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CBOR/JSON binding of IODEF
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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 JSON.

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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", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

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	"string" per [jsonschema] / 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
STRUCTURED	RFC 7213	see Section 2.2.3
EXTENSION	Section 2.16	see Section 2.2.4

Figure 1

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

Figure 2

2.2. Complex JSON Types

2.2.1. Multilingual Strings

A string that needs to be represented in a human-readable language different than the default encoding of the document is represented in the information model by the ML_STRING data type. This data type is implemented as an object with "value", "lang", and "translation-id" elements 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 SoftwareReference

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. StructuredInfo

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", "RawData", "Reference" elements. An example for embedding a structured ID is shown below.

```
"StructuredInformation": {
  "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.

```
"StructuredInformation": {
  "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",         //String
  "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 name instance? restriction? ext-restriction?	3.4
AlternativeID	restriction? ext-restriction? IncidentID+	3.5
RelatedActivity	restriction? ext-restriction? IncidentID* URL* ThreatActor* Campaign* IndicatorID* Confidence? Description* AdditionalData*	3.6
ThreatActor	restriction? ext-restriction? ThreatActorID* URL* Description* AdditionalData*	3.7
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? ext-restriction? observable-id? Application Description* DetectionConfiguration*	3.10.1
Method	restriction? ext-restriction? Reference* Description* AttackPattern* Vulnerability* Weakness* AdditionalData*	3.11
Reference	observable-id? ReferenceName? URL* Description*	3.11.1
Assessment	occurrence? 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? 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*	3.16
Node	DomainData* Address* PostalAddress? Location* Counter*	3.17
Address	value category ext-category? vlan-name? vlan-num? observable-id?	3.17.1
NodeRole	category ext-category? Description*	3.17.2

Counter	value type ext-type? unit ext-unit? meaning? duration? ext-duration?	3.17.3
DomainData	system-status ext-system-status? domain-status ext-domain-status? observable-id? Name DateDomainWasChecked? RegistrationDate? ExpirationDate? RelatedDNS* Nameservers* DomainContacts?	3.18
Nameserver	Server Address*	3.18.1
DomainContacts	SameDomainContact? Contact+	3.18.2
Service	ip-protocol? observable-id? ServiceName? Port? Portlist? ProtoCode? ProtoType? ProtoField? ApplicationHeaderField* EmailData? Application?	3.19
ServiceName	IANAService? URL* Description*	3.19.1
EmailData	observable-id? EmailTo* EmailFrom?	

	EmailSubject? EmailX-Mailer? EmailHeaderField* EmailHeaders? EmailBody? EmailMessage? HashData* Signature*	3.19.2
RecordData	restriction? ext-restriction? observable-id? DateTime? Description* Application? RecordPattern* RecordItem* URL* FileData* WindowsRegistryKeysModified* CertificateData* AdditionalData*	3.19.3
RecordPattern	type ext-type? offset? offsetunit? ext-offsetunit? instance? value	3.19.4
WindowsRegistryKeysModified	observable-id? Key+	3.20
Key	registryaction? ext-registryaction? observable-id? KeyName KeyValue?	3.20.1
CertificateData	restriction? ext-restriction? observable-id? Certificate+	3.21
Certificate	observable-id? X509Data Description*	3.21.1

FileData	restriction? ext-restriction? observable-id? File+	3.22
File	observable-id? FileName? FileSize? FileType? URL* HashData? Signature* AssociatedSoftware? FileProperties*	3.22.1
HashData	scope HashTargetID? Hash* FuzzyHash*	3.23
Hash	DigestMethod DigestValue CanonicalizationMethod? Application?	3.23.1
FuzzyHash	FuzzyHashValue+ Application? AdditionalData*	3.23.2
Indicator	restriction? ext-restriction? IndicatorID AlternativeIndicatorID* Description* StartTime? EndTime? Confidence? Contact* Observable? uid-ref? IndicatorExpression? IndicatorReference? NodeRole* AttackPhase* Reference* AdditionalData*	3.24

IndicatorID	id name version	3.24.1
AlternativeIndicatorID	restriction? ext-restriction? IndicatorReference+	3.24.2
Observable	restriction? ext-restriction? System? Address? DomainData? Service? EmailData? WindowsRegistryKeysModified? FileData? CertificateData? RegistryHandle? RecordData? EventData? Incident? Expectation? Reference? Assessment? DetectionPattern? HistoryItem? BulkObservable? AdditionalData*	3.24.3
BulkObservable	type? ext-type? BulkObservableFormat? BulkObservableList AdditionalData*	3.24.4
BulkObservableFormat	Hash? AdditionalData*	3.24.5
IndicatorExpression	operator? ext-operator? IndicatorExpression* Observable* uid-ref* IndicatorReference* Confidence? AdditionalData*	3.24.6

IndicatorReference	uid-ref? euid-ref? version?	3.24.7
AttackPhase	AttackPhaseID* URL* Description* AdditionalData*	3.24.8

3.2. Mapping between 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 class.
- 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 elements of ML_STRING type are prepared as two separate elements: one of STRING type and another of ML_STRING type, in order to maintain the simplicity of IODEF documents when writing with only STRING type characters.

4. Examples

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

4.1. Minimal Example

A document containing only the mandatory elements and attributes.

```
{
  "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"
      }]
    }]
  }]
}
```

4.2. Indicators from a Campaign

An example of C2 domains from a given campaign.

```
{
  "version": "2.0",
  "lang": "en",
  "Incidents": [
    {
      "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 camp
    aign of the Aggressive Butterfly crime gang."
  ],
  "Assessment": [
    {
      "BusinessImpact": {
        "type": "breach-proprietary"
      }
    }
  ],
  "Contacts": [
    {
      "type": "organization",
      "role": "creator",
      "ContactName": "CSIRT for example.com",
      "Email": {
        "emailTo": "contact@csirt.example.com"
      }
    }
  ],
  "IndicatorList": [
    {
      "IndicatorID": {
        "id": "G90823490",
        "name": "csirt.example.com",
        "version": "1"
      },
      "Description": "C2 domains",
      "StartTime": "2014-12-02T11:18:00-05:00",
      "Observable": {
        "BulkObservable": {
          "type": "fqdn"
        }
      },
    }
  ],
```

```

        "BulkObservableList": [
            "kj290023j09r34.example.com",
            "09ijk23j0k8.example.net",
            "klknjwfjiowjefr923.example.org",
            "oimireik79msd.example.org"
        ]
    }
}
]
}
]
}
}

```

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"

```

```
IDtype = text .regexp "[a-zA-Z_][a-zA-Z0-9_-.]*"

```

```
IDREFType = IDtype

```

```
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" / "cotact-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"

```

```
MLStringType = {
  value: text
  ?lang: lang
  ?translation-id: text
}

PositiveFloatType = {
  value: 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" /
    "ipv6-packet" / "url" / "csv" / "winreg" / "xml" / "ext-value" .de
  fault "string"
  ? ext-dtype: text
  ? meaning: text
  ? formatid: text
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  ? observable-id: IDtype
}

SoftwareType = {
  ? SoftwareReference: SoftwareReference
  ? URL: [+ uri]
  ? Description: [+ text / MLStringType]
}

SoftwareReference = {
  ? value: text
  spec-name: "custom" / "cpe" / "swid" / "ext-value"
  ? ext-spec-name: text
  ? dtype: "bytes" / "integer" / "real" / "string" / "xml" / "ext-value" .def
  fault "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: tdate
? StartTime: tdate
? EndTime: tdate
? RecoveryTime: tdate
? ReportTime: tdate
GenerationTime: tdate
? Description: [+ text / 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: [+ uri]
  ? ThreatActor: [+ ThreatActor]
  ? Campaign: [+ Campaign]
  ? IndicatorID: [+ IndicatorID]
  ? Confidence: Confidence
  ? Description: [+ text]
```

```
? AdditionalData: [+ ExtensionType]
}

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

Campaign = {
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  ? CampaignID: [+ text]
  ? URL: [+ uri]
  ? Description: [+ text / 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: [+ text / MLStringType]
  ? ContactTitle: [+ text / MLStringType]
  ? Description: [+ text / 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: text
  ? ext-type: text
  PAddress: PAddressType
  ? Description: [+ text / MLStringType]
}

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

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

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

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

Method = {
  ? restriction: restriction .default "private"
```

```

? ext-restriction: text
? Reference: [+ Reference]
? Description: [+ text / MLStringType]
? AttackPattern: [+ StructuredInformation]
? Vulnerability: [+ StructuredInformation]
? Weakness: [+ StructuredInformation]
? AdditionalData: [+ ExtensionType]
}

StructuredInformation = {
  specID: text
  ? ext-specID: text
  ? contentID: text
  ? RawData: any
  ? URL: uri
}

Reference = {
  ? observable-id: IDtype
  ? ReferenceName: ReferenceName
  ? URL: [+ uri]
  ? Description: [+ text / MLStringType]
}

ReferenceName = {
  specIndex: integer
  ID: IDtype
}

Assessment = {
  ? occurrence: "actual" / "potential"
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  ? observable-id: IDtype
  ? IncidentCategory: [+ text / MLStringType]
  Impact: [+ {SystemImpact: SystemImpact} / {BusinessImpact: BusinessImpact}
/
          {TimeImpact: TimeImpact} / {MonetaryImpact: MonetaryImpact} /
          {MonetaryImpact: MonetaryImpact} / {IntendedImpact: BusinessImpa
ct}]
  ? Counter: [+ Counter]
  ? MitigatingFactor: [+ text / MLStringType]
  ? Cause: [+ text / 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" /
      "breack-configuration" / "integrity-data" /
      "integrity-configuration" / "integrity-hardware" /
      "traffic-redirection" / "monitoring-traffic" / "monitoring-host" /
      "policy" / "unknown" / "ext-value" .default "unknown"
? ext-type: text
? Description: [+ text / MLStringType]
}

BusinessImpact = {
? severity: "none" / "low" / "medium" / "high" / "unknown" / "ext-value" .d
efault "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: [+ text / 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: tdate
  ? IncidentID: IncidentID
  ? Contact: Contact
  ? Description: [+ text / MLStringType]
  ? DefinedCOA: [+ text]
  ? AdditionalData: [+ ExtensionType]
}

EventData = {
  ? restriction: restriction .default "default"
  ? ext-restriction: text
  ? observable-id: IDtype
  ? Description: [+ text / MLStringType]
  ? DetectTime: tdate
  ? StartTime: tdate
  ? EndTime: tdate
  ? RecoveryTime: tdate
  ? ReportTime: tdate
  ? 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: [+ text / MLStringType]
  ? DefinedCOA: [+ text]
```

```
? StartTime: tdate
? EndTime: tdate
? 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: [+ text / MLStringType]
? AdditionalData: [+ ExtensionType]
}

Node = {
? DomainData: [+ DomainData]
? Address: [+ Address]
? PostalAddress: PAddressType
? Location: [+ text / 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-url" /
"ext-value" .default "ipv6-addr"
? ext-category: text
? vlan-name: text
? vlan-num: integer
? observable-id: IDtype
}
```

```

NodeRole = {
  category: "client" / "client-enterprise" / "clent-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" /
    "anomyzation" / "c2-server" / "malware-distribution" /
    "drop-server" / "hot-point" / "reflector" /
    "phishing-site" / "spear-phishing-site" / "recruiting-site" /
    "fraudulent-site" / "ext-value"
  ? ext-category: text
  ? Description: [+ text / 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 / MLStringTYpe
  ? 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: tdate
  ? RegistrationDate: tdate
  ? ExpirationDate: tdate
  ? 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: [+ uri]
  ? Description: [+ text / 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: [+ text]
}
```



```
RecordData = {
  ? restriction: restriction .default "private"
  ? ext-restriction: text
  ? observable-id: IDtype
  ? DateTime: tdate
  ? Description: [+ text / MLStringType]
  ? Applicadtion: SoftwareType
  ? RecordPattern: [+ RecordPattern]
  ? RecordItem: [+ ExtensionType]
  ? URL: [+ uri]
  ? 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: text  
  ? Description: [+ text / 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: [+ uri]  
  ? HashData: HashData  
  ? Signature: [+ text]  
  ? AssociatedSoftware: SoftwareType  
  ? FileProperties: [+ ExtensionType]  
}
```

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

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

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

```
Indicator = {
```

```
? restriction: restriction .default "private"
? ext-restriction: text
IndicatorID: IndicatorID
? AlternativeIndicatorID: [+ AlternativeIndicatorID]
? Description: [+ text / MLStringType]
? StartTime: tdate
? EndTime: tdate
? Confidence: Confidence
? Contact: [+ Contact]
? Observable: Observable
? uid-ref: IDREFType
? 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
  IndicatorReference: [+ IndicatorReference]
}

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-url" / "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: [+ uri]
? Description: [+ text / MLStringType]
```

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

Figure 3: Data Model in CDDL

6. Acknowledgements

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

7. IANA Considerations

This document registers a JSON schema.

8. Security Considerations

This memo does not provide any further security considerations than the one described in [RFC7970].

9. Normative References

[jsonschema]

"JSON Schema", 2006.

<http://json-schema.org/>

[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>>.

[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>>.

Appendix A. 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", "ext-value"]},
"duration": {"enum": ["second", "minute", "hour", "day", "month", "quarter",
    "year", "ext-value"]},
"lang": {"enum": ["en", "jp"]},
"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"},
"PORTLIST": {"type": "string"},
"URLtype": {"type": "string"},
"IDtype": {"type": "string"},
"ExtensionType": {
    "type": "object",
    "properties": {
        "name": {"type": "string"},
        "dtype": {"enum": ["boolean", "byte", "bytes", "character", "date-time",
            "ntpstamp", "integer", "portlist", "real", "string", "file",
            "path", "frame", "packet", "ipv4-packet", "ipv6-packet", "url",
            "csv", "winreg", "xml", "ext-value"]},
        "ext-dtype": {"type": "string"},
        "meaning": {"type": "string"},
        "formatid": {"type": "string"},
        "restriction": {"$ref": "#/definitions/restriction"},
        "ext-restriction": {"type": "string"},
        "observable-id": {"$ref": "#/definitions/IDtype"}}},
"ExtensionTypeList": {
    "type": "array",
    "items": {"$ref": "#/definitions/ExtensionType"}},
"SoftwareType": {
    "type": "object",
    "properties": {
        "SoftwareReference": {"$ref": "#/definitions/SoftwareReference"},
        "URL": {"$ref": "#/definitions/URLtype"},
        "Description": {"type": "array", "items": {"type": "string"}}},
    "required": [],
    "additionalProperties": false},
"SoftwareReference": {
    "type": "object",
    "properties": {
        "value": {"type": "string"},
        "spec-name": {"type": "string"},
        "ext-spec-name": {"type": "string"},
        "dtype": {"type": "string"},
        "ext-dtype": {"type": "string"}},
    "required": ["spec-name"],

```

```
"additionalProperties": false},
"StructuredInfo": {
  "type": "object",
  "properties": {
    "specID": {"type": "string"},
    "ext-specID": {"type": "string"},
    "contentID": {"type": "string"},
    "RawData": {"type": "string"},
    "URL": {"$ref": "#/definitions/URLtype"}},
  "required": ["specID"],
  "additionalProperties": false},
"Incident": {
  "title": "Incident",
  "description": "JSON schema for Incident class",
  "type": "object",
  "properties": {
    "purpose": {"$ref": "#/definitions/purpose"},
    "ext-purpose": {"type": "string"},
    "status": {"$ref": "#/definitions/status"},
    "ext-status": {"type": "string"},
    "lang": {"$ref": "#/definitions/lang"},
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "IncidentID": {"$ref": "#/definitions/IncidentID"},
    "AlternativeID": {"$ref": "#/definitions/AlternativeID"},
    "RelatedActivity": {
      "type": "array",
      "items": {"$ref": "#/definitions/RelatedActivity"}},
    "DetectTime": {"type": "string"},
    "StartTime": {"type": "string"},
    "EndTime": {"type": "string"},
    "RecoveryTime": {"type": "string"},
    "ReportTime": {"type": "string"},
    "GenerationTime": {"type": "string"},
    "Description": {"type": "array", "items": {"type": "string"}},
    "Discovery": {
      "type": "array", "items": {"$ref": "#/definitions/Discovery"}},
    "Assessment": {
      "type": "array", "items": {"$ref": "#/definitions/Assessment"}},
    "Methods": {
      "type": "array", "items": {"$ref": "#/definitions/Method"}},
    "Contacts": {
      "type": "array", "items": {"$ref": "#/definitions/Contact"}},
    "EventData": {
      "type": "array", "items": {"$ref": "#/definitions/EventData"}},
    "IndicatorList": {
      "type": "array", "items": {"$ref": "#/definitions/Indicator"}},
```

```
    "History": {"$ref": "#/definitions/History"},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": ["IncidentID", "GenerationTime", "Contacts", "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": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"}},
  "required": ["name"],
  "additionalProperties": false},
"AlternativeID": {
  "title": "AlternativeID",
  "description": "JSON schema for AlternativeID class",
  "type": "object",
  "properties": {
    "IncidentID": {
      "type": "array", "items": {"$ref": "#/definitions/IncidentID"}},
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"}},
  "required": ["IncidentID"],
  "additionalProperties": false},
"RelatedActivity": {
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "IncidentID": {
      "type": "array", "items": {"$ref": "#/definitions/IncidentID"}},
    "URL": {
      "type": "array", "items": {"$ref": "#/definitions/URLtype"}},
    "ThreatActor": {
      "type": "array", "items": {"$ref": "#/definitions/ThreatActor"}},
    "Campaign": {
      "type": "array", "items": {"$ref": "#/definitions/Campaign"}},
    "IndicatorID": {
      "type": "array", "items": {"$ref": "#/definitions/IndicatorID"}},
    "Confidence": {"$ref": "#/definitions/Confidence"},
    "Description": {"type": "array", "items": {"type": "string"}},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "additionalProperties": false},
"ThreatActor": {
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
```



```

    "ext-restriction": {"type": "string"},
    "ThreatActorID": {"type": "array", "items": {"type": "string"}},
    "Description": {"type": "array", "items": {"type": "string"}},
    "URL": {"type": "array", "items": {"$ref": "#/definitions/URLtype"}},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"},
    "additionalProperties": false},
  "Campaign": {
    "properties": {
      "restriction": {"$ref": "#/definitions/restriction"},
      "ext-restriction": {"type": "string"},
      "CampaignID": {"type": "array", "items": {"type": "string"}},
      "URL": {"type": "array", "items": {"$ref": "#/definitions/URLtype"}},
      "Description": {"type": "array", "items": {"type": "string"}},
      "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"},
          "ext-restriction": {"type": "string"},
          "ContactName": {"type": "array", "items": {"type": "string"}},
          "ContactTitle": {"type": "array", "items": {"type": "string"}},
          "Description": {"type": "array", "items": {"type": "string"}},
          "RegistryHandle": {
            "type": "array", "items": {"$ref": "#/definitions/RegistryHandle"}},
          "PostalAddress": {
            "type": "array", "items": {"$ref": "#/definitions/PostalAddress"}},
          "Email": {"type": "array", "items": {"$ref": "#/definitions/Email"}},

          "Telephone": {
            "type": "array", "items": {"$ref": "#/definitions/Telephone"}},
          "Timezone": {"type": "string"},
          "Contact": {
            "type": "array", "items": {"$ref": "#/definitions/Contact"}},
          "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
        "required": ["role", "type"],
        "additionalProperties": false},
    "RegistryHandle": {
      "type": "object",
      "properties": {
        "handle": {"type": "string"},
        "registry": {

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    "enum": ["internic","apnic","arin","lacnic","ripe","afrinic",
             "local","ext-value"]},
    "ext-registry": {"type": "string"}},
    "required": ["registry"],
    "additionalProperties": false},
"PostalAddress": {
  "type": "object",
  "properties": {
    "type": {"type": "string"},
    "ext-type": {"type": "string"},
    "PAddress": {"type": "string"},
    "Description": {"type": "array", "items": {"type": "string"}}},
    "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": {"type": "string"}}},
    "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": {"type": "string"}}},
    "required": ["TelephoneNumber"],
    "additionalProperties": false},
"Discovery": {
  "type": "object",
  "properties": {
    "source": {
      "enum": ["nidps","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": {"$ref": "#/definitions/restriction"},
      "ext-restriction": {"type": "string"},
      "Description": {"type": "array", "items": {"type": "string"}},
      "Contact": {
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    "type": "array", "items": {"$ref": "#/definitions/Contact"}},
  "DetectionPattern": {
    "type": "array",
    "items": {"$ref": "#/definitions/DetectionPattern"}},
  "required": [],
  "additionalProperties": false},
"DetectionPattern": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "Application": {"$ref": "#/definitions/SoftwareType"},
    "Description": {"type": "array", "items": {"type": "string"}},
    "DetectionConfiguration": {
      "type": "array", "items": {"type": "string"}},
    "required": ["Application"],
    "additionalProperties": false},
"Method": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "References": {
      "type": "array", "items": {"$ref": "#/definitions/Reference"}},
    "Description": {"type": "array", "items": {"type": "string"}},
    "AttackPattern": {
      "type": "array", "items": {"$ref": "#/definitions/StructuredInfo"}},
    "Vulnerability": {
      "type": "array", "items": {"$ref": "#/definitions/StructuredInfo"}},
    "Weakness": {
      "type": "array", "items": {"$ref": "#/definitions/StructuredInfo"}},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": [],
    "additionalProperties": false},
"Reference": {
  "type": "object",
  "properties": {
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "ReferenceName": {"type": "string"},
    "URL": {"type": "array", "items": {"$ref": "#/definitions/URLtype"}},
    "Description": {"type": "array", "items": {"type": "string"}},
    "required": [],
    "additionalProperties": false},
"Assessment": {
  "type": "object",
  "properties": {
    "occurrence": {"enum": ["actual", "potential"]},

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"restriction": {"$ref": "#/definitions/restriction"},
"ext-restriction": {"type": "string"},
"observable-id": {"$ref": "#/definitions/IDtype"},
"IncidentCategory": {"type": "array", "items": {"type": "string"}},
"SystemImpact": {
  "type": "array", "items": {"$ref": "#/definitions/SystemImpact"}},
"BusinessImpact": {
  "type": "array", "items": {"$ref": "#/definitions/BusinessImpact"}},
"TimeImpact": {
  "type": "array", "items": {"$ref": "#/definitions/TimeImpact"}},
"MonetaryImpact": {
  "type": "array", "items": {"$ref": "#/definitions/MonetaryImpact"}},
"IntendedImpact": {
  "type": "array", "items": {"$ref": "#/definitions/BusinessImpact"}},
"Counter": {
  "type": "array", "items": {"$ref": "#/definitions/Counter"}},
"MitigatingFactor": {
  "type": "array", "items": {"$type": "string"}},
"Cause": {"type": "array", "items": {"$type": "string"}},
"Confidence": {"$ref": "#/definitions/Confidence"},
"AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
"required": [],
"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": {"type": "string"}},
    "required": ["type"],
    "additionalProperties": false},
"BusinessImpact": {
  "type": "object",
  "properties": {
    "severity": {
      "enum": ["none", "low", "medium", "high", "unknown", "ext-value"]},

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"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": {"type": "string"}}},
"required": ["type"],
"additionalProperties": false},
"TimeImpact": {
  "type": "object",
  "properties": {
    "value": {"type": "number"},
    "severity": {"enum": ["low", "medium", "high"]},
    "metric": {"enum": ["labor", "elapsed", "downtime", "ext-value"]},
    "ext-metric": {"type": "string"},
    "duration": {"$ref": "#/definitions/duration"},
    "ext-duration": {"type": "string"}},
  "required": ["metric"],
  "additionalProperties": false},
"MonetaryImpact": {
  "type": "object",
  "properties": {
    "value": {"type": "number"},
    "severity": {"enum": ["low", "medium", "high"]},
    "currency": {"type": "string"}},
  "required": [],
  "additionalProperties": false},
"Confidence": {
  "type": "object",
  "properties": {
    "value": {"type": "number"},
    "rating": {
      "enum": ["low", "medium", "high", "numeric", "unknown", "ext-value"]},
    "ext-rating": {"type": "string"}},
  "required": ["rating"],
  "additionalProperties": false},
"History": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "HistoryItem": {
      "type": "array", "items": {"$ref": "#/definitions/HistoryItem"}},
  "required": ["HistoryItem"],
  "additionalProperties": false},
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```
"HistoryItem": {
  "type": "object",
  "properties": {
    "action": {"$ref": "#/definitions/action"},
    "ext-action": {"type": "string"},
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "DateTime": {"$ref": "#/definitions/DATETIME"},
    "IncidentID": {"$ref": "#/definitions/IncidentID"},
    "Contact": {"$ref": "#/definitions/Contact"},
    "Description": {"type": "array", "items": {"type": "string"}},
    "DefinedCOA": {"type": "array", "items": {"type": "string"}},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": ["DateTime", "action"],
  "additionalProperties": false},
"EventData": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "Description": {"type": "array", "items": {"type": "string"}},
    "DetectTime": {"type": "string"},
    "StartTime": {"type": "string"},
    "EndTime": {"type": "string"},
    "RecoveryTime": {"type": "string"},
    "ReportTime": {"type": "string"},
    "Contact": {
      "type": "array", "items": {"$ref": "#/definitions/Contact"}},
    "Discovery": {
      "type": "array", "items": {"$ref": "#/definitions/Discovery"}},
    "Assessment": {"$ref": "#/definitions/Assessment"},
    "Method": {
      "type": "array", "items": {"$ref": "#/definitions/Method"}},
    "System": {
      "type": "array", "items": {"$ref": "#/definitions/System"}},
    "Expectation": {
      "type": "array", "items": {"$ref": "#/definitions/Expectation"}},
    "RecordData": {"type": "array",
      "items": {"$ref": "#/definitions/RecordData"}},
    "EventData": {
      "type": "array", "items": {"$ref": "#/definitions/EventData"}},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": ["ReportTime"],
  "additionalProperties": false},
"Expectation": {
  "type": "object",
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"properties": {
  "action": {"$ref": "#/definitions/action"},
  "ext-action": {"type": "string"},
  "severity": {"enum": ["low", "medium", "high"]},
  "restriction": {"$ref": "#/definitions/restriction"},
  "ext-restriction": {"type": "string"},
  "observable-id": {"$ref": "#/definitions/IDtype"},
  "Description": {"type": "array", "items": {"type": "string"}},
  "DefinedCOA": {"type": "array", "items": {"type": "string"}},
  "StartTime": {"type": "string"},
  "EndTime": {"type": "string"},
  "Contact": {"$ref": "#/definitions/Contact"}},
"required": [],
"additionalProperties": false},
"System": {
  "type": "object",
  "properties": {
    "category": {
      "enum": ["source", "target", "intermediate", "sensor",
              "infrastructure", "ext-value"]},
    "ext-category": {"type": "string"},
    "interface": {"type": "string"},
    "spoofed": {"enum": ["unknown", "yes", "no"]},
    "virtual": {"enum": ["yes", "no", "unknown"]},
    "ownership": {
      "enum": ["organization", "personal", "partner", "customer",
              "no-relationship", "unknown", "ext-value"]},
    "ext-ownership": {"type": "string"},
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "Node": {"$ref": "#/definitions/Node"},
    "NodeRole": {
      "type": "array", "items": {"$ref": "#/definitions/NodeRole"}},
    "Service": {
      "type": "array", "items": {"$ref": "#/definitions/Service"}},
    "OperatingSystem": {
      "type": "array", "items": {"$ref": "#/definitions/SoftwareType"}},
    "Counter": {
      "type": "array", "items": {"$ref": "#/definitions/Counter"}},
    "AssetID": {"type": "array", "items": {"type": "string"}},
    "Description": {"type": "array", "items": {"type": "string"}},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
"required": ["Node"],
"additionalProperties": false},
"Node": {
  "type": "object",
  "properties": {

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"DomainData": {
  "type": "array", "items": {"$ref": "#/definitions/DomainData"}},
"Address": {
  "type": "array", "items": {"$ref": "#/definitions/Address"}},
"PostalAddress": {"type": "string"},
"Location": {"type": "array", "items": {"type": "string"}},
"Counter": {"type": "array",
  "items": {"$ref": "#/definitions/Counter"}},
"required": [],
"additionalProperties": false},
"Address": {
  "type": "object",
  "properties": {
    "value": {"type": "string"},
    "category": {
      "enum": ["asn", "atm", "e-mail", "ipv4-addr", "ipv4-net",
        "ipv4-net-masked", "ipv4-net-mask", "ipv6-addr", "ipv6-net",
        "ipv6-net-masked", "mac", "site-url", "ext-value"]},
    "ext-category": {"type": "string"},
    "vlan-name": {"type": "string"},
    "vlan-num": {"type": "integer"},
    "observable-id": {"$ref": "#/definitions/IDtype"}},
  "required": ["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",
        "hot-point", "reflector", "phishing-site",
        "spear-phishing-site", "recruiting-site",
        "fraudulent-site", "ext-value"]},
    "ext-category": {"type": "string"},
    "Description": {"type": "array", "items": {"type": "string"}}},
  "required": ["category"],
  "additionalProperties": false},
"Counter": {
  "type": "object",

```



```

"properties": {
  "value": {"type": "string"},
  "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": {"$ref": "#/definitions/duration"},
  "ext-duration": {"type": "string"}},
"required": ["type", "unit"],
"additionalProperties": false},
"DomainData": {
  "type": "object",
  "properties": {
    "system-status": {
      "enum": ["spoofed", "fraudulent", "innocent-hacked",
        "innocent-hijacked", "unknown", "ext-value"]},
    "ext-system-status": {"type": "string"},
    "domain-status": {
      "enum": [
        "reservedDelegation", "assignedAndActive", "assignedAndInactive",
        "assignedAndOnHold", "revoked", "transferPending", "registryLock",
        "registrarLock", "other", "unknown", "ext-value"]},
    "ext-domain-status": {"type": "string"},
    "observable-id": {"$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"}},
    "NameServers": {
      "type": "array", "items": {"$ref": "#/definitions/NameServers"}},
    "DomainContacts": {
      "$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"}},
"required": ["Server", "Address"],
"additionalProperties": false},
"DomainContacts": {

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"type": "object",
"properties": {
  "SameDomainContact": {"type": "string"},
  "Contact": {"type": "array",
    "items": {"$ref": "#/definitions/Contact"}},
  "required": ["Contact"],
  "additionalProperties": false},
"Service": {
  "type": "object",
  "properties": {
    "ip-protocol": {"type": "integer"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "ServiceName": {"$ref": "#/definitions/ServiceName"},
    "Port": {"type": "integer"},
    "Portlist": {"$ref": "#/definitions/PORTLIST"},
    "ProtoCode": {"type": "integer"},
    "ProtoType": {"type": "integer"},
    "ProtoField": {"type": "integer"},
    "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": {"type": "string"}},
  "required": [],
  "additionalProperties": false},
"EmailData": {
  "type": "object",
  "properties": {
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "EmailTo": {"type": "array", "items": {"type": "string"}},
    "EmailFrom": {"type": "string"},
    "EmailSubject": {"type": "string"},
    "EmailX-Mailer": {"type": "string"},
    "EmailHeaderField": {
      "type": "array", "items": {"$ref": "#/definitions/ExtensionType"}},
    "EmailHeaders": {"type": "string"},
    "EmailBody": {"type": "string"},
    "EmailMessage": {"type": "string"},
    "HashData": {
      "type": "array", "items": {"$ref": "#/definitions/HashData"}},
    "Signature": {"type": "array", "items": {"type": "string"}},
  "required": [],
```

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    "additionalProperties": false},
  "RecordData": {
    "type": "object",
    "properties": {
      "restriction": {"$ref": "#/definitions/restriction"},
      "ext-restriction": {"type": "string"},
      "observable-id": {"$ref": "#/definitions/IDtype"},
      "DateTime": {"$ref": "#/definitions/DATETIME"},
      "Description": {"type": "array", "items": {"type": "string"}},
      "Applicadtion": {"$ref": "#/definitions/SoftwareType"},
      "RecordPattern": {
        "type": "array", "items": {"$ref": "#/definitions/RecordPattern"}},
      "RecordItem": {
        "type": "array", "items": {"$ref": "#/definitions/ExtensionType"}},
      "URL": {
        "type": "array", "items": {"$ref": "#/definitions/URLtype"}},
      "FileData": {
        "type": "array", "items": {"$ref": "#/definitions/FileData"}},
      "WindowsRegistryKeysModified": {
        "type": "array",
        "items": {"$ref": "#/definitions/WindowsRegistryKeysModified"}},
      "CertificateData": {
        "type": "array", "items": {"$ref": "#/definitions/CertificateData"}},
      "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": [],
    "additionalProperties": false
  },
  "RecordPattern": {
    "type": "object",
    "properties": {
      "value": {"type": "string"},
      "type": {"enum": ["regex", "binary", "xpath", "ext-value"]},
      "ext-type": {"type": "string"},
      "offset": {"type": "integer"},
      "offsetunit": {"enum": ["line", "byte", "ext-value"]},
      "ext-offsetunit": {"type": "string"},
      "instance": {"type": "integer"}},
    "required": ["type"],
    "additionalProperties": false},
  "WindowsRegistryKeysModified": {
    "type": "object",
    "properties": {
      "observable-id": {"$ref": "#/definitions/IDtype"},
      "Key": {"type": "array", "items": {"$ref": "#/definitions/Key"}},
      "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"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "Certificate": {
      "type": "array", "items": {"$ref": "#/definitions/Certificate"}}},
"required": ["Certificate"],
"additionalProperties": false},
"Certificate": {
  "type": "object",
  "properties": {
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "X509Data": {"type": "string"},
    "Description": {"type": "array", "items": {"type": "string"}}},
"required": ["X509Data"],
"additionalProperties": false},
"FileData": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "observable-id": {"$ref": "#/definitions/IDtype"},
    "File": {"type": "array", "items": {"$ref": "#/definitions/File"}}},
"required": ["File"],
"additionalProperties": false},
"File": {
  "type": "object",
  "properties": {
    "FileName": {"type": "string"},
    "FileSize": {"type": "integer"},
    "FileType": {"type": "string"},
    "URL": {"type": "array", "items": {"$ref": "#/definitions/URLtype"}},
    "HashData": {"$ref": "#/definitions/HashData"},
    "Signature": {"type": "array", "items": {"type": "string"}},
    "AssociatedSoftware": {"$ref": "#/definitions/SoftwareType"},
    "FileProperties": {

```

```
    "type": "array", "items": {"$ref": "#/definitions/ExtensionType"}}},
  "required": [],
  "additionalProperties": false},
"HashData": {
  "type": "object",
  "properties": {
    "scope": {"enum": ["file-contents", "file-pe-section", "file-pe-iat",
      "file-pe-resource", "file-pdf-object", "email-hash",
      "email-hash-header", "email-hash-body"]},
    "HashTargetID": {"type": "string"},
    "Hash": {"type": "array", "items": {"$ref": "#/definitions/Hash"}},
    "FuzzyHash": {
      "type": "array", "items": {"$ref": "#/definitions/FuzzyHash"}},
    "required": ["scope"],
    "additionalProperties": false},
"Hash": {
  "type": "object",
  "properties": {
    "DigestMethod": {"type": "string"},
    "DigestValue": {"type": "string"},
    "CanonicalizationMethod": {},
    "Application": {"$ref": "#/definitions/SoftwareType"}},
    "required": ["DigestMethod", "DigestValue"],
    "additionalProperties": false},
"FuzzyHash": {
  "type": "object",
  "properties": {
    "FuzzyHashValue": {
      "type": "array", "items": {"$ref": "#/definitions/ExtensionType"}},
    "Application": {"$ref": "#/definitions/SoftwareType"},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": ["FuzzyHashValue"],
    "additionalProperties": false},
"Indicator": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "IndicatorID": {"$ref": "#/definitions/IndicatorID"},
    "AlternativeIndicatorID": {
      "type": "array",
      "items": {"$ref": "#/definitions/AlternativeIndicatorID"}},
    "Description": {"type": "array", "items": {"type": "string"}},
    "StartTime": {"$ref": "#/definitions/DATETIME"},
    "EndTime": {"$ref": "#/definitions/DATETIME"},
    "Confidence": {"$ref": "#/definitions/Confidence"},
    "Contact": {
      "type": "array", "items": {"$ref": "#/definitions/Contact"}},
```

```
"Observable": {"$ref": "#/definitions/Observable"},
"uid-ref": {"type": "string"},
"IndicatorExpression": {"$ref": "#/definitions/IndicatorExpression"},
"IndicatorReference": {"$ref": "#/definitions/IndicatorReference"},
"NodeRole": {
  "type": "array", "items": {"$ref": "#/definitions/NodeRole"}},
"AttackPhase": {
  "type": "array", "items": {"$ref": "#/definitions/AttackPhase"}},
"Reference": {
  "type": "array", "items": {"$ref": "#/definitions/Reference"}},
"AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
"required": ["IndicatorID"],
"additionalProperties": false},
"IndicatorID": {
  "type": "object",
  "properties": {
    "id": {"type": "string"},
    "name": {"type": "string"},
    "version": {"type": "string"}},
  "required": ["name", "version"],
  "additionalProperties": false},
"AlternativeIndicatorID": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "ext-restriction": {"type": "string"},
    "IndicatorReference": {
      "type": "array",
      "items": {"$ref": "#/definitions/IndicatorReference"}},
    "required": ["IndicatorReference"],
    "additionalProperties": false},
"Observable": {
  "type": "object",
  "properties": {
    "restriction": {"$ref": "#/definitions/restriction"},
    "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": {"$ref": "#/definitions/RegistryHandle"},
    "RecordData": {"type": "array",
      "item": {"$ref": "#/definitions/Record"}},
```

```

    "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": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": [],
  "additionalProperties": false},
"BulkObservable": {
  "type": "object",
  "properties": {
    "type": {"enum": ["asn", "atm", "e-mail", "ipv4-addr", "ipv4-net",
      "ipv4-net-mask", "ipv6-addr", "ipv6-net", "ipv6-net-mask",
      "mac", "site-url", "domain-name", "domain-to-ipv4",
      "domain-to-ipv6", "domain-to-ipv4-timestamp",
      "domain-to-ipv6-timestamp", "ipv4-port", "ipv6-port",
      "windows-reg-key", "file-hash", "email-x-mailer",
      "email-subject", "http-user-agent", "http-request-url",
      "mutex", "file-path", "user-name", "ext-value"]},
    "ext-type": {"type": "string"},
    "BulkObservableFormant": {
      "$ref": "#/definitions/BulkObservableFormat"},
    "BulkObservableList": {"type": "array", "item": {"type": "string"}},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": [],
  "additionalProperties": false},
"BulkObservableFormat": {
  "type": "object",
  "properties": {
    "Hash": {"$ref": "#/definitions/Hash"},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
  "required": [],
  "additionalProperties": false},
"IndicatorExpression": {
  "type": "object",
  "properties": {
    "operator": {"enum": ["not", "and", "or", "xor"]},
    "ext-operator": {"type": "string"},
    "IndicatorExpression": {
      "type": "array",
      "items": {"$ref": "#/definitions/IndicatorExpression"}},
    "Observable": {
      "type": "array", "items": {"$ref": "#/definitions/Observable"}},
    "uid-ref": {"type": "string"},
    "IndicatorReference": {

```

```

    "type": "array",
    "items": {"$ref": "#/definitions/IndicatorReference"}},
    "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": [],
    "additionalProperties": false},
  "IndicatorReference": {
    "type": "object",
    "properties": {
      "uid-ref": {"type": "string"},
      "euid-ref": {"type": "string"},
      "version": {"type": "string"}},
    "required": [],
    "additionalProperties": false},
  "AttackPhase": {
    "type": "object",
    "properties": {
      "AttackPhaseID": {"type": "array", "items": {"type": "string"}},
      "URL": {"type": "array", "items": {"$ref": "#/definitions/URLtype"}},
      "Description": {"type": "array", "items": {"type": "string"}},
      "AdditionalData": {"$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"}},
      "AdditionalData": {"$ref": "#/definitions/ExtensionTypeList"}},
    "required": ["version", "Incident"],
    "additionalProperties": false}

```

Figure 4: JSON schema

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