr" / "ipv4-net" /
    "ipv4-net-mask" / "ipv6-addr" / "ipv6-net" / "ipv6-net-mask" /
    "mac" / "site-uri" / "domain-name" / "domain-to-ipv4" /
    "domain-to-ipv6" / "domain-to-ipv4-timestamp" /
    "domain-to-ipv6-timestamp" / "ipv4-port" / "ipv6-port" /
    "windows-reg-key" / "file-hash" / "email-x-mailer" /
    "email-subject" / "http-user-agent" / "http-request-uri" /
    "mutex" / "file-path" / "user-name" / "ext-value"
  ? ext-type: text
  ? BulkObservableFormat: BulkObservableFormat
  BulkObservableList: text
  ? AdditionalData: [+ ExtensionType]
}

BulkObservableFormat = {
  (Hash: Hash // AdditionalData: [+ ExtensionType])
}

IndicatorExpression = {
  ? operator: "not" / "and" / "or" / "xor" .default "and"
  ? ext-operator: text
  ? IndicatorExpression: [+ IndicatorExpression]
  ? Observable: [+ Observable]
  ? uid-ref: [+ IDREFTYPE]
  ? IndicatorReference: [+ IndicatorReference]
  ? Confidence: Confidence
  ? AdditionalData: [+ ExtensionType]
}

IndicatorReference = {
  (uid-ref: IDREFTYPE // euid-ref: text)
  ? version: text
}

AttackPhase = {
  ? AttackPhaseID: [+ text]
```



```
? URL: [+ URLtype]
? Description: [+ MLStringType]
? AdditionalData: [+ ExtensionType]
}
```

Figure 8: Data Model in CDDL

6. IANA Considerations

This document does not require any IANA actions.

7. Security Considerations

This document does not provide any further security considerations than the one described in [[RFC7970](#)].

8. Acknowledgements

We would like to thank Henk Birkholz, Carsten Bormann, Yasuaki Morita, and Takahiko Nagata for their insightful comments on CDDL.

9. References

9.1. Normative References

- [cddlspec] Henk Birkholz, Christoph Vigano, and Carsten Bormann, "Concise data definition language (CDDL): a notational convention to express CBOR and JSON data structures", 2018.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC7203] Takahashi, T., Landfield, K., and Y. Kadobayashi, "An Incident Object Description Exchange Format (IODEF) Extension for Structured Cybersecurity Information", [RFC 7203](#), DOI 10.17487/RFC7203, April 2014, <<https://www.rfc-editor.org/info/rfc7203>>.
- [RFC7970] Danyliw, R., "The Incident Object Description Exchange Format Version 2", [RFC 7970](#), DOI 10.17487/RFC7970, November 2016, <<https://www.rfc-editor.org/info/rfc7970>>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in [RFC 2119](#) Key Words", [BCP 14](#), [RFC 8174](#), DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.

9.2. Informative References

[jsonschema]

Francis Galiegue, Kris Zyp, and Gary Court, "JSON Schema: core definitions and terminology", 2013.

Appendix A. Data Types used in this document

The CDDL prelude used in this document is mapped to JSON as shown in the table below.

CDDL Prelude	Use of JSON	Instance	Validation
bytes	n/a	string	tool available
text	string	string	unnecessary
tdate	n/a	string	7.3.1 date-time
integer	n/a	number	integer
eb64legacy	n/a	string	tool available
uri	n/a	string	7.3.6 uri
float32	float32	number	unnecessary

Figure 9: CDDL Prelude mapping in JSON

Appendix B. The IODEF Data Model (JSON Schema)

This section provides a JSON schema that defines the IODEF Data Model defined in this draft.

```
{ "$schema": "http://json-schema.org/draft-04/schema#",
  "definitions": {
    "action": { "enum": ["nothing", "contact-source-site",
      "contact-target-site", "contact-sender", "investigate",
      "block-host", "block-network", "block-port", "rate-limit-host",
      "rate-limit-network", "rate-limit-port", "redirect-traffic",
      "honeypot", "upgrade-software", "rebuild-asset", "harden-asset",
      "remediate-other", "status-triage", "status-new-info",
      "watch-and-report", "training", "defined-coa", "other",
      "ext-value"] },
    "duration": { "enum": ["second", "minute", "hour", "day", "month",
      "quarter", "year", "ext-value"] },
    "SpecID": {
      "enum": ["urn:ietf:params:xml:ns:mile:mmdef:1.2", "private"] },
```



```
"lang": {
  "type": "string", "pattern": "^$|[a-zA-Z]{1,8}(-[a-zA-Z0-9]{1,8})*",
  "purpose": {"enum": ["traceback", "mitigation", "reporting", "watch",
    "other", "ext-value"]},
  "restriction": {"enum": ["public", "partner", "need-to-know", "private",
    "default", "white", "green", "amber", "red", "ext-value"]},
  "status": {"enum": ["new", "in-progress", "forwarded", "resolved",
    "future", "ext-value"]},
  "DATETIME": {"type": "string", "format": "date-time"},
  "BYTE": {"type": "string"},
  "PortlistType": {
    "type": "string", "pattern": "\\d+(\\-\\d+)?(,\\d+(\\-\\d+)?)*",
  "TimeZonetype": {
    "type": "string", "pattern": "Z|[\\+\\-](0[0-9]|1[0-4]):[0-5][0-9]",
  "URLtype": {
    "type": "string",
    "pattern":
      "^(([^:/?#]+):)?(//([^/?#]*))?([^?#]*)(\\?([^#]*)?)?(#(.*))?",
  "IDtype": {"type": "string", "pattern": "[a-zA-Z_][a-zA-Z0-9_\\.]*"},
  "IDREFType": {"$ref": "#/definitions/IDtype"},
  "MLStringType": {
    "oneOf": [{"type": "string"},
      {"type": "object",
        "properties": {
          "value": {"type": "string"},
          "lang": {"$ref": "#/definitions/lang"},
          "translation-id": {"type": "string"}},
          "required": ["value"],
          "additionalProperties": false}}],
  "PositiveFloatType": {"type": "number", "minimum": 0},
  "PAddressType": {"$ref": "#/definitions/MLStringType"},
  "ExtensionType": {
    "type": "object",
    "properties": {
      "value": {"type": "string"},
      "name": {"type": "string"},
      "dtype": {"enum": ["boolean", "byte", "bytes", "character", "json",
        "date-time", "ntpstamp", "integer", "portlist", "real", "string",
        "file", "path", "frame", "packet", "ipv4-packet", "ipv6-packet",
        "url", "csv", "winreg", "xml", "ext-value"], "default": "string"},
      "ext-dtype": {"type": "string"},
      "meaning": {"type": "string"},
      "formatid": {"type": "string"},
      "restriction": {
        "$ref": "#/definitions/restriction", "default": "private"},
      "ext-restriction": {"type": "string"},
      "observable-id": {"$ref": "#/definitions/IDtype"}},
    "required": ["value", "dtype"],
```



```
    "additionalProperties":false},
  "ExtensionTypeList": {
    "type": "array",
    "items": {"$ref": "#/definitions/ExtensionType"},
    "minItems": 1},
  "SoftwareType": {
    "type": "object",
    "properties": {
      "SoftwareReference":{"$ref": "#/definitions/SoftwareReference"},
      "URL": {
        "type": "array",
        "items": {"$ref": "#/definitions/URLtype"},
        "minItems": 1}},
      "Description": {
        "type": "array",
        "items": {"$ref": "#/definitions/MLStringType"},
        "minItems": 1 }},
      "required": [],
      "additionalProperties": false},
  "SoftwareReference": {
    "type": "object",
    "properties": {
      "value": {"type": "string"},
      "spec-name": {"enum": ["custom","cpe","swid","ext-value"]},
      "ext-spec-name": {"type": "string"},
      "dtype": {"enum": ["bytes","integer","real","string","xml",
        "ext-value"] , "default": "string"},
      "ext-dtype": {"type": "string"}},
      "required": ["spec-name"],
      "additionalProperties": false},
  "StructuredInfo": {
    "type": "object",
    "properties": {
      "SpecID": {"$ref": "#/definitions/SpecID"},
      "ext-SpecID": {"type": "string"},
      "ContentID": {"type": "string"},
      "RawData": {
        "type": "array",
        "items": {"$ref": "#/definitions/BYTE"},
        "minItems": 1
      },
    },
    "Reference": {
      "type": "array",
      "items": {"$ref": "#/definitions/Reference"},
      "minItems": 1
    },
  },
  "Platform": {
    "type": "array",
```



```
    "items": {"$ref": "#/definitions/Platform"},
    "minItems": 1
  },
  "Scoring": {
    "type": "array",
    "items": {"$ref": "#/definitions/Scoring"},
    "minItems": 1}},
  "allOf": [
    {"required": ["SpecID"]},
    {"anyOf": [
      {"oneOf": [
        {"required": ["Reference"]},
        {"required": ["RawData"]}]}],
      { "not" : {"required": ["Reference", "RawData"]}}}],
  "additionalProperties": false},
"Platform": {
  "type": "object",
  "properties": {
    "SpecID": {"$ref": "#/definitions/SpecID"},
    "ext-SpecID": {"type": "string"},
    "ContentID": {"type": "string"},
    "RawData": {
      "type": "array",
      "items": {"$ref": "#/definitions/BYTE"},
      "minItems": 1
    },
  },
  "Reference": {
    "type": "array",
    "items": {"$ref": "#/definitions/Reference"},
    "minItems": 1}},
  "required": ["SpecID"],
  "additionalProperties": false},
"Scoring": {
  "type": "object",
  "properties": {
    "SpecID": {"$ref": "#/definitions/SpecID"},
    "ext-SpecID": {"type": "string"},
    "ContentID": {"type": "string"},
    "RawData": {
      "type": "array",
      "items": {"$ref": "#/definitions/BYTE"},
      "minItems": 1
    },
  },
  "Reference": {
    "type": "array",
    "items": {"$ref": "#/definitions/Reference"},
    "minItems": 1}},
  "required": ["SpecID"],
```



```
"additionalProperties": false},
"Incident": {
  "title": "Incident",
  "description": "JSON schema for Incident class",
  "type": "object",
  "properties": {
    "purpose": {"$ref": "#/definitions/purpose"},
    "ext-purpose": {"type": "string"},
    "status": {"$ref": "#/definitions/status"},
    "ext-status": {"type": "string"},
    "lang": {"$ref": "#/definitions/lang"},
    "restriction": {"$ref": "#/definitions/restriction",
      "default": "private"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "IncidentID": {"$ref": "#/definitions/IncidentID"},
    "AlternativeID": {"$ref": "#/definitions/AlternativeID"},
    "RelatedActivity": {
      "type": "array",
      "items": {"$ref": "#/definitions/RelatedActivity"},
      "minItems": 1},
    "DetectTime": {"$ref": "#/definitions/DATETIME"},
    "StartTime": {"$ref": "#/definitions/DATETIME"},
    "EndTime": {"$ref": "#/definitions/DATETIME"},
    "RecoveryTime": {"$ref": "#/definitions/DATETIME"},
    "ReportTime": {"$ref": "#/definitions/DATETIME"},
    "GenerationTime": {"$ref": "#/definitions/DATETIME"},
    "Description": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1},
    "Discovery": {
      "type": "array",
      "items": {"$ref": "#/definitions/Discovery"},
      "minItems": 1},
    "Assessment": {
      "type": "array",
      "items": {"$ref": "#/definitions/Assessment"},
      "minItems": 1},
    "Method": {
      "type": "array",
      "items": {"$ref": "#/definitions/Method"},
      "minItems": 1},
    "Contact": {
      "type": "array",
      "items": {"$ref": "#/definitions/Contact"},
      "minItems": 1},
    "EventData": {
```



```
    "type": "array",
    "items": {"$ref": "#/definitions/EventData"},
    "minItems": 1},
  "Indicator": {
    "type": "array",
    "items": {"$ref": "#/definitions/Indicator"},
    "minItems": 1},
  "History": {"$ref": "#/definitions/History"},
  "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": ["IncidentID", "GenerationTime", "Contact", "purpose"],
  "additionalProperties": false},
"IncidentID": {
  "title": "IncidentID",
  "description": "JSON schema for IncidentID class",
  "type": "object",
  "properties": {
    "id": {"type": "string"},
    "name": {"type": "string"},
    "instance": {"type": "string"},
    "restriction": {"$ref": "#/definitions/restriction",
                  "default": "private"},
    "ext-restriction": {"type": "string"}},
  "required": ["id", "name"],
  "additionalProperties": false},
"AlternativeID": {
  "title": "AlternativeID",
  "description": "JSON schema for AlternativeID class",
  "type": "object",
  "properties": {
    "IncidentID": {
      "type": "array",
      "items": {"$ref": "#/definitions/IncidentID"},
      "minItems": 1},
    "restriction": {"$ref": "#/definitions/restriction",
                  "default": "private"},
    "ext-restriction": {"type": "string"}},
  "required": ["IncidentID"],
  "additionalProperties": false},
"RelatedActivity": {
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction",
                  "default": "private"},
    "ext-restriction": {"type": "string"},
    "IncidentID": {
      "type": "array",
      "items": {"$ref": "#/definitions/IncidentID"},
      "minItems": 1},
    "URL": {
```



```
    "type": "array",
    "items": {"$ref": "#/definitions/URLtype"},
    "minItems": 1},
  "ThreatActor": {
    "type": "array",
    "items": {"$ref": "#/definitions/ThreatActor"},
    "minItems": 1},
  "Campaign": {
    "type": "array",
    "items": {"$ref": "#/definitions/Campaign"},
    "minItems": 1},
  "IndicatorID": {
    "type": "array",
    "items": {"$ref": "#/definitions/IndicatorID"},
    "minItems": 1},
  "Confidence": {"$ref": "#/definitions/Confidence"},
  "Description": {
    "type": "array",
    "items": {"type": "string"},
    "minItems": 1},
  "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "additionalProperties": false},
"ThreatActor": {
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction",
                    "default": "private"},
    "ext-restriction": {"type": "string"},
    "ThreatActorID": {
      "type": "array",
      "items": {"type": "string"},
      "minItems": 1},
    "Description": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1},
    "URL": {
      "type": "array",
      "items": {"$ref": "#/definitions/URLtype"},
      "minItems": 1},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "additionalProperties": false},
"Campaign": {
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction",
                    "default": "private"},
    "ext-restriction": {"type": "string"},
    "CampaignID": {
      "type": "array",
```



```
    "items": {"type": "string"},
    "minItems": 1},
  "URL": {
    "type": "array",
    "items": {"$ref": "#/definitions/URLtype"},
    "minItems": 1},
  "Description": {
    "type": "array",
    "items": {"$ref": "#/definitions/MLStringType"},
    "minItems": 1},
  "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
"Contact": {
  "type": "object",
  "properties": {
    "role": {
      "enum": ["creator", "reporter", "admin", "tech", "provider", "user",
        "billing", "legal", "irt", "abuse", "cc", "cc-irt", "leo",
        "vendor", "vendor-support", "victim", "victim-notified",
        "ext-value"]},
    "ext-role": {"type": "string"},
    "type": {"enum": ["person", "organization", "ext-value"]},
    "ext-type": {"type": "string"},
    "restriction": {"$ref": "#/definitions/restriction",
      "default": "private"},
    "ext-restriction": {"type": "string"},
    "ContactName": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1},
    "ContactTitle": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1},
    "Description": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1},
    "RegistryHandle": {
      "type": "array",
      "items": {"$ref": "#/definitions/RegistryHandle"},
      "minItems": 1},
    "PostalAddress": {
      "type": "array",
      "items": {"$ref": "#/definitions/PostalAddress"},
      "minItems": 1},
    "Email": {
      "type": "array",
      "items": {"$ref": "#/definitions/Email"},
```



```
    "minItems": 1},
  "Telephone": {
    "type": "array",
    "items": {"$ref": "#/definitions/Telephone"},
    "minItems": 1},
  "Timezone": {"$ref": "#/definitions/TimeZonetype"},
  "Contact": {
    "type": "array",
    "items": {"$ref": "#/definitions/Contact"},
    "minItems": 1},
  "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"},
  "required": ["role", "type"],
  "additionalProperties": false},
"RegistryHandle": {
  "type": "object",
  "properties": {
    "handle": {"type": "string"},
    "registry": {
      "enum": ["internic", "apnic", "arin", "lacnic", "ripe", "afrinic",
        "local", "ext-value"]},
    "ext-registry": {"type": "string"}},
  "required": ["handle", "registry"],
  "additionalProperties": false},
"PostalAddress": {
  "type": "object",
  "properties": {
    "type": {
      "enum": ["street", "mailing", "ext-value"]},
    "ext-type": {"type": "string"},
    "PAddress": {"$ref": "#/definitions/PAddressType"},
    "Description": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1}},
    "required": ["PAddress"],
    "additionalProperties": false},
"Email": {
  "type": "object",
  "properties": {
    "type": {
      "enum": ["direct", "hotline", "ext-value"]},
    "ext-type": {"type": "string"},
    "EmailTo": {"type": "string"},
    "Description": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1}},
    "required": ["EmailTo"],
```



```
    "additionalProperties": false},
  "Telephone": {
    "type": "object",
    "properties": {
      "type": {
        "enum": ["wired", "mobile", "fax", "hotline", "ext-value"]},
      "ext-type": {"type": "string"},
      "TelephoneNumber": {"type": "string"},
      "Description": {
        "type": "array",
        "items": {"$ref": "#/definitions/MLStringType"},
        "minItems": 1}},
    "required": ["TelephoneNumber"],
    "additionalProperties": false},
  "Discovery": {
    "type": "object",
    "properties": {
      "source": {
        "enum": ["nids", "hips", "siem", "av", "third-party-monitoring",
          "incident", "os-log", "application-log", "device-log",
          "network-flow", "passive-dns", "investigation", "audit",
          "internal-notification", "external-notification", "leo",
          "partner", "actor", "unknown", "ext-value"]},
      "ext-source": {"type": "string"},
      "restriction": {"$ref": "#/definitions/restriction",
        "default": "private"},
      "ext-restriction": {"type": "string"},
      "Description": {
        "type": "array",
        "items": {"$ref": "#/definitions/MLStringType"},
        "minItems": 1},
      "Contact": {
        "type": "array",
        "items": {"$ref": "#/definitions/Contact"},
        "minItems": 1},
      "DetectionPattern": {
        "type": "array",
        "items": {"$ref": "#/definitions/DetectionPattern"},
        "minItems": 1}},
    "required": [],
    "additionalProperties": false},
  "DetectionPattern": {
    "type": "object",
    "properties": {
      "restriction": {"$ref": "#/definitions/restriction",
        "default": "private"},
      "ext-restriction": {"type": "string"},
      "observable-id": {"$ref": "#/definitions/IDtype"},

```



```
"Application": {"$ref": "#/definitions/SoftwareType"},
"Description": {
  "type": "array",
  "items": {"$ref": "#/definitions/MLStringType"},
  "minItems": 1},
"DetectionConfiguration": {
  "type": "array",
  "items": {"type": "string"},
  "minItems": 1}},
"allOf": [
  {"required": ["Application"]},
  {"oneOf": [
    {"required": ["Description"]},
    {"required": ["DetectionConfiguration"]}]}],
"additionalProperties": false},
"Method": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction",
                  "default": "private"},
    "ext-restriction": {"type": "string"},
    "Reference": {
      "type": "array",
      "items": {"$ref": "#/definitions/Reference"},
      "minItems": 1},
    "Description": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1},
    "AttackPattern": {
      "type": "array",
      "items": {"$ref": "#/definitions/StructuredInfo"},
      "minItems": 1},
    "Vulnerability": {
      "type": "array",
      "items": {"$ref": "#/definitions/StructuredInfo"},
      "minItems": 1},
    "Weakness": {
      "type": "array",
      "items": {"$ref": "#/definitions/StructuredInfo"},
      "minItems": 1},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": [],
  "additionalProperties": false},
"Reference": {
  "type": "object",
  "properties": {
    "observable-id": {"$ref": "#/definitions/IDtype"},
```



```
"ReferenceName": {"$ref": "#/definitions/ReferenceName"},
"URL": {
  "type": "array",
  "items": {"$ref": "#/definitions/URLtype"},
  "minItems": 1},
"Description": {
  "type": "array",
  "items": {"$ref": "#/definitions/MLStringType"},
  "minItems": 1}},
"required": [],
"additionalProperties": false},
"ReferenceName" : {
  "type": "object",
  "properties": {
    "specIndex": {"type": "number"},
    "ID": {"$ref": "#/definitions/IDtype"}},
  "required": ["specIndex", "ID"],
  "additionalProperties": false},
"Assessment": {
  "type": "object",
  "properties": {
    "occurrence": {"enum": ["actual", "potential"]},
    "restriction": {"$ref": "#/definitions/restriction",
      "default": "private"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "IncidentCategory": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1},
    "Impact": {
      "type": "array",
      "items": {
        "properties": {
          "SystemImpact": {"$ref": "#/definitions/SystemImpact"},
          "BusinessImpact": {"$ref": "#/definitions/BusinessImpact"},
          "TimeImpact": {"$ref": "#/definitions/TimeImpact"},
          "MonetaryImpact": {"$ref": "#/definitions/MonetaryImpact"},
          "IntendedImpact": {"$ref": "#/definitions/BusinessImpact"}},
          "additionalProperties": false},
        "minItems" : 1
      },
    },
    "Counter": {
      "type": "array",
      "items": {"$ref": "#/definitions/Counter"},
      "minItems": 1},
    "MitigatingFactor": {
      "type": "array",
```



```
    "items": {"$ref": "#/definitions/MLStringType"},
    "minItems": 1},
  "Cause": {
    "type": "array",
    "items": {"$ref": "#/definitions/MLStringType"},
    "minItems": 1},
  "Confidence": {"$ref": "#/definitions/Confidence"},
  "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": ["Impact"],
  "additionalProperties": false},
  "SystemImpact": {
    "type": "object",
    "properties": {
      "severity": {"enum": ["low", "medium", "high"]},
      "completion": {"enum": ["failed", "succeeded"]},
      "type": {
        "enum": ["takeover-account", "takeover-service",
          "takeover-system", "cps-manipulation", "cps-damage",
          "availability-data", "availability-account",
          "availability-service", "availability-system",
          "damaged-system", "damaged-data", "breach-proprietary",
          "breach-privacy", "breach-credential",
          "breach-configuration", "integrity-data",
          "integrity-configuration", "integrity-hardware",
          "traffic-redirection", "monitoring-traffic",
          "monitoring-host", "policy", "unknown", "ext-value"]},
        "ext-type": {"type": "string"},
      "Description": {
        "type": "array",
        "items": {"$ref": "#/definitions/MLStringType"},
        "minItems": 1}},
      "required": ["type"],
      "additionalProperties": false},
    "BusinessImpact": {
      "type": "object",
      "properties": {
        "severity": {"enum": ["none", "low", "medium", "high", "unknown",
          "ext-value"], "default": "unknown"},
        "ext-severity": {"type": "string"},
        "type": {"enum": ["breach-proprietary", "breach-privacy",
          "breach-credential", "loss-of-integrity", "loss-of-service",
          "theft-financial", "theft-service", "degraded-reputation",
          "asset-damage", "asset-manipulation", "legal", "extortion",
          "unknown", "ext-value"]},
        "ext-type": {"type": "string"},
        "Description": {
          "type": "array",
          "items": {"$ref": "#/definitions/MLStringType"},
```



```
    "minItems": 1}},
    "required": ["type"],
    "additionalProperties": false},
  "TimeImpact": {
    "type": "object",
    "properties": {
      "value": {"$ref": "#/definitions/PositiveFloatType"},
      "severity": {"enum": ["low", "medium", "high"]},
      "metric": {"enum": ["labor", "elapsed", "downtime", "ext-value"]},
      "ext-metric": {"type": "string"},
      "duration": {"$ref": "#/definitions/duration", "default": "hour"},
      "ext-duration": {"type": "string"}},
    "required": ["value", "metric"],
    "additionalProperties": false},
  "MonetaryImpact": {
    "type": "object",
    "properties": {
      "value": {"$ref": "#/definitions/PositiveFloatType"},
      "severity": {"enum": ["low", "medium", "high"]},
      "currency": {"type": "string"}},
    "required": ["value"],
    "additionalProperties": false},
  "Confidence": {
    "type": "object",
    "properties": {
      "value": {"type": "number"},
      "rating": {"enum": ["low", "medium", "high", "numeric", "unknown",
        "ext-value"]},
      "ext-rating": {"type": "string"}},
    "required": ["value", "rating"],
    "additionalProperties": false},
  "History": {
    "type": "object",
    "properties": {
      "restriction": {"$ref": "#/definitions/restriction",
        "default": "private"},
      "ext-restriction": {"type": "string"},
      "HistoryItem": {
        "type": "array",
        "items": {"$ref": "#/definitions/HistoryItem"},
        "minItems": 1}},
    "required": ["HistoryItem"],
    "additionalProperties": false},
  "HistoryItem": {
    "type": "object",
    "properties": {
      "action": {"$ref": "#/definitions/action", "default": "other"},
      "ext-action": {"type": "string"},
```



```
"restriction": {"$ref": "#/definitions/restriction",
                "default": "private"},
"ext-restriction": {"type": "string"},
"observable-id": {"$ref": "#/definitions/IDtype"},
"DateTime": {"$ref": "#/definitions/DATETIME"},
"IncidentID": {"$ref": "#/definitions/IncidentID"},
"Contact": {"$ref": "#/definitions/Contact"},
"Description": {
  "type": "array",
  "items": {"$ref": "#/definitions/MLStringType"},
  "minItems": 1},
"DefinedCOA": {
  "type": "array",
  "items": {"type": "string"},
  "minItems": 1},
"AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
"required": ["DateTime", "action"],
"additionalProperties": false},
"EventData": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction",
                  "default": "private"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "Description": {"type": "array",
                  "items": {"$ref": "#/definitions/MLStringType"}},
    "DetectTime": {"$ref": "#/definitions/DATETIME"},
    "StartTime": {"$ref": "#/definitions/DATETIME"},
    "EndTime": {"$ref": "#/definitions/DATETIME"},
    "RecoveryTime": {"$ref": "#/definitions/DATETIME"},
    "ReportTime": {"$ref": "#/definitions/DATETIME"},
    "Contact": {
      "type": "array",
      "items": {"$ref": "#/definitions/Contact"},
      "minItems": 1},
    "Discovery": {
      "type": "array",
      "items": {"$ref": "#/definitions/Discovery"},
      "minItems": 1},
    "Assessment": {"$ref": "#/definitions/Assessment"},
    "Method": {
      "type": "array",
      "items": {"$ref": "#/definitions/Method"},
      "minItems": 1},
    "System": {
      "type": "array",
      "items": {"$ref": "#/definitions/System"},
```



```
    "minItems": 1},
    "Expectation": {
      "type": "array",
      "items": {"$ref": "#/definitions/Expectation"},
      "minItems": 1},
    "RecordData": {
      "type": "array",
      "items": {"$ref": "#/definitions/RecordData"},
      "minItems": 1},
    "EventData": {
      "type": "array",
      "items": {"$ref": "#/definitions/EventData"},
      "minItems": 1},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": [],
    "additionalProperties": false},
  "Expectation": {
    "type": "object",
    "properties": {
      "action": {"$ref": "#/definitions/action", "default": "other"},
      "ext-action": {"type": "string"},
      "severity": {"enum": ["low", "medium", "high"]},
      "restriction": {"$ref": "#/definitions/restriction",
        "default": "default"},
      "ext-restriction": {"type": "string"},
      "observable-id": {"$ref": "#/definitions/IDtype"},
      "Description": {
        "type": "array",
        "items": {"$ref": "#/definitions/MLStringType"},
        "minItems": 1},
      "DefinedCOA": {
        "type": "array",
        "items": {"type": "string"},
        "minItems": 1},
      "StartTime": {"$ref": "#/definitions/DATETIME"},
      "EndTime": {"$ref": "#/definitions/DATETIME"},
      "Contact": {"$ref": "#/definitions/Contact"}},
    "required": [],
    "additionalProperties": false},
  "System": {
    "type": "object",
    "properties": {
      "category": {
        "enum": ["source", "target", "intermediate", "sensor",
          "infrastructure", "ext-value"]},
      "ext-category": {"type": "string"},
      "interface": {"type": "string"},
      "spoofed": {"enum": ["unknown", "yes", "no"], "default": "unknown"},
```



```
"virtual": {"enum": ["yes", "no", "unknown"], "default": "unknown"},
"ownership": {
  "enum": ["organization", "personal", "partner", "customer",
    "no-relationship", "unknown", "ext-value"]},
"ext-ownership": {"type": "string"},
"restriction": {"$ref": "#/definitions/restriction",
  "default": "private"},
"ext-restriction": {"type": "string"},
"observable-id": {"$ref": "#/definitions/IDtype"},
"Node": {"$ref": "#/definitions/Node"},
"NodeRole": {
  "type": "array",
  "items": {"$ref": "#/definitions/NodeRole"},
  "minItems": 1},
"Service": {
  "type": "array",
  "items": {"$ref": "#/definitions/Service"},
  "minItems": 1},
"OperatingSystem": {
  "type": "array",
  "items": {"$ref": "#/definitions/SoftwareType"},
  "minItems": 1},
"Counter": {
  "type": "array",
  "items": {"$ref": "#/definitions/Counter"},
  "minItems": 1},
"AssetID": {
  "type": "array",
  "items": {"type": "string"},
  "minItems": 1},
"Description": {
  "type": "array",
  "items": {"$ref": "#/definitions/MLStringType"},
  "minItems": 1},
"AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
"required": ["Node"],
"additionalProperties": false},
"Node": {
  "type": "object",
  "properties": {
    "DomainData": {
      "type": "array",
      "items": {"$ref": "#/definitions/DomainData"},
      "minItems": 1},
    "Address": {
      "type": "array",
      "items": {"$ref": "#/definitions/Address"},
      "minItems": 1},
```



```
"PostalAddress": {"$ref": "#/definitions/PostalAddress"},
"Location": {
  "type": "array",
  "items": {"$ref": "#/definitions/MLStringType"},
  "minItems": 1},
"Counter": {
  "type": "array",
  "items": {"$ref": "#/definitions/Counter"},
  "minItems": 1}},
"anyOf": [
  {"required": ["DomainData"]},
  {"required": ["Address"]}
],
"additionalProperties": false},
"Address": {
  "type": "object",
  "properties": {
    "value": {"type": "string"},
    "category": {
      "enum": ["asn", "atm", "e-mail", "ipv4-addr", "ipv4-net",
        "ipv4-net-masked", "ipv4-net-mask", "ipv6-addr", "ipv6-net",
        "ipv6-net-masked", "mac", "site-uri", "ext-value"],
      "default": "ipv6-addr"},
    "ext-category": {"type": "string"},
    "vlan-name": {"type": "string"},
    "vlan-num": {"type": "number"},
    "observable-id": {"$ref": "#/definitions/IDtype"}},
  "required": ["value", "category"],
  "additionalProperties": false},
"NodeRole": {
  "type": "object",
  "properties": {
    "category": {
      "enum": ["client", "client-enterprise", "client-partner",
        "client-remote", "client-kiosk", "client-mobile",
        "server-internal", "server-public", "www", "mail", "webmail",
        "messaging", "streaming", "voice", "file", "ftp", "p2p", "name",
        "directory", "credential", "print", "application", "database",
        "backup", "dhcp", "assessment", "source-control",
        "config-management", "monitoring", "infra", "infra-firewall",
        "infra-router", "infra-switch", "camera", "proxy",
        "remote-access", "log", "virtualization", "pos", "scada",
        "scada-supervisory", "sinkhole", "honeypot", "anonymization",
        "c2-server", "malware-distribution", "drop-server",
        "hop-point", "reflector", "phishing-site",
        "spear-phishing-site", "recruiting-site", "fraudulent-site",
        "ext-value"]},
    "ext-category": {"type": "string"},
```



```
    "Description": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1}},
    "required": ["category"],
    "additionalProperties": false},
  "Counter": {
    "type": "object",
    "properties": {
      "value": {"type": "number"},
      "type": {"enum": ["count", "peak", "average", "ext-value"]},
      "ext-type": {"type": "string"},
      "unit": {"enum": ["byte", "mbit", "packet", "flow", "session", "alert",
        "message", "event", "host", "site", "organization", "ext-value"]},
      "ext-unit": {"type": "string"},
      "meaning": {"type": "string"},
      "duration": {"$ref": "#/definitions/duration", "default": "hour"},
      "ext-duration": {"type": "string"}},
    "required": ["value", "type", "unit"],
    "additionalProperties": false},
  "DomainData": {
    "type": "object",
    "properties": {
      "system-status": {
        "enum": ["spoofed", "fraudulent", "innocent-hacked",
          "innocent-hijacked", "unknown", "ext-value"]},
      "ext-system-status": {"type": "string"},
      "domain-status": {
        "enum": [ "reservedDelegation", "assignedAndActive",
          "assignedAndInactive", "assignedAndOnHold", "revoked",
          "transferPending", "registryLock", "registrarLock",
          "other", "unknown", "ext-value"]},
      "ext-domain-status": {"type": "string"},
      "observable-id": {"$ref": "#/definitions/IDtype"},
      "Name": {"type": "string"},
      "DateDomainWasChecked": {"$ref": "#/definitions/DATETIME"},
      "RegistrationDate": {"$ref": "#/definitions/DATETIME"},
      "ExpirationDate": {"$ref": "#/definitions/DATETIME"},
      "RelatedDNS": {
        "type": "array",
        "items": {"$ref": "#/definitions/ExtensionType"},
        "minItems": 1},
      "NameServers": {
        "type": "array",
        "items": {"$ref": "#/definitions/NameServers"},
        "minItems": 1},
      "DomainContacts": {"$ref": "#/definitions/DomainContacts"}},
    "required": ["Name", "system-status", "domain-status"],
```



```
    "additionalProperties": false},
  "NameServers": {
    "type": "object",
    "properties": {
      "Server": {"type": "string"},
      "Address": {
        "type": "array",
        "items": {"$ref": "#/definitions/Address"},
        "minItems": 1}},
    "required": ["Server", "Address"],
    "additionalProperties": false},
  "DomainContacts": {
    "type": "object",
    "properties": {
      "SameDomainContact": {"type": "string"},
      "Contact": {
        "type": "array",
        "items": {"$ref": "#/definitions/Contact"},
        "minItems": 1}},
    "oneOf": [
      {"required": ["SameDomainContact"]},
      {"required": ["Contact"]}],
    "additionalProperties": false},
  "Service": {
    "type": "object",
    "properties": {
      "ip-protocol": {"type": "number"},
      "observable-id": {"$ref": "#/definitions/IDtype"},
      "ServiceName": {"$ref": "#/definitions/ServiceName"},
      "Port": {"type": "number"},
      "Portlist": {"$ref": "#/definitions/PortlistType"},
      "ProtoCode": {"type": "number"},
      "ProtoType": {"type": "number"},
      "ProtoField": {"type": "number"},
      "ApplicationHeaderField": {
        "$ref": "#/definitions/ExtensionTypeList"},
      "EmailData": {"$ref": "#/definitions/EmailData"},
      "Application": {"$ref": "#/definitions/SoftwareType"}},
    "required": [],
    "additionalProperties": false},
  "ServiceName": {
    "type": "object",
    "properties": {
      "IANAService": {"type": "string"},
      "URL": {
        "type": "array", "items": {"$ref": "#/definitions/URLtype"}},
      "Description": {
        "type": "array",
```



```
        "items": {"$ref": "#/definitions/MLStringType"},
        "minItems": 1}},
    "required": [],
    "additionalProperties": false},
    "EmailData": {
        "type": "object",
        "properties": {
            "observable-id": {"$ref": "#/definitions/IDtype"},
            "EmailTo": {
                "type": "array",
                "items": {"type": "string"},
                "minItems": 1},
            "EmailFrom": {"type": "string"},
            "EmailSubject": {"type": "string"},
            "EmailX-Mailer": {"type": "string"},
            "EmailHeaderField": {
                "type": "array",
                "items": {"$ref": "#/definitions/ExtensionType"},
                "minItems": 1},
            "EmailHeaders": {"type": "string"},
            "EmailBody": {"type": "string"},
            "EmailMessage": {"type": "string"},
            "HashData": {
                "type": "array",
                "items": {"$ref": "#/definitions/HashData"},
                "minItems": 1},
            "Signature": {
                "type": "array",
                "items": {"$ref": "#/definitions/BYTE"},
                "minItems": 1}},
        "required": [],
        "additionalProperties": false},
    "RecordData": {
        "type": "object",
        "properties": {
            "restriction": {"$ref": "#/definitions/restriction",
                           "default": "private"},
            "ext-restriction": {"type": "string"},
            "observable-id": {"$ref": "#/definitions/IDtype"},
            "DateTime": {"$ref": "#/definitions/DATETIME"},
            "Description": {
                "type": "array",
                "items": {"$ref": "#/definitions/MLStringType"},
                "minItems": 1},
            "Application": {"$ref": "#/definitions/SoftwareType"},
            "RecordPattern": {
                "type": "array",
                "items": {"$ref": "#/definitions/RecordPattern"},
```



```
    "minItems": 1},
  "RecordItem": {
    "type": "array",
    "items": {"$ref": "#/definitions/ExtensionType"},
    "minItems": 1},
  "URL": {
    "type": "array",
    "items": {"$ref": "#/definitions/URLtype"},
    "minItems": 1},
  "FileData": {
    "type": "array",
    "items": {"$ref": "#/definitions/FileData"},
    "minItems": 1},
  "WindowsRegistryKeysModified": {
    "type": "array",
    "items": {"$ref": "#/definitions/WindowsRegistryKeysModified"},
    "minItems": 1},
  "CertificateData": {
    "type": "array",
    "items": {"$ref": "#/definitions/CertificateData"},
    "minItems": 1},
  "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": [],
  "additionalProperties": false},
"RecordPattern": {
  "type": "object",
  "properties": {
    "value": {"type": "string"},
    "type": {"enum": ["regex", "binary", "xpath", "ext-value"],
              "default": "regex"},
    "ext-type": {"type": "string"},
    "offset": {"type": "number"},
    "offsetunit": {"enum": ["line", "byte", "ext-value"],
                  "default": "line"},
    "ext-offsetunit": {"type": "string"},
    "instance": {"type": "number"}},
  "required": ["value", "type"],
  "additionalProperties": false},
"WindowsRegistryKeysModified": {
  "type": "object",
  "properties": {
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "Key": {
      "type": "array",
      "items": {"$ref": "#/definitions/Key"},
      "minItems": 1}},
  "required": ["Key"],
  "additionalProperties": false},
```



```
"Key": {
  "type": "object",
  "properties": {
    "registryaction": {"enum": ["add-key", "add-value", "delete-key",
                                "delete-value", "modify-key", "modify-value",
                                "ext-value"]},
    "ext-registryaction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "KeyName": {"type": "string"},
    "KeyValue": {"type": "string"}},
  "required": ["KeyName"],
  "additionalProperties": false},
"CertificateData": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction",
                   "default": "private"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "Certificate": {
      "type": "array",
      "items": {"$ref": "#/definitions/Certificate"},
      "minItems": 1}},
  "required": ["Certificate"],
  "additionalProperties": false},
"Certificate": {
  "type": "object",
  "properties": {
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "X509Data": {"$ref": "#/definitions/BYTE"},
    "Description": {
      "type": "array",
      "items": {"$ref": "#/definitions/MLStringType"},
      "minItems": 1}},
  "required": ["X509Data"],
  "additionalProperties": false},
"FileData": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "File": {
      "type": "array",
      "items": {"$ref": "#/definitions/File"},
      "minItems": 1}},
  "required": ["File"],
  "additionalProperties": false},
```



```
"File": {
  "type": "object",
  "properties": {
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "FileName": {"type": "string"},
    "FileSize": {"type": "number"},
    "FileType": {"type": "string"},
    "URL": {
      "type": "array",
      "items": {"$ref": "#/definitions/URLtype"},
      "minItems": 1},
    "HashData": {"$ref": "#/definitions/HashData"},
    "Signature": {
      "type": "array",
      "items": {"$ref": "#/definitions/BYTE"},
      "minItems": 1},
    "AssociatedSoftware": {"$ref": "#/definitions/SoftwareType"},
    "FileProperties": {
      "type": "array",
      "items": {"$ref": "#/definitions/ExtensionType"},
      "minItems": 1}},
  "required": [],
  "additionalProperties": false},
"HashData": {
  "type": "object",
  "properties": {
    "scope": {"enum": ["file-contents", "file-pe-section",
      "file-pe-iat", "file-pe-resource", "file-pdf-object",
      "email-hash", "email-headers-hash", "email-body-hash",
      "ext-value"]},
    "HashTargetID": {"type": "string"},
    "Hash": {
      "type": "array",
      "items": {"$ref": "#/definitions/Hash"},
      "minItems": 1},
    "FuzzyHash": {
      "type": "array",
      "items": {"$ref": "#/definitions/FuzzyHash"},
      "minItems": 1}},
  "required": ["scope"],
  "additionalProperties": false},
"Hash": {
  "type": "object",
  "properties": {
    "DigestMethod": {"$ref": "#/definitions/BYTE"},
    "DigestValue": {"$ref": "#/definitions/BYTE"},
    "CanonicalizationMethod": {"$ref": "#/definitions/BYTE"},
    "Application": {"$ref": "#/definitions/SoftwareType"}},
```



```
    "required": ["DigestMethod", "DigestValue"],
    "additionalProperties": false},
  "FuzzyHash": {
    "type": "object",
    "properties": {
      "FuzzyHashValue": {
        "type": "array",
        "items": {"$ref": "#/definitions/ExtensionType"},
        "minItems": 1},
      "Application": {"$ref": "#/definitions/SoftwareType"},
      "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": ["FuzzyHashValue"],
    "additionalProperties": false},
  "Indicator": {
    "type": "object",
    "properties": {
      "restriction": {"$ref": "#/definitions/restriction",
                     "default": "private"},
      "ext-restriction": {"type": "string"},
      "IndicatorID": {"$ref": "#/definitions/IndicatorID"},
      "AlternativeIndicatorID": {
        "type": "array",
        "items": {"$ref": "#/definitions/AlternativeIndicatorID"},
        "minItems": 1},
      "Description": {
        "type": "array",
        "items": {"$ref": "#/definitions/MLStringType"},
        "minItems": 1},
      "StartTime": {"$ref": "#/definitions/DATETIME"},
      "EndTime": {"$ref": "#/definitions/DATETIME"},
      "Confidence": {"$ref": "#/definitions/Confidence"},
      "Contact": {
        "type": "array",
        "items": {"$ref": "#/definitions/Contact"},
        "minItems": 1},
      "Observable": {"$ref": "#/definitions/Observable"},
      "uid-ref": {"$ref": "#/definitions/IDREFType"},
      "IndicatorExpression": {
        "$ref": "#/definitions/IndicatorExpression"},
      "IndicatorReference": {
        "$ref": "#/definitions/IndicatorReference"},
      "NodeRole": {
        "type": "array",
        "items": {"$ref": "#/definitions/NodeRole"},
        "minItems": 1},
      "AttackPhase": {
        "type": "array",
        "items": {"$ref": "#/definitions/AttackPhase"},
```



```
    "minItems": 1},
  "Reference": {
    "type": "array",
    "items": {"$ref": "#/definitions/Reference"},
    "minItems": 1},
  "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "allOf": [
    {"required": ["IndicatorID"]},
    {"oneOf": [
      {"required": ["Observable"]},
      {"required": ["uid-ref"]},
      {"required": ["IndicatorExpression"]},
      {"required": ["IndicatorReference"]}]}],
  "additionalProperties": false},
  "IndicatorID": {
    "type": "object",
    "properties": {
      "id": {"type": "string"},
      "name": {"type": "string"},
      "version": {"type": "string"}},
    "required": ["id", "name", "version"],
    "additionalProperties": false},
  "AlternativeIndicatorID": {
    "type": "object",
    "properties": {
      "restriction": {"$ref": "#/definitions/restriction",
        "default": "private"},
      "ext-restriction": {"type": "string"},
      "IndicatorID": {
        "type": "array",
        "items": {"$ref": "#/definitions/IndicatorID"},
        "minItems": 1}},
    "required": ["IndicatorID"],
    "additionalProperties": false},
  "Observable": {
    "type": "object",
    "properties": {
      "restriction": {"$ref": "#/definitions/restriction",
        "default": "private"},
      "ext-restriction": {"type": "string"},
      "System": {"$ref": "#/definitions/System"},
      "Address": {"$ref": "#/definitions/Address"},
      "DomainData": {"$ref": "#/definitions/DomainData"},
      "EmailData": {"$ref": "#/definitions/EmailData"},
      "Service": {"$ref": "#/definitions/Service"},
      "WindowsRegistryKeysModified": {
        "$ref": "#/definitions/WindowsRegistryKeysModified"},
      "FileData": {"$ref": "#/definitions/FileData"},

```



```
"CertificateData": {"$ref": "#/definitions/CertificateData"},
"RegistryHandle": {"$ref": "#/definitions/RegistryHandle"},
"RecordData": {"$ref": "#/definitions/RecordData"},
"EventData": {"$ref": "#/definitions/EventData"},
"Incident": {"$ref": "#/definitions/Incident"},
"Expectation": {"$ref": "#/definitions/Expectation"},
"Reference": {"$ref": "#/definitions/Reference"},
"Assessment": {"$ref": "#/definitions/Assessment"},
"DetectionPattern": {"$ref": "#/definitions/DetectionPattern"},
"HistoryItem": {"$ref": "#/definitions/HistoryItem"},
"BulkObservable": {"$ref": "#/definitions/BulkObservable"},
"AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
"oneOf": [
  {"required": ["System"]},
  {"required": ["Address"]},
  {"required": ["DomainData"]},
  {"required": ["EmailData"]},
  {"required": ["Service"]},
  {"required": ["WindowsRegistryKeysModified"]},
  {"required": ["FileData"]},
  {"required": ["CertificateData"]},
  {"required": ["RegistryHandle"]},
  {"required": ["RecordData"]},
  {"required": ["EventData"]},
  {"required": ["Incident"]},
  {"required": ["Expectation"]},
  {"required": ["Reference"]},
  {"required": ["Assessment"]},
  {"required": ["DetectionPattern"]},
  {"required": ["HistoryItem"]},
  {"required": ["BulkObservable"]},
  {"required": ["AdditionalData"]}],
"additionalProperties": false},
"BulkObservable": {
  "type": "object",
  "properties": {
    "type": {"enum": ["asn", "atm", "e-mail", "ipv4-addr", "ipv4-net",
      "ipv4-net-mask", "ipv6-addr", "ipv6-net", "ipv6-net-mask",
      "mac", "site-uri", "domain-name", "domain-to-ipv4",
      "domain-to-ipv6", "domain-to-ipv4-timestamp",
      "domain-to-ipv6-timestamp", "ipv4-port", "ipv6-port",
      "windows-reg-key", "file-hash", "email-x-mailer",
      "email-subject", "http-user-agent", "http-request-url",
      "mutex", "file-path", "user-name", "ext-value"]},
    "ext-type": {"type": "string"},
    "BulkObservableFormat": {
      "$ref": "#/definitions/BulkObservableFormat"},
    "BulkObservableList": {"type": "string"},
```



```
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": ["BulkObservableList"],
    "additionalProperties": false},
  "BulkObservableFormat": {
    "type": "object",
    "properties": {
      "Hash": {"$ref": "#/definitions/Hash"},
      "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "oneOf": [
      {"required": ["Hash"]},
      {"required": ["AdditionalData"]}
    ],
    "additionalProperties": false},
  "IndicatorExpression": {
    "type": "object",
    "properties": {
      "operator": {"enum": ["not", "and", "or", "xor"], "default": "and"},
      "ext-operator": {"type": "string"},
      "IndicatorExpression": {
        "type": "array",
        "items": {"$ref": "#/definitions/IndicatorExpression"},
        "minItems": 1},
      "Observable": {
        "type": "array",
        "items": {"$ref": "#/definitions/Observable"},
        "minItems": 1},
      "uid-ref": {
        "type": "array",
        "items": {"$ref": "#/definitions/IDREFTType"},
        "minItems": 1},
      "IndicatorReference": {
        "type": "array",
        "items": {"$ref": "#/definitions/IndicatorReference"},
        "minItems": 1},
      "Confidence": {"$ref": "#/definitions/Confidence"},
      "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": [],
    "additionalProperties": false},
  "IndicatorReference": {
    "type": "object",
    "properties": {
      "uid-ref": {"$ref": "#/definitions/IDREFTType"},
      "euid-ref": {"type": "string"},
      "version": {"type": "string"}},
    "oneOf": [
      {"required": ["uid-ref"]},
      {"required": ["euid-ref"]}
    ],
  },
```



```
    "additionalProperties": false},
  "AttackPhase": {
    "type": "object",
    "properties": {
      "AttackPhaseID": {
        "type": "array",
        "items": {"type": "string"},
        "minItems": 1},
      "URL": {
        "type": "array",
        "items": {"$ref": "#/definitions/URLtype"},
        "minItems": 1},
      "Description": {
        "type": "array",
        "items": {"$ref": "#/definitions/MLStringType"},
        "minItems": 1},
      "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": [],
    "additionalProperties": false}},
  "title": "IODEF-Document",
  "description": "JSON schema for IODEF-Document class",
  "type": "object",
  "properties": {
    "version": {"type": "string"},
    "lang": {"$ref": "#/definitions/lang"},
    "format-id": {"type": "string"},
    "private-enum-name": {"type": "string"},
    "private-enum-id": {"type": "string"},
    "Incident": {
      "type": "array",
      "items": {"$ref": "#/definitions/Incident"},
      "minItems": 1},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": ["version", "Incident"],
  "additionalProperties": false}
```

Figure 10: JSON schema

Authors' Addresses

Takeshi Takahashi
National Institute of Information and Communications Technology
4-2-1 Nukui-Kitamachi
Koganei, Tokyo 184-8795
Japan

Phone: +81 42 327 5862
Email: takeshi_takahashi@nict.go.jp

Roman Danyliw
CERT, Software Engineering Institute, Carnegie Mellon University
4500 Fifth Avenue
Pittsburgh, PA
USA

Email: rdd@cert.org

Mio Suzuki
National Institute of Information and Communications Technology
4-2-1 Nukui-Kitamachi
Koganei, Tokyo 184-8795
Japan

Email: mio@nict.go.jp

