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IODEF Usage Guidance
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Abstract

The Incident Object Description Exchange Format [RFC5070] defines a data representation that provides a framework for sharing information commonly exchanged by Computer Security Incident Response Teams (CSIRTs) about computer security incidents. Since the IODEF model includes a wealth of available options that can be used to describe a security incident or issue, it can be challenging for implementers to develop tools that can Leverage IODEF for incident sharing. This document provides guidelines for IODEF implementers. It will also address how common security indicators can be represented in IODEF and use-cases of how IODEF is being used so far.The goal of this document is to make IODEF's adoption by vendors easier and encourage faster and wider adoption of the model by Computer Security Incident Response Teams (CSIRTs) around the world.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on April 21, 2016.

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1. Introduction

The Incident Object Description Exchange Format in [RFC5070] defines a data representation that provides a framework for sharing information commonly exchanged by Computer Security Incident Response

Teams (CSIRTs) about computer security incidents. The IODEF data model consists of multiple classes and data types that are used in the IODEF XML schema.

The IODEF schema was designed to be able to describe all the possible fields that would be needed in a security incident exchange. Thus, IODEF contains plenty data constructs that could potentially make it harder for IODEF implementers to decide which are the most important ones. Additionally, in the IODEF schema, there exist multiple fields and classes which do not necessarily need to be used in every possible data exchange. Moreover, there are fields that are useful only in data exchanges of non-traditional security events. This document tries to address the issues above. It will also address how common security indicators can be represented in IODEF. It will point out the most important IODEF classes for an implementer and describe other ones that are not as important. Also, it addresses some common challenges for IODEF implementers and how they should be addressed. The end goal of this document is to make IODEF's adoption by vendors easier and encourage faster and wider adoption of the model by Computer Security Incident Response Teams (CSIRTs) around the world.

Section 3 discusses the recommended classes and how an IODEF implementer should chose the classes to implement. Section 4 presents common considerations and implementer will come across and how to address them. Section 5 goes over some basic security concepts and how they can be expressed in IODEF.

2. Terminology

The terminology used in this document follows the one defined in [RFC5070] and [RFC7203].

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].

3. Implementation Strategy

It is important for IODEF implementers to be able to distinguish how the IODEF classes will be used for incident information exchanges. It is critical for an implementer to follow a strategy according to which he will chose to implement various IODEF classes. It is also important to know what the most common classes that will be used to describe common security incident or indicators. Thus, this section will describe the most important classes and factors an IODEF implementer should take into consideration before designing the implementation or tool.

3.1. Recommended classes to implement

This section explains the mandatory to implement IODEF classes that are required more than once and also are useful. The mandatory top level class is the IODEF-Document class. One or more Incident class that represents the incident information need to be arranged under the IODEF-Document class. IncidentID, ReportTime, Assessment, and Contact under Incident class are mandatory classes. EventData, Record, Assessment, ReportTime, DetectTime, StartTime, ReportTime Description, Discovery

[TODO: More to be added...]

3.2. Decide what IODEF will be used for

This section describes that there is no need to implement all fields of IODEF, the ones that are necessary for your use-cases. The implementer should look into the schema and decide classes to implement (or not) Also it explains that other external schemata might be needed to describe incidents or indicators, based on SCI draft extensions.

[TODO: More to be added...]

4. IODEF considerations and how to address them

4.1. Unnecessary Fields

This section talks about fields that do not always play in important role like Assessment, Impact

[TODO: More to be added...]

4.2. External References

The IODEF format has the Reference class that refers to external information such as a vulnerability, Intrusion Detection System (IDS) alert, malware sample, advisory, or attack technique. However, due to insufficiency of the capability of the Reference class itself to describe external enumeration specifications, the Enumeretion Reference Format needs to be used with. The Enumeration Reference Format[RFC7495] specifies a format to include enumeration values from external data representations into IODEF, and manages references to external representations using IANA registry.

[TODO: More to be added...]

4.3. Extensions

The IODEF data model ([RFC5070]) is extensible. Many class attributes and their values can be extended using using the "ext-*" prefix. Additional classed can also be defined by using the AdditionalData and RecordItem classes. An extension to the AdditionalData class for reporting Phishing emails is defined in [RFC5901].

Additionally, IODEF can import existing schemata by using an extension framework defined in [RFC7203]. The framework enables IODEF users to embed XML data inside an IODEF document using external schemata or structures defined by external specifications. Examples include CVE, CVRF and OVAL. Thus, [RFC7203] enhances the IODEF capabilities without further extending the data model.

IODEF implementers should consider using their own IODEF extensions only for data that cannot be described using existing standards or importing them in and IODEF document using [RFC7203] is not a suitable option.

4.4. Predicate logic

IODEF [I-D.ietf-mile-rfc5070-bis] allows for nesting of incident information. For example, a EventData Class could include multiple Flows or Records. In turn, a Flow could consist of many Nodes and a Record of many RecordData classes. To ensure consistency, IODEF presumes certain predicate logic.

An EventData class that contains multiple EventData classes depicts an Event that consists of smaller events. For the parent event to take place, all the children EventData events SHOULD take place.

An EventData class with multiple Flows means that all the information defined in the flows need to exist for the event described to take place. For Records, the Records in an event just add more context to the event, they do not all need to be present for the event to take place. A Record in an EventData class with three RecordData in it, means that either of these RecordData classes needs to be present for the event described to take place.

In [RFC5070], if a Flow Class contained two System classes that have "source" and "target" as the category attributes, both Systems SHOULD be present in order for the Flow to be true and thus marked as an event. There SHOULD NOT be more than one "source" or "watchlist-source" and one "target" or "watchlist-target" Systems per Flow.

In Node class, Node information grouped together under a System class depicts different representations of the same System. For example, if a System consists of different Nodes with an IPv4 address, a domain-name and an IPv6 address, they all represent the same system. Of course, different representations could also be grouped under the same Node class.

[I-D.ietf-mile-rfc5070-bis] defined the HashData Class that describes a file's hash information as also described in [RFC5901]. Similar to the Node, if a HashData class consists of many digital signatures, the signatures represent alternative hash algorithms for the same signature. For example, if the HashData type is file-hash, then the signatures represent MD5, SHA1, SHA2 etc hashes.

For grouped Key classes the logic changes. Multiple Key classes in a WindowsRegistryKeysModified class represent necessary Windows Registry Keys that constitute an indicator. All SHOULD be present in order for the indicator to be present. Multiple WindowsRegistryKeysModified classes grouped under the same RecordData class represent alternatives for the same indicator. For example, if a RecordData class included two WindowsRegistryKeysModified classes, if either of the classes was true the RecordData class would be true.

4.5. Predicate Logic for watchlist of indicators

Multiple indicators occasionally need to be combined in an IODEF document. For example, a botnet might have multiple command and control servers. A consistent predicate logic for indicators SHOULD be followed in order to present such relationships in IODEF.

[I-D.ietf-mile-rfc5070-bis] defines two new category attributes in the System Class that can enhance the IODEF predicate logic functionality. These are watchlist-source and watchlist-target and they serve for watchlist indicator groupings. A watchlist of Systems means that the information is ORed with the information in the Flow section. In other words, if a Flow Class consists of multiple Systems with watchlist-source or watchlist-target attributes the Systems of the same watchlist type are ORed in the Flow Class. Multiple Flows in the EventData Class follow AND logic. There SHOULD NOT be more than one "watchlist-source" and one "watchlist-target" Systems per Flow. In the following example the EventData class will evaluates as a Flow of one System with source address being (10.10.10.104 OR 10.10.10.106) AND target address 10.1.1.1

```
<!-- ...XML code omitted... -->
<iodef:EventData>
   <iodef:Flow>
      <iodef:System category="watchlist-source" spoofed="no">
         <iodef:Node>
            <iodef:Address category="ipv4-addr">
               10.10.10.104
            </iodef:Address>
         </iodef:Node>
         <iodef:Node>
            <iodef:Address category="ipv4-addr">
               10.10.10.106
            </iodef:Address>
         </iodef:Node>
      </iodef:System>
      <iodef:System category="target">
         <iodef:Node>
            <iodef:Address category="ipv4-addr">
               10.1.1.1
            </iodef:Address>
         </iodef:Node>
      </iodef:System>
   </iodef:Flow>
</iodef:EventData>
<!-- ...XML code omitted... -->
```

Similarly, the HashData Class includes a type attribute that introduces watchlist groupings (i.e. PKI_email_ds_watchlist, PGP_email_ds_watchlist, file_hash_watchlist, email_hash_watchlist). Two HashData classes that contain a watchlist type attribute follow OR logic in a RecordData class. In the following example the RecordData class consists of either of the two files with two different hashes.

```
<!-- ...XML code omitted... -->
<iodef:RecordData>
   <iodef:HashData type="file-hash-watchlist">
      <iodef:FileName>dummy.txt</iodef:FileName>
      <ds:Reference>
         <ds:DigestMethod Algorithm=
           "http://www.w3.org/2001/04/xmlenc#sha256"/>
         <ds:DigestValue>
           141accec23e7e5157de60853cb1e01bc38042d
           08f9086040815300b7fe75c184
         </ds:DigestValue>
      </ds:Reference>
   </iodef:HashData>
   <iodef:HashData type="file-hash-watchlist">
      <iodef:FileName>dummy2.txt</iodef:FileName>
      <ds:Reference>
         <ds:DigestMethod Algorithm=
          "http://www.w3.org/2001/04/xmlenc#sha256"/>
         <ds:DigestValue>
           141accec23e7e5157de60853cb1e01bc38042d
           08f9086040815300b7fe75c184
         </ds:DigestValue>
      </ds:Reference>
   </iodef:HashData>
</iodef:RecordData>
<!-- ...XML code omitted... -->
```

Similarly, [I-D.ietf-mile-rfc5070-bis] introduces the WindowsRegistryKeyModified Class which consists of Key Classes. Key has an optional type attribute which has watchlist as an option in order to include the ability to group Keys. Multiple Keys of the same watchlist of indicators SHOULD be grouped in the same WindowsRegistryKeysModified Class. These Keys follow OR logic.

4.6. Indicator identifiers

[I-D.ietf-mile-rfc5070-bis] defines attrbutes indicator-set-id and indicator-uid. These are data elements that are commonly used as indicators. They are used in mutliple IODEF classes. Their purpose is to be able to define indicator relationships and reference respectively. The indicator-uid is used as a unique indicator identifier. Practitioners MAY use them to establish that a class represents an indicator that is different than other IODEF contextual information.

On the other hand, an IODEF report could contain multiple indicators that are part of the same or different indicator group. For example, an IP source address, a target address, that consitute a Flow and a

RecordData class respectively could be representing indicators of a virous and the traffic it generates. In such a situation, the indicator-set-id for all the classes (Address, RecordData) MUST be the same. Unrelated indicators MUST contain different indicator-set-id attributes or no indicator-set-id attributes.

Similarly,

4.7. Restrictions in IODEF

This section describes how Restriction can pose challenges

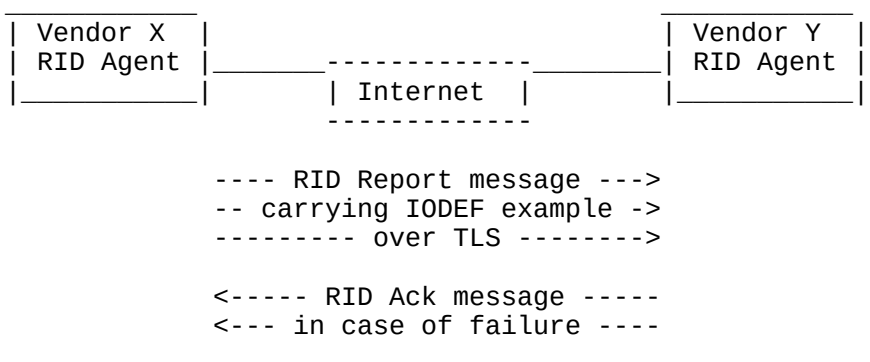
[TODO: More to be added...]

5. Current uses of IODEF

IODEF is currently used by various organizations in order to represent security incidents and share incident and threat information between security operations organizations.

5.1. Inter-vendor and Service Provider Exercise

Various vendors organized and executed an exercise where multiple threat indicators were exchanged using IODEF. The transport protocol used was RID. The threat information shared included incidents like DDoS attacks. Malware and Spear-Phishing. As this was a proof-of-concept (PoC) exercise only example information (no real threats) were shared as part of the exchanges.



PoC peering topology

The figure above shows how RID interactions took place during the PoC. Participating organizations were running RID Agent software on-premises. The RID Agents formed peering relationships with other participating organizations. When Entity X had a new incident to

exchange it would package it in IODEF and send it to Entity Y over TLS in a RID Report message. In case there was an issue with the message, Entity Y would send an RID Acknowledgement message back to Entity X which included an application level message to describe the issue. Interoperability between RID agents and the standards, [RFC6545] and [RFC6546], was also proven in this exercise. Appendix A includes some of the incident IODEF example information that was exchanged by the organizations' RID Agents as part of this proof-of-concept.

The first use-case included sharing of Malware Data Related to an Incident between CSIRTs. After Entity X detected an incident, she would put data about malware found during the incident in a backend system. Entity X then decided to share the incident information with Entity Y about the malware discovered. This could be a human decision or part of an automated process.

Below are the steps followed for the malware information exchange that was taking place:

(1) Entity X has a sharing agreement with Entity Y, and has already been configured with the IP address of Entity Y's RID Agent

(2) Entity X's RID Agent connects to Entity Y's RID Agent, and mutual authentication occurs using PKI certificates.

(3) Entity X pushes out a RID Report message which contains information about N pieces of discovered malware. IODEF is used in RID to discribe the

    (a) Hash of malware files

    (b) Registry settings changed by the malware

    (c) C&C Information for the malware

(4) Entity Y receives RID Report message, sends RID Acknowledgement message

(5) Entity Y stores the data in a format that makes it possible for the back end to know which source the data came from.

Another use-case was sharing Distributed Denial of Service (DDoS) as presented below information: Entity X, a Critical Infrastructure and Key Resource (CIKR) company detects that their internet connection is saturated with an abnormal amount of traffic. Further investigation determines that this is an actual DDoS attack. Entity X's computer incident response team (CIRT) contacts their ISP and shares

information with them about the attack traffic characteristics. In addition, Entity X has an information sharing relationship with Entity Y. It shares information with Entity Y on characteristics of the attack to watch for. Entitty X's ISP is being overwhelmed by the amount of traffic, so it shares attack signatures and IP addresses of the most prolific hosts with its adjacent ISPs.

Below are the steps followed for a DDoS information exchange:

(1) Entity X has a sharing agreement with Entity Y, and has already been configured with the IP address of Entity Y's RID Agent

(2) Entity X's RID Agent connects to Entity Y's RID Agent, and mutual authentication occurs using PKI certificates.

(3) Entity X pushes out a RID Report message which contains information about the DDoS attack. IODEF is used in RID to discribe the

    (a) Start and Detect dates and times

    (b) IP Addresses of nodes sending DDoS Traffic

    (c) Sharing and Use Restrictions

    (d) Traffic characteristics (protocols and ports)

    (e) HTTP User-Agents used

    (f) IP Addresses of C&C for a botnet

(4) Entity Y receives RID Report message, sends RID Acknowledgement message

(5) Entity Y stores the data in a format that makes it possible for the back end to know which source the data came from.

One more use-case was sharing spear-phishing email information as explained in the following scenario: The board members of several defense contractors receive an email inviting them to attend a conference in San Francisco. The board members are asked to provide their personally identifiable information such as their home address, phone number, corporate email, etc in an attached document which came with the email. The board members were also asked to click on a URL which would allow them to reach the sign up page for the conference. One of the recipients believes the email to be a phishing attempt and forwards the email to their corporate CSIRT for analysis. The CSIRT

identifies the email as an attempted spear phishing incident and distributes the indicators to their sharing partners.

Below are the steps followed for a spear-phishing information exchange between CSIRTs that was part of this PoC.

(1) Entity X has a sharing agreement with Entity Y, and has already been configured with the IP address of Entity Y's RID Agent

(2) Entity X's RID Agent connects to Entity Y's RID Agent, and mutual authentication occurs using PKI certificates.

(3) Entity X pushes out a RID Report message which contains information about the spear-phishing email. IODEF is used in RID to discribe the

    (a) Attachment details (file Name, hash, size, malware family

    (b) Target description (IP, domain, NSLookup)

    (c) Email information (From, Subject, header information, date/ time, digital signature)

    (d) Confidence Score

(4) Entity Y receives RID Report message, sends RID Acknowledgement message

(5) Entity Y stores the data in a format that makes it possible for the back end to know which source the data came from.

5.2. Implementations

[TODO: Mention and quickly describe [I-D.ietf-mile-implementreport] ...]

5.3. Other

IODEF is also used in various projects and products to consume and share security information. Various vendor incident reporting products have the ability to consume and export in IODEF format [implementations]. Perl and Python modules (XML::IODEF, Iodef::Pb, iodeflib) exist in order to parse IODEF documents and their extensions. Additionally, some worldwide CERT organizations are already able to use receive incident information in IODEF.

Future use-cases of IODEF could be:

(1) ISP notifying a national CERT or organization when it identifies and acts upon an incident and CERTs notifying ISPs when they are aware of incidents.

(2) Suspected phishing emails could be shared amongst organizations and national agencies. Automation could validate web content that the suspicious emails are pointing to. Identified malicious content linked in a phishing email could then be shared using IODEF. Phishing campaigns could thus be subverted much faster by automating information sharing using IODEF.

(3) When finding a certificate that should be revoked, a thrid-party would forward an automated IODEF message to the CA with the full context of the certificate and the CA could act accordingly after checking its validity. Alternatively, in the event of a compromise of the private key of a certificate, a third-party could alert the certificate owner about the compromise using IODEF.

6. Security Considerations

7. Updates

version -04 updates:

(1) Expanded on the Extensions section using Take’s suggestion.

(2) Moved Future use-cases under the Other section.

(3) CIF and APWG were consolidated in one "Implementation" section

(4) Added abstract of RFC7495 to the "External References" section

(5) Added Kathleen’s example of malware delivery URL to "Appendix"

(6) Added a little description to "Recommended classes to implement" section

version -03 updates:

(1) Added "Updates" section.

(2) Added details about the flow of information exchanges in "Inter-vendor and Service Provider Exercise" section. Also updated the usecases with more background information.

(3) Added future use-cases in the "Collective Intelligence Framework" section

(4) Updated Perl and Python references with the actual module names. Added IODEF implementation reference "implementations".

(5) Added Predicate logic section

(6) Updated Logic of watchlist of indicators section to simplify the logic and include examples.

(7) Renamed Externally defined indicators section to Indicator reference and elaborated on the use of indicator-uid and indicator-set-uid attribute use.

version -02 updates:

(1) Updated the "Logic for watchlist of indications" section to clarify the logic based on community feedback.

(2) Added "Inter-vendor and Service Provider Exercise" section.

(3) Added Appendix to include actual use-case IODEF examples.

8. Acknowledgements

9. Security Considerations

10. References

10.1. Normative References

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[RFC5901] Cain, P. and D. Jevans, "Extensions to the IODEF-Document Class for Reporting Phishing", RFC 5901, DOI 10.17487/RFC5901, July 2010, <http://www.rfc-editor.org/info/rfc5901>.

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[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, <http://www.rfc-editor.org/info/rfc7203>.

[RFC7495] Montville, A. and D. Black, "Enumeration Reference Format for the Incident Object Description Exchange Format (IODEF)", RFC 7495, DOI 10.17487/RFC7495, March 2015, <http://www.rfc-editor.org/info/rfc7495>.

10.2. Informative References

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[CIF] "CIF", <http://csirtgadgets.org/collective-intelligence-framework/>.

[I-D.ietf-mile-implementreport] Inacio, C. and d. daisu-mi@nc.u-tokyo.ac.jp, "MILE Implementation Report", draft-ietf-mile-implementreport-06 (work in progress), October 2015.

[I-D.ietf-mile-rfc5070-bis] Danyliw, R. and P. Stoecker, "The Incident Object Description Exchange Format v2", draft-ietf-mile-rfc5070-bis-15 (work in progress), October 2015.

[implementations] "Implementations on IODEF", <http://siis.realmv6.org/implementations/>.

Appendix A. Inter-vendor and Service Provider Exercise Examples

Below some of the incident IODEF example information that was exchanged by the vendors as part of this proof-of-concept Inter-vendor and Service Provider Exercise.

A.1. Malware

In this test, malware information was exchanged using RID and IODEF. The information included file hashes, registry setting changes and the C&C servers the malware uses.

```
<?xml version="1.0" encoding="UTF-8"?>
            <iodef:IODEF-Document xmlns:ds="
                http://www.w3.org/2000/09/xmldsig#"
                xmlns:iodef="urn:ietf:params:xml:ns:iodef-1.41">
          <iodef:Incident purpose="reporting">
            <iodef:ReportID name="EXAMPLE CSIRT">
               189234
            </iodef:ReportID>
            <iodef:ReportTime>
               2013-03-07T16:14:56.757+05:30
            </iodef:ReportTime>
            <iodef:Description>
               Malware and related indicators identified
            </iodef:Description>
            <iodef:Assessment occurrence="potential">
              <iodef:Impact severity="medium" type="info-leak">
                 Malware with Command and Control Server
                 and System Changes
              </iodef:Impact>
            </iodef:Assessment>
            <iodef:Contact role="creator" type="organization">
              <iodef:ContactName>EXAMPLE CSIRT</iodef:ContactName>
              <iodef:Email>emccirt@emc.com</iodef:Email>
            </iodef:Contact>
            <iodef:EventData>
              <iodef:Method>
                <iodef:Reference>
                  <iodef:ReferenceName>Zeus</iodef:ReferenceName>
                  <iodef:URL>
                      http://www.threatexpert.com/report.aspx?
                      md5=e2710ceb088dacdcb03678db250742b7
                  </iodef:URL>
                </iodef:Reference>
              </iodef:Method>
              <iodef:Flow>
                <iodef:System category="watchlist-source">
                  <iodef:Node>
                    <iodef:Address category="ipv4-addr">
                       192.168.2.200
                    </iodef:Address>
                    <iodef:Address category="site-uri">
                       http://zeus.556677889900.com/log-bin/
                       lunch_install.php?aff_id=1&amp;amp;
                       lunch_id=1&amp;amp;maddr=&amp;amp;
                       action=install
                    </iodef:Address>
                    <iodef:NodeRole attacktype="c2-server"/>
                  </iodef:Node>
```

```
        </iodef:System>
      </iodef:Flow>
      <iodef:Record>
        <iodef:RecordData>
          <iodef:HashData>
            <ds:Reference>
              <ds:DigestMethod Algorithm="
                 http://www.w3.org/2001/04/xmlenc#sha1"/>
              <ds:DigestValue>
                   MHg2NzUxQTI1MzQ4M0E2N0Q4NkUwRjg0NzYwRj
                   YxRjEwQkJDQzJFREZG</ds:DigestValue>
            </ds:Reference>
          </iodef:HashData>
          <iodef:HashData>
            <ds:Reference>
              <ds:DigestMethod Algorithm="
                  http://www.w3.org/2001/04/xmlenc#md5"/>
              <ds:DigestValue>
                  MHgyRTg4ODA5ODBENjI0NDdFOTc5MEFGQTg5NTE
                  zRjBBNA==
              </ds:DigestValue>
            </ds:Reference>
          </iodef:HashData>
          <iodef:WindowsRegistryKeysModified>
            <iodef:Key registryaction="add_value">
              <iodef:KeyName>
                  HKLM\Software\Microsoft\Windows\
                  CurrentVersion\Run\tamg
              </iodef:KeyName>
              <iodef:Value>
                 ?\?\?%System%\wins\mc.exe\?\??
              </iodef:Value>
            </iodef:Key>
            <iodef:Key registryaction="modify_value">
              <iodef:KeyName>HKLM\Software\Microsoft\
                 Windows\CurrentVersion\Run\dqo
              </iodef:KeyName>
              <iodef:Value>"\"\"%Windir%\Resources\
                  Themes\Luna\km.exe\?\?"
              </iodef:Value>
            </iodef:Key>
          </iodef:WindowsRegistryKeysModified>
        </iodef:RecordData>
      </iodef:Record>
    </iodef:EventData>
    <iodef:EventData>
      <iodef:Method>
        <iodef:Reference>
```

```
                    <iodef:ReferenceName>Cridex</iodef:ReferenceName>
                    <iodef:URL>
                        http://www.threatexpert.com/report.aspx?
                        md5=c3c528c939f9b176c883ae0ce5df0001
                    </iodef:URL>
                  </iodef:Reference>
                </iodef:Method>
                <iodef:Flow>
                  <iodef:System category="watchlist-source">
                    <iodef:Node>
                      <iodef:Address category="ipv4-addr">
                         10.10.199.100
                      </iodef:Address>
                      <iodef:NodeRole attacktype="c2-server"/>
                    </iodef:Node>
                    <iodef:Service ip_protocol="6">
                      <iodef:Port>8080</iodef:Port>
                    </iodef:Service>
                  </iodef:System>
                </iodef:Flow>
                <iodef:Record>
                  <iodef:RecordData>
                    <iodef:HashData>
                      <ds:Reference>
                        <ds:DigestMethod Algorithm="
                           http://www.w3.org/2001/04/xmlenc#sha1"/>
                        <ds:DigestValue>
                           MHg3MjYzRkUwRDNBMDk1RDU5QzhFMEM4OTVBOUM
                           1ODVFMzQzRTcxNDFD
                        </ds:DigestValue>
                      </ds:Reference>
                      <ds:Reference>
                        <ds:DigestMethod Algorithm="
                           http://www.w3.org/2001/04/xmlenc#md5"/>
                        <ds:DigestValue>MHg0M0NEODUwRkNEQURFNDMzMEE1
                           QkVBNkYxNkVFOTcxQw==</ds:DigestValue>
                      </ds:Reference>
                    </iodef:HashData>
                    <iodef:HashData>
                      <ds:Reference>
                        <ds:DigestMethod Algorithm="
                            http://www.w3.org/2001/04/xmlenc#md5"/>
                        <ds:DigestValue>MHg0M0NEODUwRkNEQURFNDMzMEE
                            1QkVBNkYxNkVFOTcxQw==</ds:DigestValue>
                      </ds:Reference>
                      <ds:Reference>
                        <ds:DigestMethod Algorithm="http://www.w3.org/
                            2001/04/xmlenc#sha1"/>
```

```
                    <ds:DigestValue>MHg3MjYzRkUwRDNBMDk1RDU5QzhFME
                        M4OTVBOUM1ODVFMzQzRTcxNDFD</ds:DigestValue>
                  </ds:Reference>
                </iodef:HashData>
                <iodef:WindowsRegistryKeysModified>
                  <iodef:Key registryaction="add_value">
                    <iodef:KeyName>
                       HKLM\Software\Microsoft\Windows\
                       CurrentVersion\Run\KB00121600.exe
                    </iodef:KeyName>
                    <iodef:Value>
                       \?\?%AppData%\KB00121600.exe\?\?
                    </iodef:Value>
                  </iodef:Key>
                </iodef:WindowsRegistryKeysModified>
              </iodef:RecordData>
            </iodef:Record>
          </iodef:EventData>
          <iodef:EventData>
            <iodef:Expectation action="other"/>
              <iodef:Flow>
                <iodef:System category="source"
                      indicator-set-id="91011">
                  <iodef:Node>
                      <iodef:Address category="url"
                         indicator-uid="qrst">
                            http://foo.com:12345/evil/cc.php
                      </iodef:Address>
                  <iodef:NodeName indicator-uid="rstu">
                      evil.com
                  </iodef:NodeName>
                      <iodef:Address category="ipv4-addr"
                         indicator-uid="stuv">
                            1.2.3.4</iodef:Address>
                      <iodef:Address category="ipv4-addr"
                         indicator-uid="tuvw">
                            5.6.7.8 </iodef:Address>
                      <iodef:Address category="ipv6-addr"
                         indicator-uid="uvwx">
                             2001:dead:beef::</iodef:Address>
                   <iodef:NodeRole category="c2-server"/>
                   </iodef:Node>
              </iodef:System>
            </iodef:Flow>
            <iodef:Record>
              <iodef:RecordData indicator-set-id="91011">
                <iodef:HashData>
                   <ds:Reference>
```

```
                        <ds:DigestMethod Algorithm=
                            "http://www.w3.org/2001/04/xmlenc
                             #sha256"/>
                         <ds:DigestValue>
                          141accec23e7e5157de60853cb1e01bc3804
                          2d08f9086040815300b7fe75c184
                         </ds:DigestValue>
                       </ds:Reference>
                     </iodef:HashData>
                   <iodef:WindowsRegistryKeysModified
                     indicator-set-id="91011">
                     <iodef:Key registryaction="add_key"
                     indicator-uid="vwxy">
                       <iodef:KeyName>
                           HKLM\SYSTEM\CurrentControlSet\
                           Services\.Net CLR
                       </iodef:KeyName>
                     </iodef:Key>
                     <iodef:Key registryaction="add_key"
                       indicator-uid="wxyz">
                       <iodef:KeyName>
                           HKLM\SYSTEM\CurrentControlSet\
                           Services\.Net CLR\Parameters
                       </iodef:KeyName>
                       <iodef:Value>
                           \"\"%AppData%\KB00121600.exe\"\"
                       </iodef:Value>
                     </iodef:Key>
                     <iodef:Key registryaction="add_value"
                       indicator-uid="xyza">
                       <iodef:KeyName>
                          HKLM\SYSTEM\CurrentControlSet\Services\
                          .Net CLR\Parameters\ServiceDll
                       </iodef:KeyName>
                       <iodef:Value>C:\bad.exe</iodef:Value>
                     </iodef:Key>
                     <iodef:Key registryaction="modify_value"
                       indicator-uid="zabc">
                       <iodef:KeyName>
                           HKLM\SYSTEM\CurrentControlSet\
                           Services\.Net CLR\Parameters\Bar
                       </iodef:KeyName>
                       <iodef:Value>Baz</iodef:Value>
                     </iodef:Key>
                   </iodef:WindowsRegistryKeysModified>
                 </iodef:RecordData>
               </iodef:Record>
             </iodef:EventData>
```

```
            </iodef:Incident>
          </iodef:IODEF-Document>
```

A.2. Malware Delivery URL

[TODO: fix indicator_uid attribute to Indicator class]

This example indicates malware and related URL for file delivery.

```
<?xml version="1.0" encoding="UTF-8"?>
<IODEF-Document version="1.00" lang="en"
        xmlns="urn:ietf:params:xml:ns:iodef-1.0"
        xmlns:iodef="urn:ietf:params:xml:ns:iodef-1.0"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<iodef:Incident purpose="reporting">
      <iodef:IncidentID name="csirt.example.com">
          189801
      </iodef:IncidentID>
      <iodef:ReportTime>2012-12-05T12:20:00+00:00</iodef:ReportTime>
      <iodef:Description>Malware and related indicators</iodef:Description>
          <iodef:Assessment occurrence="potential">
              <iodef:Impact severity="medium" type="info-leak">Malware with C&am
p;C </iodef:Impact>
           </iodef:Assessment>
                   <iodef:Contact role="creator" type="organization">
                <iodef:ContactName>example.com CSIRT
                </iodef:ContactName>
                <iodef:Email>contact@csirt.example.com</iodef:Email>
            </iodef:Contact>
            <iodef:EventData>
            <iodef:Flow>
<iodef:System category="source">
                  <iodef:Node>
                    <iodef:Address indicator_uid="xxxxx" category="ipv4-addr">19
2.168.2.200</iodef:Address>
                    <iodef:Address indicator_uid="xxxxx" category="url">
                      http://zeus.556677889900.example.com/log-bin/lunch_install
.php?aff_id=1&amp;lunch_id=1&amp;maddr=&amp;action=install</iodef:Address>
                    <iodef:NodeRole category="c2-server"/>
                  </iodef:Node>
              </iodef:System>
            </iodef:Flow>
        </iodef:EventData>
    </iodef:Incident>
</IODEF-Document>
```

A.3. DDoS

The DDoS test exchanged information that described a DDoS including protocols and ports, bad IP addresses and HTTP User-Agent fields.

The IODEF version used for the data representation was based on [I-D.ietf-mile-rfc5070-bis]

```
<?xml version="1.0" encoding="UTF-8"?>
<IODEF-Document version="1.00" lang="en"
    xmlns="urn:ietf:params:xml:ns:iodef-1.41"
    xmlns:iodef="urn:ietf:params:xml:ns:iodef-1.41"
    xmlns:iodef-sci="urn:ietf:params:xml:ns:iodef-sci-1.0"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:ds="http://www.w3.org/2000/09/xmldsig#">
     <iodef:Incident purpose="reporting" restriction="default">
         <iodef:IncidentID name="csirt.example.com">
             189701
         </iodef:IncidentID>
         <iodef:StartTime>2013-02-05T00:34:45+00:00</iodef:StartTime>
         <iodef:DetectTime>2013-02-05T01:15:45+00:00</iodef:DetectTime>
         <iodef:ReportTime>2013-02-05T01:34:45+00:00</iodef:ReportTime>
         <iodef:description>DDoS Traffic Seen</iodef:description>
            <iodef:Assessment occurrence="actual">
                <iodef:Impact severity="medium" type="dos">
                DDoS Traffic</iodef:Impact>
                <iodef:Confidence rating="numeric">90
                </iodef:Confidence>
            </iodef:Assessment>
            <iodef:Contact role="creator" type="organization">
                <iodef:ContactName>Dummy Test</iodef:ContactName>
                <iodef:Email>contact@dummytest.com</iodef:Email>
            </iodef:Contact>
            <iodef:EventData>
               <iodef:Description>
                   Dummy Test sharing with ISP1
               </iodef:Description>
            <iodef:Expectation action="other"/>
            <iodef:Method>
               <iodef:Reference>
                  <iodef:ReferenceName>
                      Low Orbit Ion Cannon User Agent
                  </iodef:ReferenceName>
                  <iodef:URL>
                     http://blog.spiderlabs.com/2011/01/loic-ddos-
                     analysis-and-detection.html
                  </iodef:URL>
                  <iodef:URL>
                     http://en.wikipedia.org/wiki/Low_Orbit_Ion_Cannon
                  </iodef:URL>
               </iodef:Reference>
            </iodef:Method>
            <iodef:Flow>
```

```
               <iodef:System category="watchlist-source" spoofed="no">
                  <iodef:Node>
                    <iodef:Address category="ipv4-addr">
                       10.10.10.104</iodef:Address>
                  </iodef:Node>
                  <iodef:Node>
                    <iodef:Address category="ipv4-addr">
                       10.10.10.106</iodef:Address>
                                  </iodef:Node>
                  <iodef:Node>
                    <iodef:Address category="ipv4-net">
                     172.16.66.0/24</iodef:Address>
                     </iodef:Node>
                  <iodef:Node>
                    <iodef:Address category="ipv6-addr">
                     2001:db8:dead:beef::</iodef:Address>
                               </iodef:Node>
    <iodef:Service ip_protocol="6">
       <iodef:Port>1337</iodef:Port>
       <iodef:Application user-agent="Mozilla/5.0 (Macintosh; U;
              Intel Mac OS X 10.5; en-US; rv:1.9.2.12) Gecko/
              20101026 Firefox/3.6.12">
       </iodef:Application>
    </iodef:Service>
               </iodef:System>
                <iodef:System category="target">
                   <iodef:Node>
                     <iodef:Address category="ipv4-addr">
    10.1.1.1</iodef:Address>
                  </iodef:Node>
                  <iodef:Service ip_protocol="6">
                    <iodef:Port>80</iodef:Port>
                  </iodef:Service>
               </iodef:System>
               <iodef:System category="sensor"><iodef:Description>
                   Information provided in FLow class instance is from
                   Inspection of traffic from network tap
               </iodef:Description></iodef:System>
            </iodef:Flow>
         </iodef:EventData>
     </iodef:Incident>
 </IODEF-Document>
```

A.4. Spear-Phishing

The Spear-Phishing test exchanged information that described a Spear-Phishing email including DNS records and addresses about the sender, malicious attached file information and email data. The IODEF

version used for the data representation was based on [I-D.ietf-mile-rfc5070-bis].

```
<?xml version="1.0" encoding="UTF-8"?>
<IODEF-Document version="1.00" lang="en"
    xmlns="urn:ietf:params:xml:ns:iodef-1.41"
    xmlns:iodef="urn:ietf:params:xml:ns:iodef-1.41"
    xmlns:iodef-sci="urn:ietf:params:xml:ns:iodef-sci-1.0"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:ds="http://www.w3.org/2000/09/xmldsig#">
     <iodef:Incident purpose="reporting">
         <iodef:IncidentID name="csirt.example.com">
            189601
         </iodef:IncidentID>
         <iodef:StartTime>2013-01-04T08:01:34+00:00</iodef:StartTime>
         <iodef:StopTime>2013-01-04T08:31:27+00:00</iodef:StopTime>
         <iodef:DetectTime>2013-01-04T08:06:12+00:00</iodef:DetectTime>
         <iodef:ReportTime>2013-01-04T09:15:45+00:00</iodef:ReportTime>
         <iodef:description>
            Zeus Spear Phishing E-mail with Malware Attachment
         </iodef:description>
            <iodef:Assessment occurrence="potential">
                <iodef:Impact severity="medium" type="info-leak">
                Malware with Command and Control Server and System
                Changes</iodef:Impact>
            </iodef:Assessment>
            <iodef:Contact role="creator" type="organization">
                <iodef:ContactName>example.com CSIRT
                </iodef:ContactName>
                <iodef:Email>contact@csirt.example.com</iodef:Email>
            </iodef:Contact>
            <iodef:EventData>
              <iodef:Description>Targeting Defense Contractors,
                 specifically board members attending Dummy Con
              </iodef:Description>
            <iodef:Expectation action="other"/>
            <iodef:Method>
               <iodef:Reference indicator_uid="1234">
                  <iodef:ReferenceName>Zeus</iodef:ReferenceName>
                  </iodef:Reference>
            </iodef:Method>
            <iodef:Flow>
               <iodef:System category="source">
                  <iodef:Node>
                    <iodef:Address category="url">
                          http://www.zeusevil.com</iodef:Address>
                    <iodef:Address category="ipv4-addr">
                          10.10.10.166</iodef:Address>
```

```
                    <iodef:Address category="as">
                           225</iodef:Address>
                     <iodef:Address category="ext-value"
                       ext-category="as-name">
                       EXAMPLE-AS - University of Example"
                       </iodef:Address>
                     <iodef:Address category="ext-value"
                       ext-category="as-prefix">
                       172.16..0.0/16
                       </iodef:Address>
                     <iodef:NodeRole category="www"
                       attacktype="malware-distribution"/>
                  </iodef:Node>
               </iodef:System>
            </iodef:Flow>
            <iodef:Flow>
               <iodef:System category="source">
                  <iodef:Node>
                   <iodef:NodeName>mail1.evildave.com</iodef:NodeName>
                    <iodef:Address category="ipv4-addr">
                           172.16.55.6</iodef:Address>
                    <iodef:Address category="asn">
                           225</iodef:Address>
                     <iodef:Address category="ext-value"
                       ext-category="as-name">
                       EXAMPLE-AS - University of Example
                     </iodef:Address>
    <iodef:DomainData>
       <iodef:Name>evildaveexample.com</iodef:Name>
       <iodef:DateDomainWasChecked>2013-01-04T09:10:24+00:00
       </iodef:DateDomainWasChecked>
       <iodef:RelatedDNS RecordType="MX">
           evildaveexample.com MX prefernce = 10, mail exchanger
           = mail1.evildave.com</iodef:RelatedDNS>
       <iodef:RelatedDNS RecordType="A">
           mail1.evildaveexample.com
           internet address = 172.16.55.6</iodef:RelatedDNS>
       <iodef:RelatedDNS RecordType="SPF">
            zuesevil.com. IN TXT \"v=spf1 a mx -all\"
       </iodef:RelatedDNS>
    </iodef:DomainData>
                  <iodef:NodeRole category="mail"
                        attacktype="spear-phishing"/>
                  </iodef:Node>
                  <iodef:Service>
                     <iodef:EmailInfo>
                        <iodef:Email>emaildave@evildaveexample.com
                        </iodef:Email>
```

```
                    <iodef:EmailSubject>Join us at Dummy Con
                    </iodef:EmailSubject>
                    <iodef:X-Mailer>StormRider 4.0
                    </iodef:X-Mailer>
                 </iodef:EmailInfo>
              </iodef:Service>
           </iodef:System>
           <iodef:System category="target">
              <iodef:Node>
                 <iodef:Address category="ipv4">
                   192.168.54.2</iodef:Address>
              </iodef:Node>
            </iodef:System>
         </iodef:Flow>

         <iodef:Record>
           <iodef:RecordData>
             <iodef:HashData type="file_hash"
                indicator_uid="1234">
                <iodef:FileName>Dummy Con Sign Up Sheet.txt
                </iodef:FileName>
                <iodef:FileSize>152</iodef:FileSize>
             <ds:Reference>
                <ds:DigestMethod Algorithm=
                   "http://www.w3.org/2001/04/xmlenc#sha256"/>
                   <ds:DigestValue>
                     141accec23e7e5157de60853cb1e01bc38042d
                     08f9086040815300b7fe75c184
                   </ds:DigestValue>
             </ds:Reference>
           </iodef:HashData>
          </iodef:RecordData>
          <iodef:RecordData>
           <iodef:HashData type="PKI_email_ds" valid="0">
             <ds:Signature>
              <ds:KeyInfo>
                 <ds:X509Data>
                    <ds:X509IssuerSerial>
                       <ds:X509IssuerName>FakeCA
                    </ds:X509IssuerName>
                    </ds:X509IssuerSerial>
                    <ds:X509SubjectName>EvilDaveExample
                    </ds:X509SubjectName>
                 </ds:X509Data>
              </ds:KeyInfo>
                 <ds:SignedInfo>
                  <ds:Reference>
                     <ds:DigestMethod Algorithm=
```

```
                          "http://www.w3.org/2001/04/xmlenc#sha256"/>
                        <ds:DigestValue>
                         352bddec13e4e5257ee63854cb1f05de48043d09f9
                         076070845307b7ce76c185
                        </ds:DigestValue>
                      </ds:Reference>
                    </ds:SignedInfo>
                  </ds:Signature>
               </iodef:HashData>
            </iodef:RecordData>
          </iodef:Record>
        </iodef:EventData>
     </iodef:Incident>
 </IODEF-Document>
```

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