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Using Network Based Security Systems to Search for STIX and TAXII Based Indicators of Compromise

GIAC (GCIA) Gold Certification

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Abstract

As the interest in collecting actionable cyber intelligence has grown substantially over the last several years in response to the growing sophistication of attackers, with it has come the need for organizations to more readily process indicators of compromise – and act immediately upon them to determine if they are present in a given enterprise environment. While host-based tools have been designed for this very purpose, they can be challenging to deploy on an enterprise-wide basis and are dependent on frequent updates. This paper will propose several methodologies by which these indicators of compromise may be visible within network traffic. It will further study how key network security devices (e.g. Snort IDS, IPTables Firewall, Web Proxy, etc.) can be used to effectively identify and alert on indicators of compromise both on the way into the network and also via analysis of outbound traffic. In addition, STIX and TAXII will be thoroughly investigated as individual protocols, including how they can best be incorporated into the rapid generation of customized network monitoring rules.

1. Introduction

The field of cyber intelligence is a new but quickly growing discipline within Information Security. As successful attacks have become both more complex and more frequent, the need has never been greater to work collaboratively to stop malicious attackers before they are able to do harm to protected systems. One of the most effective ways to establish this collaboration has been through the creation and sharing of so-called “Indicators of Compromise” (IOC).

The OpenIOC project, an open source initiative founded by Mandiant and located at <http://www.OpenIOC.org>, defines an IOC as “specific artifacts left by an intrusion, or greater sets of information that allow for the detection of intrusions or other activities conducted by attackers.” (OpenIOC) Common IOCs may include hashes of known malicious files, IP addresses or DNS names of Command and Control (C&C) servers, registry keys and the contents of files (Decianno). The entire process by which IOCs are created and compared is summed up in this diagram from the OpenIOC project:

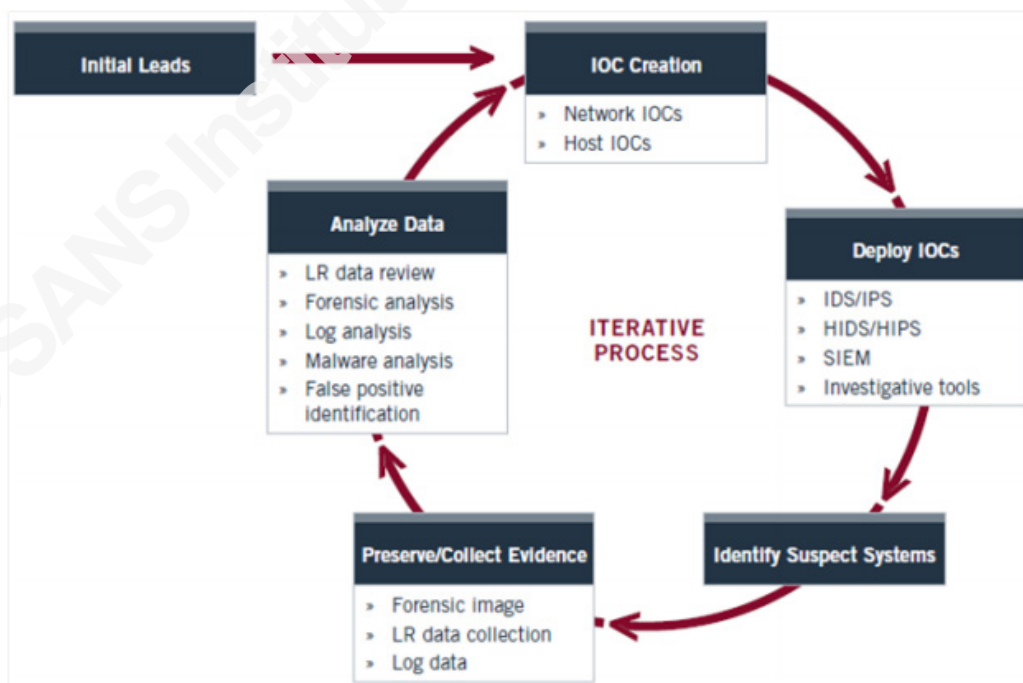


Figure 1: An Introduction to OpenIOC (Source: http://OpenIOC.org/resources/An_Introduction_to_OpenIOC.pdf).

In the above example, we see that the process begins with initial leads (which can also be thought of as intelligence collection), followed by IOC creation and deployment, and finally ends with a review for the presence of indicators in daily system and network activity.

Although this paper will touch upon all of these phases, the primary concentration will be on IOC deployment and identification within network traffic. In addition, although OpenIOC provides a framework to automate nearly all parts of the aforementioned process, we will be investigating the new STIX and TAXII standards – complementary but different technologies that have been adopted by NIST and MITRE for standardizing the sharing of IOCs.

However, before we can look at standardization in sharing, it is important to understand the technical basis of an IOC. Each specific IOC, be it shared via intelligence collaboration or collected internally, has a reason for its existence and a corresponding set of network technologies that would make the best choice for the implementation of detective and preventive controls. We will look at different examples of IOCs but will start with the most basic: making use of a network firewall to identify traffic from a known malicious IP address.

2. Finding Evil – Common Indicators of Compromise

2.1. IP Addresses

As mentioned, probably the most trivial IOC to work with is a simple IP address. In most modern host and network-based compromises, at least one C&C system is normally involved, although certainly the protocol it uses (HTTP, HTTPS, DNS) may vary (Qinetiq 2). Most C&C systems are deployed as part of a Botnet to send instructions to nodes known as zombies. These botnets can be extremely large, with one that was recently taken down numbering upwards of 1.9 million compromised hosts (Symantec).

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Identifying IP address communication is fundamental when monitoring IPV4 based communication. Consider the following example connection to google.com, captured using Wireshark (resolved via DNS to 195.122.30.55):

398	4	91925100	192.168.1.104	195.122.30.55	TCP	66	27581-80	[SYN]	Seq=0	Win=8192	Len=0	MSS=1460	WS=4	SACK_PERM=1	
399	4	91951900	192.168.1.104	195.122.30.55	TCP	66	27582-80	[SYN]	Seq=0	Win=8192	Len=0	MSS=1460	WS=4	SACK_PERM=1	
444	5	04648400	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=1	Ack=1	Win=65700	Len=0			
446	5	04785300	192.168.1.104	195.122.30.55	TCP	54	27581-80	[ACK]	Seq=1	Ack=1	Win=65700	Len=0			
448	5	04885200	192.168.1.104	195.122.30.55	TCP	54	27578-80	[ACK]	Seq=1	Ack=1	Win=65700	Len=0			
450	5	04893900	192.168.1.104	195.122.30.55	TCP	54	27579-80	[ACK]	Seq=1	Ack=1	Win=65700	Len=0			
452	5	05182300	192.168.1.104	195.122.30.55	TCP	54	27582-80	[ACK]	Seq=1	Ack=1	Win=65700	Len=0			
454	5	13140600	192.168.1.104	195.122.30.55	HTTP	395	GET / HTTP/1.1								
461	5	32250300	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=2921	Win=65700	Len=0			
464	5	32323800	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=5841	Win=65700	Len=0			
467	5	32420800	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=8761	Win=65700	Len=0			
470	5	32521500	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=11681	Win=64240	Len=0			
473	5	32543500	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=14601	Win=61320	Len=0			
474	5	32642000	192.168.1.104	195.122.30.55	TCP	54	[TCP window update]	27580-80	[ACK]	Seq=342	Ack=14601	Win=62780	Len=0		
475	5	32653600	192.168.1.104	195.122.30.55	TCP	54	[TCP window update]	27580-80	[ACK]	Seq=342	Ack=14601	Win=65700	Len=0		
479	5	45184000	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=37521	Win=65700	Len=0			
482	5	45265200	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=20441	Win=65700	Len=0			
485	5	47387400	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=23361	Win=65700	Len=0			
488	5	47465600	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=26281	Win=65700	Len=0			
491	5	48703300	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=29201	Win=65700	Len=0			
494	5	48758500	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=32121	Win=65700	Len=0			
497	5	49996400	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=342	Ack=35041	Win=65700	Len=0			
500	5	64849000	192.168.1.104	195.122.30.55	HTTP	970	GET /gen_2047v=3&=webhp&inc=1&lim=1&imp=0&ei=H1QjvbaRNIksAGZtYQQDw&e=4011550,4011551,4011557,4011559,402								
506	6	01639400	192.168.1.104	195.122.30.55	TCP	54	27580-80	[ACK]	Seq=1258	Ack=36337	Win=64404	Len=0			

Figure 2: Sample connection to Google obtained using live testing.

In this example, as seen in the third column of the packet capture (after the timestamp), Google's destination IP address can be clearly identified in the TCP/IP header. It is therefore possible to either alert or block connections to known compromised IP addresses (whether they come from open source intelligence, honeypots, or an organization's own intelligence collection efforts) using either a firewall or an IDS/IPS.

In practice, identifying an IOC within firewall logs is a relatively simple process. For example, analyzing the network addresses of known BlackPOS Malware C&C systems that were identified in a recent community intelligence bulletin from Crowdstrike, we can use IPTables to identify and block the IOCs:

```
iptables -N LOGGING
iptables -A INPUT -j LOGGING
iptables -A LOGGING -m limit --limit 2/min -j LOG --log-prefix "IPTables Packet Dropped: " --log-level 7
iptables -A INPUT -s 199.188.204.182 -- dport 21 j DROP
iptables -A INPUT -s 50.87.167.144 -- dport 21 j DROP
iptables -A INPUT -s 63.111.113.99 -- dport 21 j DROP
```

(Source: Natarjan).

Similar rules may be implemented using the Snort IDS/IPS to alert on the presence of known C&C destination traffic:

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```
alert tcp any any <> 199.188.204.182 21 (msg: "TargetBreach Exfil C2"; sid: xxx;)
alert tcp any any <> 50.87.167.144 21 (msg: "TargetBreach Exfil C2"; sid: xxx;)
alert tcp any any <> 63.111.113.99 21 (msg: "TargetBreach Exfil C2"; sid: xxx;)
```

(Source: Crowdstrike).

2.2. Domain Names and DNS

While IP addresses may be simple, a large portion of the network traffic that traverses the Internet every day is Domain Name-based. Domain names are the mapping between a URL and an IP address. When an IOC is presented as a domain name, it can be useful to both monitor it for active connections and block it in the future. In its simplest form, any host attempt to connect to a domain name will be predicated by a DNS request. The following is a simple but useful diagram of this process:

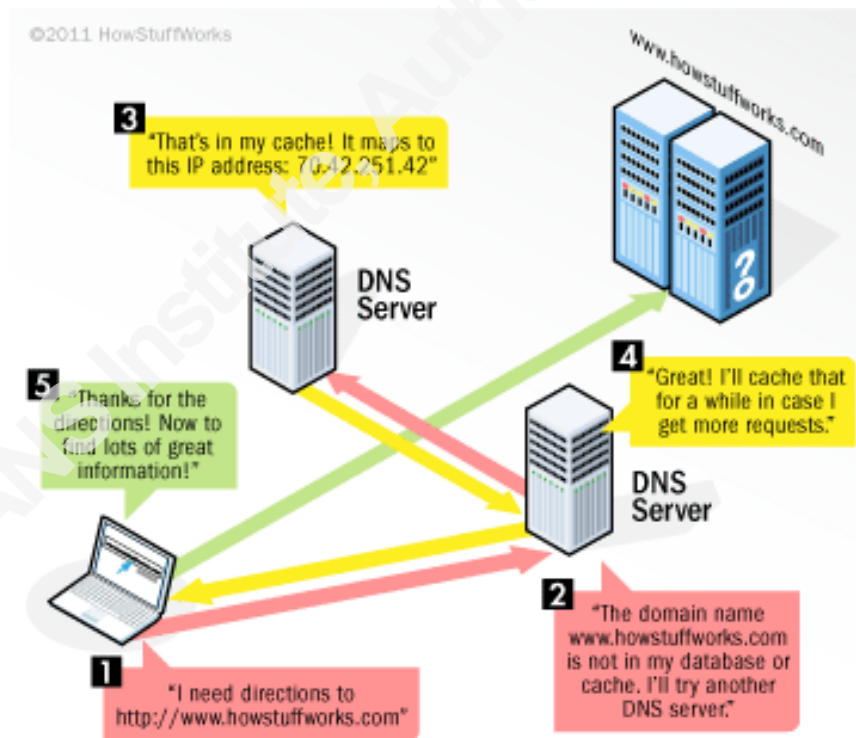


Figure 3: How Domain Name Servers Work (Source: <http://computer.howstuffworks.com/dns.htm>).

This diagram depicts that in order to capture potentially malicious DNS traffic, we need only capture traffic destined from client systems to DNS servers – at which point it would

then be possible to map client requests back to the domains being specifically requested. In practice, this traffic is relatively easy to identify through the use of a typical packet capture utility like Wireshark:

480	3.24474700	192.168.1.104	192.168.1.1	DNS	72 Standard query 0xa56b A www.sans.edu
481	3.24585500	192.168.1.1	192.168.1.104	DNS	102 Standard query response 0x60c3 A 66.35.59.213
482	3.24665900	192.168.1.104	192.168.1.1	DNS	84 Standard query 0x73d8 A www.securityinthehuman.org
508	3.26237600	192.168.1.1	192.168.1.104	DNS	88 Standard query response 0xa56b A 66.35.59.213
512	3.28017200	192.168.1.104	192.168.1.1	DNS	73 Standard query 0x5458 A adadvisor.net

Figure 4: Sample DNS connection traffic obtained using live testing.

In this very simple example, we see a DNS query and subsequent response in packets 480 and 508 (identified by the packet ID field in the first column of each line). Packet 480 indicates that a client system (likely a web browser but it could be an application or even malware) has made a request to the local domain server for the IP address of www.sans.org. Subsequently packet 508 contains the response from the DNS server: that the IP address for www.sans.org is 66.35.59.213. As a result of analyzing this short packet capture, we can further determine that 192.168.1.104 was the client that made the original DNS request, so if www.sans.org were in fact a malicious site, incident responders could then take appropriate action now knowing that 192.168.1.104 may be infected.

Realistically, however, this is not likely the most efficient way to monitor DNS traffic for known compromised sites. Probably one of the best tools available to do this is a web proxy. In fact, “there are numerous other ways to slice and dice Web proxy logs to find bad things. For example, comparing a list of currently known malicious domains or Zeus malware domains and IPs to the proxy logs can help find hosts that have been attacked or infected, but not blocked by the Web proxy.” (Sawyer 2011)

In addition to web proxies, there are also many content filtering tools, both commercial and free that have similar functionality. A recent survey from SMB-centric community site Spiceworks provides a long list of products that stem from OpenDNS, to BlueCoat, to Squid Proxy (Spiceworks). Once a web proxy or content filtering device is deployed,

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it is as simple as alerting on known bad sites or actively monitoring the logs. Log formats can differ based upon the product deployed, but will likely look something like the following:

Source Host	Destination URL / Domain Name	Action Taken (ie: Blocked, Allowed)	Categorization (If content filter)
-------------	-------------------------------	-------------------------------------	------------------------------------

Besides web proxies, IDS/IPS devices can also be used to look for connections to malicious domain names – by automating much of what was previously described using Wireshark. Here are sample Snort IDS rules covering two IOCs: one that alerts on any direct connection attempt using a known malicious string, and another that alerts on DNS requests to an identified malicious system:

```
alert tcp $HOME_NET any -> $EXTERNAL_NET $HTTP_PORTS (msg:"Trojan Command And Control Request"; flow:established,to_server; uricontent:"/control_me_i_am_yours.php"; nocase; classtype:trojan-activity; sid:1233333; rev:1;)
```

```
alert udp !$DNS_SERVERS any -> $DNS_SERVERS 53 (msg:"DNS request for iamacontrolserver.ru"; content:"|01 00 00 01 00 00 00 00 00 00|"; depth:10; offset:2; content:"iamacontrolserver|02|ru"; nocase; distance:0; classtype:trojan-activity; sid:1232313; rev:1;)
```

(Source: KaffeNews).

2.3. HTTP Application Headers

Although IP addresses and DNS traffic both make for easy to process IOCs, they can be highly prone to false positives since by their nature they are of only limited specificity. Particularly with IP addresses, the following complaint is common:

“Although IP addresses are a great pivot point because of their ubiquity and the amount of sources available to check against, there is one major problem with using IP addresses as a pivot point: a high rate of false-positives. The time to live (TTL) for an IP address as an effective indicator of compromise can be very low. Compromised hosts get patched, illicitly acquired hosting space is turned off, and malicious hosts are quickly identified and blocked or the traffic is black-holed by the ISP. Even when an IP address is being used for malicious activity it can

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sometimes be hard to block. Blocking an IP address on a shared hosting server with thousands of other legitimate sites, means also blocking all of those sites.”

(Lindka 108)

As a result, it can be useful to create and process IOCs that are more specific than just a basic IP address or domain name. These are some examples using Snort to target the same POS malware previously discussed in Section 2.1, but with specific rules for digging into the HTTP headers themselves:

```
alert tcp $HOME_NET any -> $EXTERNAL_NET $HTTP_PORTS (msg:"MALWARE-CNC Win.Tinybanker variant outbound connection"; flow:to_server,established; content:"User-Agent: Mozilla/5.0 (compatible|3B| MSIE 9.0|3B| Windows NT 6.1|3B| Trident/5.0)|OD 0A|Content-Type: application/x-www-form-urlencoded|OD 0A|Host: "; fast_pattern:only; http_header; content:"|OD 0A|Content-Length: 13|OD 0A|Connection: Close|OD 0A|Cache-Control: no-cache|OD 0A OD 0A|"; pcre:"/[^\x20-\x7e\r\n]{3}/P"; metadata:impact_flag red, policy balanced-ips drop, policy security-ips drop, ruleset community, service http; reference:url,blog.avast.com/2014/07/17/tinybanker-trojan-targets-banking-customers/; reference:url,www.virustotal.com/en/file/b88b978d00b9b3a011263f398fa6a21098aba714db14f7e71062ea4a6b2e974e/analysis/; classtype:trojan-activity; sid:31641; rev:1;)
```

```
alert tcp $HOME_NET any -> $EXTERNAL_NET $HTTP_PORTS (msg:"MALWARE-CNC Win.Tinybanker variant outbound connection"; flow:to_server,established; urilen:4; content:"/de/"; fast_pattern:only; http_uri; content:"User-Agent: Mozilla/5.0 (compatible|3B| MSIE 9.0|3B| Windows NT 6.1|3B| Trident/5.0)|OD 0A|Content-Type: application/x-www-form-urlencoded|OD 0A|Host: "; content:"Content-Length: 13|OD 0A|Connection: Close|OD 0A|Cache-Control: no-cache|OD 0A OD 0A|"; distance:0; metadata:impact_flag red, policy balanced-ips drop, policy security-ips drop, ruleset community, service http; reference:url,blog.avast.com/2014/07/17/tinybanker-trojan-targets-banking-customers/; reference:url,www.virustotal.com/en/file/b88b978d00b9b3a011263f398fa6a21098aba714db14f7e71062ea4a6b2e974e/analysis/; classtype:trojan-activity; sid:31642; rev:1;)
```

(Source: CrowdStrike).

In these examples, we see that rather than target only a single impacted system, Snort is instead performing deep packet inspection, a task that it does in its default configuration. Dissecting the rules, alerts would occur only on outbound established connections, with specific user agents – likely to eliminate false positives for those platforms that are not affected by the suspected malware. Further packet matching occurs by inspecting the HTTP header only, and looking for specific “raw data” within the packet payload itself. Similar to an IDS/IPS, any tool that is capable of viewing and dissecting Layer 7 headers would be able to perform similar functionality. An excellent example of this might be an application firewall.

2.4. In File Contents

As mentioned at the very beginning, IOCs may include specific data in files; for example, malicious registry keys found in Windows “.reg” files. Although using network-based tools to identify a specific registry key already in place in the Windows system registry is not likely, it is quite feasible to identify this common indicator when it is in transit via IDS/IPS and through raw packet capture.

In the case of an IDS/IPS, we are able to make use of Snort’s extensive rule content-searching capabilities to look for specific strings, phrases and values. Here are a couple of good examples from the Emerging Threats rule library located at <http://rules.emergingthreats.net/open/snort-2.9.0/emerging-all.rules>:

```
alert tcp $EXTERNAL_NET any -> $HOME_NET any (msg:"ET MALWARE IE
homepage hijacking"; flow: from_server,established; content:"wsh.RegWrite";
nocase; content:"HKLM\\Software\\Microsoft\\Internet
Explorer\\Main\\Start Page"; nocase;
reference:url,www.geek.com/news/geeknews/2004Jun/gee20040610025522.ht
m; reference:url,doc.emergingthreats.net/bin/view/Main/2000514;
classtype:misc-attack; sid:2000514; rev:7;)
```

```
alert tcp $SMTP_SERVERS any -> $EXTERNAL_NET 25 (msg:"ET DELETED SMTP
US Confidential PROPIN"; flow:to_server,established; content:"Subject|3A|";
pcre:"/(CONFIDENTIAL|C)//[\\s\\w,-]*PROPIN[\\s\\w,-]*(?=(25)?X[1-9])/ism";
reference:url,doc.emergingthreats.net/bin/view/Main/2002447;
classtype:policy-violation; sid:2002447; rev:4;)
```

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In the first rule, Snort alerts on browser hijack attempts by identifying any packets containing code that would modify the Windows Registry setting for Internet Explorer's default homepage. For the second rule, Snort would trigger an alert for any email message that contained confidential markings within its body. Both of these examples are of course quite simple and may be prone to false positives (particularly the second rule), however, they do represent an overall perspective of the power of Snort for detecting file content patterns if an IOC requires it.

Another potential mechanism to accomplish the payload file matching of network traffic is a live packet capture accompanied by an appropriate content searching tool. While some packet capture applications (notably Wireshark) have the capability to search output using sophisticated search strings based on regular expressions, a better option for this task would be YARA. This is a tool that supports the creation of signatures to search the contents of files, network traffic or any other type of input for known malicious strings or IOCs. YARA is also based on Perl regular expressions with the signatures themselves contained in text files that are then processed for analysis (French). As an example, here is a YARA signature for the Scraze malware:

```
rule Scraze
{
  strings:
    $strval1 = "C:\Windows\ScreenBlazeUpgrader.bat"
    $strval2 = "\ScreenBlaze.exe "
  condition:
    all of them
}
```

2.5. Specific File Hashes

Although all of the examples presented thus far are important and represent a large percentage of the network-based IOCs available in common intelligence data sets, we would be remiss if we did not address file hashes. This is because file hashes,

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particularly those derived by the MD5 algorithm, are very commonly used to identify known malware samples. In many cases, IOCs start out as very simple – involving only a hash and a filename for a known bad file (Gibb 2013). Indeed, it has been this author's personal experience that when receiving a document containing known IOCs (particularly from law enforcement sources), more often than not it will contain some sort of MD5 file hash.

A real world example of this was recently provided by the US Department of Homeland Security's US-CERT – in a public bulletin issued to network defenders in response to a major cyber-attack: <https://www.us-cert.gov/ncas/alerts/TA14-353A>. This bulletin also represents a demonstrable case for why MD5 hashing continues to persist in the field of cyber threat intelligence despite the fact that SHA1 and SHA2 have long been considered cryptographically superior. While MD5 is certainly a weak hash for comparing files when integrity must be absolutely guaranteed, in the case of threat intelligence sharing the data is only as good as what is provided – as in the example here by US-CERT. Thus, as long as threat intelligence providers continue to share file hashes using MD5 and not the superior SHA1/2 algorithms (in order to ensure maximum compatibility or usability), MD5 will continue to be the hashing algorithm implemented in IOC processing.

The technical process of searching for file hashes within network traffic is not in and of itself difficult. It involves two types of tools: A packet capture program and an MD5 file calculation tool. For example, using Wireshark, we are able to analyze traffic destined to sans.org in order to identify the presence of a specific file, as shown in the following figure:

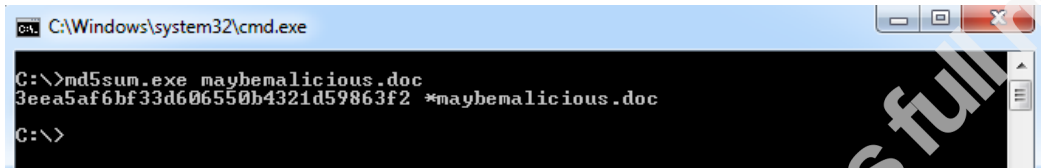


Figure 5: Sample download of file from sans.org obtained using live testing.

By identifying and following the established TCP stream within Wireshark, we are able to recreate the file that was requested, and if needed then download it locally. This

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becomes much more useful when there is reason to believe that the file downloaded may be malicious because once the file is downloaded locally, without even needing to do any kind of malware analysis or reverse engineering, we can quickly compare its MD5 hash to determine if it matches any known IOCs:



```
C:\Windows\system32\cmd.exe
C:\>md5sum.exe maybemalicious.doc
3eea5af6bf33d606550b4321d59863f2 *maybemalicious.doc
C:\>
```

Figure 6: Sample execution of *md5sum* against a file obtained via Wireshark from Figure 5 obtained using live testing.

Obviously, following this process in each suspected case of malicious system communication would be highly inefficient. However, when combining this strategy of automated search using packet capture along with a recording appliance such as those from Fluke, NetScout, NetWitness or Solera – it becomes possible to extract streams such as these automatically and subsequently perform hashing and follow-up comparisons.

3. Generating IOCs Based on Local Network Traffic

3.1. Background

All of the previous IOC types have one thing in common: they are based on the processing of intelligence that was likely received from network and system data observed by others. It can be extremely useful, however, to generate IOCs based directly on anomalous activity seen on a local network. We have already discussed the types of network security devices that could be used to identify this traffic – firewalls, IDS/IPS, DNS servers, packet capture appliances and web proxy devices. This simply leaves us to determine which network activity we should be identifying that constitutes an IOC. Or more specifically, we need to ask the question: “What type of network traffic would likely represent malicious activity?”

Although this will of course be different for each environment, the information obtained from the following table is a good starting point:

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Table 1: “Top 15 Indicators of Compromise” (Source: <http://www.darkreading.com/attacks-breaches/top-15-indicators-of-compromise/d/d-id/1140647?>)

Description	Examples
Unusual Outbound Network Traffic	Requests to multiple sequential IP addresses, Connections to known C&C systems, Requests on unusual ports
Unusual Privileged User Account Activity	Admin accounts logging in at odd times, accessing files they don't normally
Traffic from unexpected geographic locations	Interaction with an IP in a country that would have no legitimate reason for connectivity, logins to the same UserID from multiple geographic locations
Unusual login information	Failed logins for accounts that don't exist, off hour logins, logins for multiple accounts in a short time period
Increase in volume of database accesses	An unusually high number of database queries – or large transfer amount
Particularly large HTML Response Sizes	Responses to get requests greater than a normal HTML page indicating successful SQL injection or database compromise
Large number of requests for the same file	Accessing the same PHP, JSP, ASP file repetitively but changing the URL string
Application requests on network ports	Traffic that looks like DNS on port 80, HTTP traffic on port 25, FTP over port 22
Suspicious registry or system file changes	Anything different from a baseline, changes to Autorun, creation of hidden files in system directories
Anomalous DNS Requests	A larger than normal volume of DNS requests, DNS responses without requests, DNS traffic to unusual geographic sites
Unexpected patching of systems	Patches applied outside of schedule
Unexplained mobile device profile change	Creation of new mobile device profiles, changes to existing (e.g. new certificates)
Large amounts of data in unusual locations	Unexplained large file archives, important files in Recycle Bin, executables in temp
Web traffic that appears to not be originating from a human requestor	Large volume of web traffic in a short time, unexpected browser user agent, invalid browser usage agent string
Any indication of DDOS Activity	Slow network or host performance, website unavailability, failover of critical devices, unusually high network load

While obviously these are only some examples of traffic that could be seen as malicious, they form a good basis for generating IOCs when reviewing local network traffic. In addition, while some of these indicators may require a host agent to optimally monitor and discover threats, they at least give the analyst an idea of what particular activities should be acted upon when seen. Typical response actions should include the implementation of blacklists, enhanced logging and monitoring or the commencement of the incident response process.

3.2. Examples

Now that we have described what constitutes an IOC, the next logical step is to be able to actually identify them, ideally in an automated fashion. Methodologies for this can range from the basic running of a *grep* command to look for suspicious patterns, to implementing a Security Incident and Event Management (SIEM) tool with correlation rules, to creating OpenIOC objects to automate the searching for each individual indicators. We will investigate each of these methods in detail.

Grep is a tool available by default in nearly all Unix installations, and can be downloaded and installed for free if running Windows. It provides a scriptable method to parse logs for suspicious traffic and has the capability of identifying just about anything using regular expressions. For example, we can identify files with encoding types potentially used to hide malware:

```
grep -Er "(gzinfl|base64_d)" *
```

(Source: Reilink)

While *grep* is quite simple to install and execute, full implementation of a SIEM is a much more complex process, the details of which are beyond the scope of this paper. However, using Open Source Security Information Management (OSSIM) as an example, it is possible once implemented to easily ingest indicators identified by most of the tools previously described in Section 2 and create automatic alerts. These rules are known as

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correlation rules, and they are essentially an XML chain of rules that query logs of network devices. So looking at two example rules prior to correlation:

```
<rule type="detector" name="Windows cmd.exe detected" reliability="6"
time_out="60" occurrence="1" from="1:DST_IP" to="1:SRC_IP"
port_from="2:DST_PORT" port_to="2:SRC_PORT" plugin_id="1001"
plugin_sid="2123">
```

```
<rule type="monitor" name="Established session against abnormal port"
reliability="10" from="1:SRC_IP" to="1:DST_IP" port_from="2:SRC_PORT"
port_to="2:DST_PORT" plugin_id="2005" plugin_sid="248" condition="ge"
value="10" interval="20" absolute="true" />
```

(Source: Karg)

Correlation is as simple as creating an XML list of rules and identifying priorities. Using the previous two examples, a correlation rule could look like this:

```
<rule type="detector" name="Windows cmd.exe detected"
<rule type="detector" name="Strange connection after 135/tcp or 445/tcp"
```

While SIEM rules can be very good for automatic notification and likely should be part of any IOC monitoring strategy no matter what technique is used, it is useful to have a purpose-built language for the sole purpose of creating new IOCs quickly and acting on them. In the introduction, we introduced the concept of OpenIOC and we will revisit it now as it provides an ideal methodology for creating IOCs based on live traffic. Here is an example IOC object called “Jason’s Evil Indicator” which identifies the characteristics highlighted in bold:

```
<?xml version="1.0" encoding="us-ascii"?>
<ioc xmlns:xsi=http://www.w3.org/2001/XMLSchema-instance
xmlns:xsd="http://www.w3.org/2001/XMLSchema" id="23d1895c-1f57-4267-
8f9d-a290b99e8f21" last-modified="2015-07-11T14:23:50"
xmlns="http://schemas.mandiant.com/2010/ioc">
  <short_description>Jason Mack</short_description>
  <description>Example OpenIOC Indicator for SANS 503.
We saw some suspicious traffic with the following characteristics on our
network:
```

Jason Mack, jasonmack@gmail.com

1. Port 80 HTTP traffic to 10.11.12.13 2. DNS Traffic to www.definitelyevil.com 3. User Agent is "Mozilla/5.0 (Windows; U; Windows NT 5.1; de; rv:1.9.2.3) Gecko/20100401 Firefox/3.6.3". 4. Payload content EITHER "12596" OR "35935"

```
</description>
<authored_by>Jason's Evil Indicator</authored_by>
<authored_date>2015-07-11T14:03:59</authored_date>
<links />
<definition>
<Indicator operator="OR" id="71d34d22-b178-4607-8b6a-5f5af154d1ab">
<Indicator operator="AND" id="a66ba37d-2774-4bbf-83a5-cce542d1a111">
<IndicatorItem id="97560b0e-bb03-4060-a105-7fb077c212b6" condition="is">
<Context document="PortItem" search="PortItem/remotePort" type="mir" />
<Content type="int">80</Content>
</IndicatorItem>
  <IndicatorItem id="16e91343-c739-45cd-936e-78a8596b2ca6"
condition="contains">
  <Context document="PortItem" search="PortItem/remoteIP" type="mir" />
  <Content type="IP">10.11.12.13</Content>
</IndicatorItem>
  <IndicatorItem id="920eba7b-8242-4640-8a01-080217534f0b"
condition="contains">
  <Context document="Network" search="Network/DNS" type="mir" />
  <Content type="string">definitelyevil.com</Content>
</IndicatorItem>
  <IndicatorItem id="dd3c3b03-0dc4-46b3-a946-76c769985d43"
condition="contains">
  <Context document="Network" search="Network/UserAgent" type="mir" />
  <Content type="string">"Mozilla/5.0 (Windows; U; Windows NT 5.1; de;
rv:1.9.2.3) Gecko/20100401 Firefox/3.6.3"</Content>
</IndicatorItem>
</Indicator>
<Indicator operator="OR" id="812d03d8-a157-4a8f-a180-6d655035e87b">
  <IndicatorItem id="c8533755-475e-4951-8c1d-75eb426899ae"
condition="contains">
  <Context document="Network" search="Network/String" type="mir" />
  <Content type="string">"12596"</Content>
</IndicatorItem>
  <Indicator operator="OR" id="0dec26a2-4fc5-4fc6-9680-a56f3ca79685">
  <IndicatorItem id="c6bccad4-42ea-4d8e-9744-d9a9cf1b4828"
condition="contains">
  <Context document="Network" search="Network/String" type="mir" />
  <Content type="string">"35935"</Content>
```

```
</IndicatorItem>  
</Indicator>  
</Indicator>  
</Indicator>  
</definition>  
</ioc>
```

Using OpenIOC as both a framework and an implementation tool, indicators can be created rapidly, and enabled for deployment to both monitoring and endpoint security devices – while also sharing with the community at large. After all, in nearly all of the previous examples, we have been referring to intelligence that likely has been derived from external sources – and the field of cyber intelligence is only as good as those organizations that are willing to share observations.

Although OpenIOC was previously referred to as a “complementary” technology to STIX & TAXII, a better description might be an “enabler” of them. The framework forms the first link in an effective, repeatable and automated chain by which IOCs can be created using OpenIOC, converted to STIX format, and then shared or deployed to network security devices using TAXII.








4. Tying it all together: STIX and TAXII

4.1. STIX

Due to their time sensitive nature, IOCs are maximally effective when they can be shared and acted upon as quickly as possible. With this goal in mind, STIX (Structured Threat Information eXpression) development began in 2010 by NIST. Its goal was to provide a common methodology and language by which all cyber threat intelligence professionals would be able to exchange data freely. The STIX format relies on what are known as “observables” or details of the specific activity that is occurring (Barnum). For example, phishing campaigns, a DDoS or a malware attack would all be examples of observables. Within each observable, STIX supports the following data elements:

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Table 2: STIX Standard Protocol Description (Source: official STIX project documentation at <http://stixproject.github.io/data-model/1.1/>).

Category	Description	Examples
 Indicator	Specific signs unique to the malicious activity	IP Addresses, DNS names, MD5 hashes
 Incident	Systems, networks, and locations where the activity has been seen	External Mail Servers, Members of the G8, The SANS Institute
 TTP	The specific tools & methods being used	Malware signatures, exploits, source IPs, social engineering
 ExploitTarget	Vulnerabilities or other weakness being exploited	CVEs, configuration issue, end users, third party vendors
 Campaign	Motivation and reasoning for the activity	Cybercrime, Cyberespionage, Hacktivism
 ThreatActor	Who is responsible for the activity	Org. Crime, Nation State, Inside Threat
 Course of Action	What can be done to stop the activity	Apply patch, block in firewall, IDS/IPS rule

As our focus has been primarily IOCs, the primary STIX observable type of interest would be indicators. According to best practices, an indicator should contain at least the following items (StixProject):

- Some sort of observable to identify the malicious code or pattern that is being looked for;
- A title;
- A type (for example: malware, botnet, etc.);

- Valid Time Position (The period of time for which the indicator should be considered valid);
- Indicated_TTP (A reference to a separate STIX Tactics, Techniques, and Procedures object);
- Level of confidence that the indicator is valid.

Many additional values may be part of the STIX indicator field. Some of the more interesting ones include (StixProject):

- A reference from a different source (e.g. a Snort rule or an intelligence bulletin ID);
- A “negate” value to indicate that it is actually the absence of the indicator that would be a sign of compromise;
- A description in human readable format as to what exactly the IOC is detecting;
- Which if any phases of the “Kill Chain” that this IOC is part of;
- Suggested test mechanism to verify the presence of the indicator;
- The likely impact to an individual system if the indicator were to be found;
- Suggested next steps should the indicators be found;
- Any special handling instructions;
- Notable history of sightings;
- Other related indicators or campaigns.

With this information available, it is then possible to build a STIX object that contains enough data to be both understandable and automatable. The implementation of STIX objects themselves has been largely automated by MITRE, through the creation of the STIX project located at <https://github.com/STIXProject>. Every major observable type as described in Table 2 has been implemented in Python – and can be easily called by any script or application that implements the STIX design standard (See Appendix 8.2 for implementation of the “Indicator” observable specifically). An example of just such a script is MITRE’s Python conversion script for converting OpenIOC objects to STIX format. As we saw previously in Section 3.2, it is possible to express live network

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indicators in OpenIOC format, so when coupled with this script these indicators can be placed into a fully compliant STIX object. Appendix 8.1 contains the source code for the OpenIOC -> STIX script, and makes use of the Indicator library source code included in Appendix 8.2.

4.2. TAXII

TAXII was developed concurrently with STIX by the same authors and is an acronym for Trusted Automated eXchange of Indicator Information. It was developed with the goal of guaranteeing secure transport of STIX content and includes four core services: Discovery, Feed Management, Poll and Inbox. Together these services ensure the secure transfer and delivery of STIX objects as described by the following diagram (MITRE):

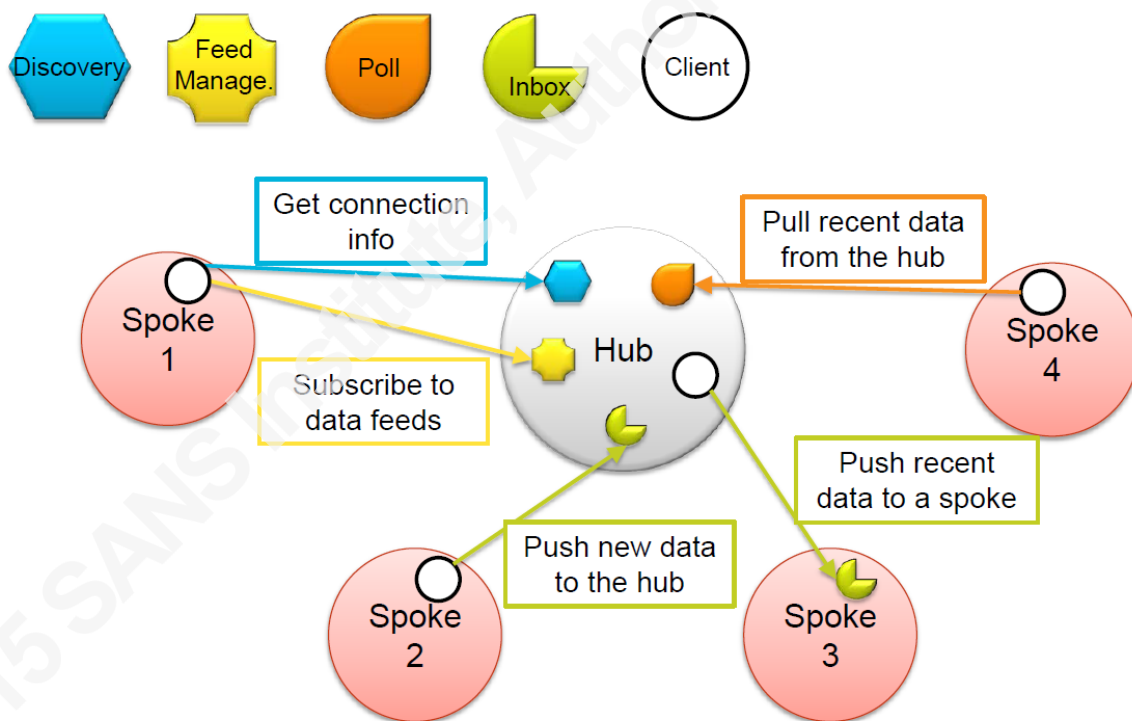


Figure 6: A Description of the TAXII specification (Source: TAXII_Overview_briefing_July_2013.pdf from <https://taxii.mitre.org>).

The discovery service provides a list of available TAXII capable services supported by a given endpoint and when queried by a client will provide its TAXII capabilities. Feed management, as its name suggests, will provide the list of data feeds that are hosted on

the TAXII endpoint. The poll function provides the ability to request updated STIX feed data on demand. Finally, the inbox feature serves as a way to receive feed data in STIX format as it is delivered in real time (MITRE).

Just as was the case with STIX, MITRE has also provided a full Python implementation of the TAXII protocol through the development of LibTAXII (See Appendix 8.3 for most of the relevant code). This code, located at <http://github.com/TAXIIPROJECT/libtaxii>, is slightly different than the previously discussed STIXProject code in that it is not necessarily designed to be a standalone implementation of the protocol. The primary reason for this lies in the fact that STIX is more of a design standard, while TAXII actually functions as the primary application for the transfer of STIX content. Putting both of these pieces together is what makes STIX & TAXII function in implementation.

4.3. Plugging IOCs into the STIX and TAXII Infrastructure

In addition to the development of the StixProject, MITRE has also developed support for many of the examples previously described in Section 2. For example, a Snort rule can be expressed as a STIX object using the indicator module while also including the relevant portions of the TTP and Exploit Target modules as well. Here is an example of this in practice for the recent Heartbleed vulnerability:

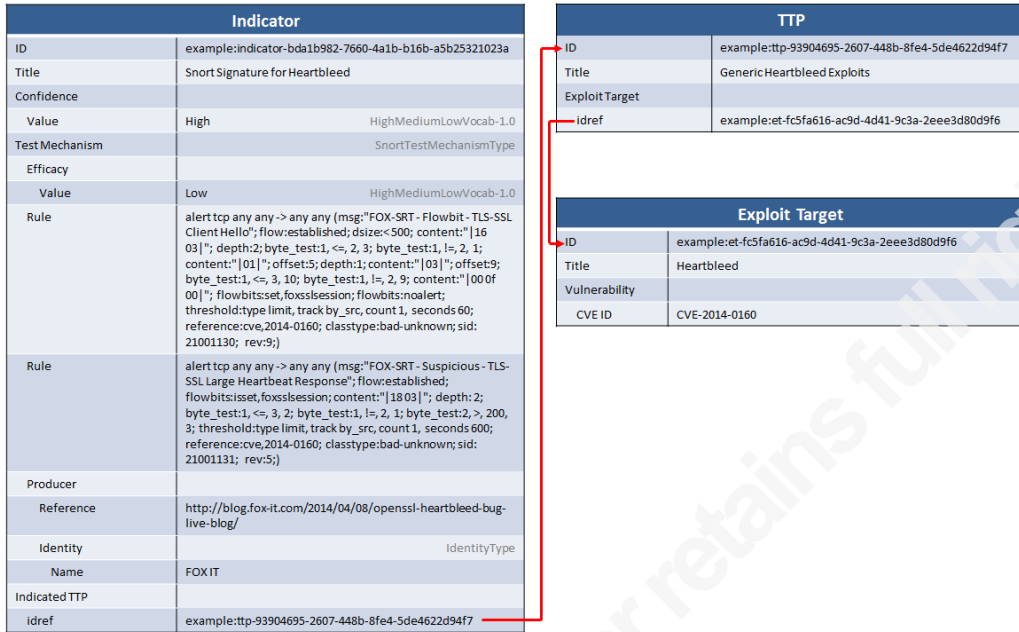


Figure 7: Sample Indicator integration into a Snort Signature (Source: <http://stixproject.github.io/documentation/idioms/snort-test-mechanism>).

Studying this example, the author has created a STIX Observable of type “Rule” and created the required title, a confidence value of high, reference and pointers to both a related TTP and Exploit Target. It is worth noting that the author did not include a valid time position, mentioned earlier as being a STIX best practice to include.

Here is an additional example, this time embedding a firewall rule:

Course of Action	
ID	example:coa-55f57cc7-ddd5-467b-a3a2-6fd602549d9e
Title	Block traffic to PIVY C2 Server (10.10.10.10)
Stage	Response <small>COAStageVocab-1.0</small>
Type	Perimeter Blocking <small>CourseOfActionTypeVocab-1.0</small>
Objective	
Description	Block communication between the PIVY agents and the C2 Server
Applicability Confidence	
Value	High <small>HighMediumLowVocab-1.0</small>
Impact	
Value	Low <small>HighMediumLowVocab-1.0</small>
Description	This IP address is not used for legitimate hosting so there should be no operational impact.
Cost	
Value	Low <small>HighMediumLowVocab-1.0</small>
Efficacy	
Value	High <small>HighMediumLowVocab-1.0</small>
Parameter_Observables	
Observable	
Object	
Properties	Address Object
Address_Value	10.10.10.10
Category	IPV4Address

Figure 8: Sample Indicator integration into a firewall rule from <http://stixproject.github.io/documentation/idioms/block-network-traffic/>.

In this example, rather than using the “Indicator” module we are instead making use of the “Course of Action” module. The IOC is an IP address of 10.10.10.10 that is being associated with the PIVY C&C Server Infrastructure in the form of a TTP. As this is in fact a “course of action” and not an “indicator,” the STIX object is essentially indicating that blocking this particular TTP would serve as a way to eliminate the threat or avoid it in the first place.

Both of these examples could be either automatically created using the previously described STIX libraries, or by being converted into STIX format using a script similar to the OpenIOC -> STIX tool. Once all the necessary STIX objects have been created, we would then rely on TAXII to share them and move them to sensors and monitoring points. Currently, there are two well-known TAXII clients: Soltra Edge, located at <http://www.soltra.com>, and TAXII Project available at <https://github.com/TAXIIProject>.

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Soltra Edge is free to use (but not open source), while the TAXIIProject is a direct implementation by MITRE with source code available. While Soltra is functional essentially out of the box, MITRE's solution requires a few additional components. Specifically, the Django-Taxii-Services are required in order to provide an implementation-ready instance of LibTaxii and YETI is necessary to provide the actual client functionality. YETI does not currently implement feed management, leaving it to the user to manually manage all TAXII feed subscriptions. In actuality, this is not a significant limitation however, as the number of publicly accessible, non-proprietary TAXII feeds currently available is quite limited. Just about the only current example is the Hail A Taxii project, maintained by one of the Soltra developers:

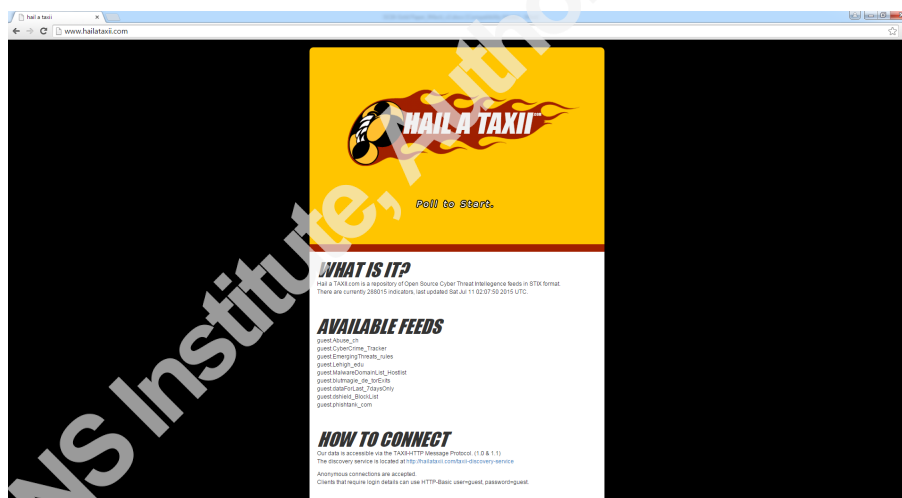


Figure 9: Screenshot of <http://www.hailataxii.com>

Hail A Taxii aggregates content from Dshield, Emerging Threats, Phishtank, and several others. No matter which TAXII client is used, however, the process for obtaining data from the site is the same:

1. The discovery service identifies the site as TAXII compliant and establishes communication;
2. The feed management service identifies all the content available on the site and allows the user to select any or all of it for download in STIX format;

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3. The poll function allows for the actual download of the feeds;
4. The inbox feature receives the STIX content, and processes it in a way that is dependent on the client itself. This can be as simple as a grouping of files in the case of YETI, or as complex as a searchable database in the case of Soltra Edge;
5. Once the STIX data has been processed through the inbox, the TAXII protocol has finished its job – and it is then the role of additional, non STIX/TAXII software to process the indicators and send them to various monitoring and defense points where they can be best used (e.g. SIEM, IDS, Firewall).

Unfortunately, even though there are two well-known TAXII clients available for use, there is still no native support by the more popular network security tools themselves – such as Snort. As a result, direct integration of STIX and TAXII based content with Snort is not possible, although this certainly does not mean it cannot be done. The easiest solution is to use one of the previously described TAXII clients alongside either automated scripts (Soltra develops several directly) or a well-established auto updater such as Oinkmaster in order to implement this functionality.

5. Limitations of Current Technology

Despite some of the strategies presented thus far, the process of identifying IOCs in network traffic is far from perfect. Primary limitations currently exist in two areas. The first lies in the capabilities and inherent weaknesses of the network security devices themselves, while the second is the lack of widespread STIX and TAXII adoption. Automated threat intelligence sharing could be vastly improved with appropriate advances in both of these areas.

As previously mentioned, a network firewall is one of the simplest devices in the network security stack – and as such, its ability to do any kind of “deep dive” for IOCs is limited. Additional functionality can be found in application firewalls that are able to more accurately inspect packet headers; however, this will limit traffic visibility to supported protocols such as HTTP and HTTPS, not to mention introduce more significant overhead. In addition, as firewalls are typically employed as detective and preventive controls

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between security zones, they do not have the capability to detect a system that is already compromised but that is not actively beaconing outbound traffic.

Network IDS/IPS devices suffer from a similar inherent limitation in detecting non-beaconing compromised systems. In addition, although network IDS/IPS systems such as Snort do a great job at deep packet inspection and make it possible to do deeper level packet analysis than just about any other network based technology, it still has limited capabilities when it comes to assembling very large streams. As a result, it is not able to look for specific file hashes of known malware such as a host-based system might be able to. Moreover, although its SSL preprocessor allows for the detection of anomalies that may actually be IDS evasion techniques, Snort (or any network device for that matter) would not have the capability to directly inspect SSL encrypted traffic – a common avenue for malicious activity.

Although network devices do have their technical limitations, the biggest challenge is likely the adoption of the STIX and TAXII standards themselves. While the OpenIOC project has been around for some time, STIX and TAXII as a standard has only been introduced over the last few years so adoption has only just begun. This is quite evident when one looks at the relatively minimal number of TAXII clients available – and the fact that, as previously discussed, major security products such as Snort do not provide native support. While these standards have been completely embraced by some large vendors, like any new technology, full adoption will take time.

6. Conclusion

Automated sharing of IOCs is a growing requirement. Nothing makes this statement more evident than the recent executive order instituted by President of the United States Barack Obama in response to the substantial increase in major cyber incidents:

“In order to address cyber threats to public health and safety, national security, and economic security of the United States, private companies, nonprofit organizations, executive departments and agencies (agencies), and other entities

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must be able to share information related to cybersecurity risks and incidents and collaborate to respond in as close to real time as possible.”

(Source: <https://www.whitehouse.gov/the-press-office/2015/02/13/executive-order-promoting-private-sector-cybersecurity-information-shari>)

While the President has mandated that sharing of intelligence be made easier, the primary method by which this occurs, via the collection and distribution of IOCs, are only of use if they can be acted on quickly and if the indicator is accurate from the beginning. Consequently, as threat actors continue to develop the ability to more quickly modify their TTPs, traditional IOCs become less relevant and their useful lifetime become shorter. Fortunately, with the development of fuzzy hashing, it is possible to “compare two distinctly different items and determine a fundamental level of similarity (expressed as a percentage) between the two” (Fuzzy Clarity).

However, just like STIX and TAXII, this technology is only as good as the ability of the network security devices that support it. Fuzzy hashing capabilities, as well as the more mainstream support of full file reconstruction and hash comparison within common network security systems like Snort is critical to a future where IOCs can still prove to be useful. In addition, the adoption of STIX and TAXII must also continue as it represents the best current opportunity for all sharing parties (whether they are private industry, government or individuals) to react rapidly to new threats. In an age when it seems that a new cyber event is reported every day, it is more important than ever to stay one-step ahead of the threat actors. With some improvements to the capabilities of network security devices along with the full adoption of STIX and TAXII this will become a reality.

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7. References

- Actionable Indicators for Detection of Signs of Compromise from Target-related Breaches » Adversary Manifesto. (2014, January 16). Retrieved from: <http://blog.crowdstrike.com/actionable-indicators-detection-signs-compromise-target-related-breaches>.
- Barnum, S. (n.d.). Standardizing Cyber Threat Intelligence Information with the Structured Threat Information eXpression (STIX™). Retrieved from: https://stix.mitre.org/about/documents/STIX_Whitepaper_v1.1.pdf.
- Best Content Filtering Appliance. (n.d.). Retrieved from: http://community.spiceworks.com/spice_lists/7.
- Command & Control: Understanding, denying, detecting. (n.d.). Retrieved from: http://www.cpni.gov.uk/documents/publications/2014/2014-04-11-cc_qinetiq_report.pdf.
- Decianno, J. (2014, December 9). Indicators of Attack vs. Indicators of Compromise » Adversary Manifesto. Retrieved from: <http://blog.crowdstrike.com/indicators-attack-vs-indicators-compromise>.
- Detecting Malware infections with Snort DNS Monitoring | KaffeNews. (n.d.). Retrieved from: <http://blog.kaffenews.com/2010/03/04/detecting-malware-infections-with-snort-dns-monitoring>.
- French, D. Writing Effective YARA Signatures to Identify Malware » SEI Blog. Retrieved from: <http://blog.sei.cmu.edu/post.cfm/writing-effective-yara-signatures-to-identify-malware>.
- “FUZZY CLARITY” Using Fuzzy Hashing Techniques to Identify Malicious Code. (n.d.). Retrieved from: <http://www.shadowserver.org/wiki/uploads/Information/FuzzyHashing.pdf>.
- Gibb, W. (n.d.). OpenIOC Series: Investigating with Indicators of Compromise (IOCs) – Part I retrieved from: <https://www.mandiant.com/blog/OpenIOC-series-investigating-indicators-compromise-IOCs-part>.

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Grappling with the ZeroAccess Botnet. (n.d.). Retrieved from:

<http://www.symantec.com/connect/blogs>.

Hurcombe, J. (n.d.). Malicious links: Spammers change malware delivery tactics.

Retrieved from: <http://www.symantec.com/connect/blogs/malicious-links-spammers-change-malware-delivery-tactics>.

Jordan, B. (n.d.). STIX and TAXII: On the road to becoming the de facto standard | Blue

Coat. Retrieved from: <https://www.bluecoat.com/security-blog/2014-08-26/stix-and-taxii-road-becoming-de-facto-standard>.

Karg, Dominique. (n.d.). OSSIM: Correlation Engine Explained. Retrieved from:

https://www.alienvault.com/docs/correlation_engine_explained_rpc_dcom_example.pdf

Liska, A., & Gallo, T. (n.d.). Building an intelligence-led security program.

Meltzer, D. (2015, March 3). Look How Easy TAXII Is. Retrieved from:

<http://www.tripwire.com/state-of-security/security-data-protection/cyber-security/look-how-easy-taxii-is>.

Natarjan, R. (n.d.). 25 Most Frequently Used Linux IPTables Rules Examples. Retrieved

from: <http://www.thegeekstuff.com/2011/06/iptables-rules-examples>.

Reilink, Jan (n.d.). Using grep.exe for forensic log parsing and analysis on Windows

Server and IIS. Retrieved from: <https://www.saotn.org/using-grep-exe-for-forensic-log-parsing-and-analysis-on-windows-server-iis/>

Sawyer, J. (n.d.). Mining Web Proxy Logs For Interesting, Actionable Data. Retrieved

from: <http://www.darkreading.com/risk/mining-web-proxy-logs-for-interesting-actionable-data/d/d-id/1135002?>

SNORT User's Manual 2.9.7. (n.d.). Retrieved from: <http://manual.snort.org>.

StixProject. IndicatorTypeIndicator Schema. (n.d.). Retrieved from:

<http://stixproject.github.io/data-model/1.1.1/indicator/IndicatorType>.

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8. Appendix

8.1. Python Conversion Script for OpenIOC to STIX

The following script is by MITRE Corporation which is free to use according to their license. It has been included here so that the reader can readily study the code to better understand the technical details of OpenIOC and STIX.

```
# Copyright (c) 2015, The MITRE Corporation. All rights reserved.
# See LICENSE.txt for complete terms.

# OpenIOC to STIX Script
# Wraps output of OpenIOC to CyBOX Script
# v0.13

import sys
import os
import traceback
import warnings
import openioc #OpenIOC Bindings
import openioc_to_cybox #OpenIOC to CyBOX Script
from cybox.core import Observables
import stix.utils
from stix.indicator import Indicator
from stix.core import STIXPackage, STIXHeader

__VERSION__ = 0.13

USAGE_TEXT = """
OpenIOC --> STIX Translator
v0.13 BETA // Compatible with STIX v1.1.1 and CyBOX v2.1

Outputs a STIX Package with one or more STIX Indicators containing
Cybox Observables translated from an input OpenIOC XML file.

Usage: python openioc_to_stix.py -i <openioc xml file> -o <stix xml file>
"""

#Print the usage text
def usage():
    print USAGE_TEXT
    sys.exit(1)

def main():
    infile = ""
    outfile = ""

    #Get the command-line arguments
    args = sys.argv[1:]

    if len(args) < 4:
        usage()
        sys.exit(1)

    for i in range(0, len(args)):
        if args[i] == '-i':
            infile = args[i+1]
        elif args[i] == '-o':
            outfile = args[i+1]
    if os.path.isfile(infile):
        try:
            # Perform the translation using the methods from the OpenIOC to CyBOX Script
            openioc_indicators = openioc.parse(infile)
            observables_obj = openioc_to_cybox.generate_cybox(openioc_indicators, infile, True)
            observables_cls = Observables.from_obj(observables_obj)
```

Jason Mack, jasonmack@gmail.com

```

# Set the namespace to be used in the STIX Package
stix.utils.set_id_namespace({"https://github.com/STIXProject/openioc-to-stix":"openiocToSTIX"})

# Wrap the created Observables in a STIX Package/Indicator
stix_package = STIXPackage()
# Add the OpenIOC namespace
input_namespaces = {"http://openioc.org/":"openioc"}
stix_package.__input_namespaces__ = input_namespaces

for observable in observables_cls.observables:
    indicator_dict = {}
    producer_dict = {}
    producer_dict['tools'] = [{'name':'OpenIOC to STIX Utility', 'version':str(__VERSION__)}]
    indicator_dict['producer'] = producer_dict
    indicator_dict['title'] = "CybOX-represented Indicator Created from OpenIOC File"
    indicator = Indicator.from_dict(indicator_dict)
    stix_package.add_observable(observables_cls.observables[0])
    stix_package.add_indicator(indicator)

# Create and write the STIX Header
stix_header = STIXHeader()
stix_header.package_intent = "Indicators - Malware Artifacts"
stix_header.description = "CybOX-represented Indicators Translated from OpenIOC File"
stix_package.stix_header = stix_header

# Write the generated STIX Package as XML to the output file
outfile = open(outfilename, 'w')
# Ignore any warnings - temporary fix for no schemaLocation w/ namespace
with warnings.catch_warnings():
    warnings.simplefilter("ignore")
    outfile.write(stix_package.to_xml())
    warnings.resetwarnings()
outfile.flush()
outfile.close()
except Exception, err:
    print("\nError: %s\n" % str(err))
    traceback.print_exc()
else:
    print("\nError: Input file not found or inaccessible.")
    sys.exit(1)

if __name__ == "__main__":
    main()

```

8.2. Python Source Code for the STIX “Indicator” Observable

The following script is by MITRE Corporation which is free to use according to their license. It has been included here so that the reader can readily study the code to better understand the technical details STIX.

```

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# See LICENSE.txt for complete terms.

```

```

# external
from cybox.core import Observable, ObservableComposition
from cybox.common import Time

# internal
import stix
import stix.utils as utils
from stix.common import (
    Identity, InformationSource, VocabString, Confidence,
    RelatedTTP, Statement, CampaignRef
)

```

Jason Mack, jasonmack@gmail.com

```

from stix.common.related import (
    GenericRelationshipList, RelatedCOA, RelatedIndicator, RelatedCampaignRef,
    RelatedPackageRefs
)
from stix.common.vocabs import IndicatorType
from stix.common.kill_chains import KillChainPhasesReference
import stix.bindings.indicator as indicator_binding

```

```

# relative
from .test_mechanism import TestMechanisms
from .sightings import Sightings
from .valid_time import _ValidTimePositions

```

```

class SuggestedCOAs(GenericRelationshipList):
    """The ``SuggestedCOAs`` class provides functionality for adding
    :class:`stix.common.related.RelatedCOA` instances to an :class:`Indicator`
    instance.

    The ``SuggestedCOAs`` class implements methods found on
    ``collections.MutableSequence`` and as such can be interacted with as a
    ``list`` (e.g., ``append()``).

    The ``append()`` method can accept instances of
    :class:`stix.common.related.RelatedCOA` or :class:`stix.coa.CourseOfAction`
    as an argument.

```

Note:

```

    Calling ``append()`` with an instance of
    :class:`stix.coa.CourseOfAction` will wrap that instance in a
    :class:`stix.common.related.RelatedCOA` layer, with the ``item`` set to
    the :class:`stix.coa.CourseOfAction` instance.

```

Examples:

```

    Append an instance of :class:`stix.coa.CourseOfAction` to the
    ``Indicator.suggested_coas`` property. The instance of
    :class:`stix.coa.CourseOfAction` will be wrapped in an instance of
    :class:`stix.common.related.RelatedCOA`.

```

```

>>> coa = CourseOfAction()
>>> indicator = Indicator()
>>> indicator.suggested_coas.append(coa)
>>> print type(indicator.suggested_coas[0])
<class 'stix.common.related.RelatedCOA'>

```

```

    Iterate over the ``suggested_coas`` property of an :class:`Indicator`
    instance and print the ids of each underlying
    :class:`stix.coa.CourseOfAction` instance.

```

```

>>> for related_coa in indicator.suggested_coas:
>>>     print related_coa.item.id_

```

Args:

```

    suggested_coas(list): A list of :class:`stix.coa.CourseOfAction`
    or :class:`stix.common.related.RelatedCOA` instances.
    scope (str): The scope of the items. Can be set to ``"inclusive"``
    or ``"exclusive"``. See
    :class:`stix.common.related.GenericRelationshipList` documentation
    for more information.

```

Attributes:

```

    scope (str): The scope of the items. Can be set to ``"inclusive"``
    or ``"exclusive"``. See
    :class:`stix.common.related.GenericRelationshipList` documentation
    for more information.

```

```

"""
__namespace__ = "http://stix.mitre.org/Indicator-2"
__binding__ = indicator_binding

```

```

__binding_class = indicator_binding.SuggestedCOAsType
__binding_var = "Suggested_COA"
__contained_type = RelatedCOA
__inner_name = "suggested_coas"

```

```

def __init__(self, suggested_coas=None, scope=None):
    super(SuggestedCOAs, self).__init__(scope, suggested_coas)

```

```

class RelatedIndicators(GenericRelationshipList):
    """The ``RelatedIndicators`` class provides functionality for adding
    :class:`stix.common.related.RelatedIndicator` instances to an
    :class:`Indicator` instance.

```

The ``RelatedIndicators`` class implements methods found on
``collections.MutableSequence`` and as such can be interacted with as a
``list`` (e.g., ``append()``).

The ``append()`` method can accept instances of
:class:`stix.common.related.RelatedIndicator` or
:class:`Indicator` as an argument.

Note:

Calling ``append()`` with an instance of
:class:`stix.coa.CourseOfAction` will wrap that instance in a
:class:`stix.common.related.RelatedIndicator` layer, with ``item``
set to the :class:`Indicator` instance.

Examples:

Append an instance of :class:`Indicator` to the
``Indicator.related_indicators`` property. The instance of
:class:`Indicator` will be wrapped in an instance of
:class:`stix.common.related.RelatedIndicator`:

```

>>> related = Indicator()
>>> parent_indicator = Indicator()
>>> parent_indicator.related_indicators.append(related)
>>> print type(indicator.related_indicators[0])
<class 'stix.common.related.RelatedIndicator'>

```

Iterate over the ``related_indicators`` property of an
:class:`Indicator` instance and print the ids of each underlying
:class:`Indicator`` instance:

```

>>> for related in indicator.related_indicators:
>>>     print related.item.id_

```

Args:

related_indicators (list, optional): A list of :class:`Indicator` or
:class:`stix.common.related.RelatedIndicator` instances.
scope (str, optional): The scope of the items. Can be set to
``"inclusive"`` or ``"exclusive"``. See
:class:`stix.common.related.GenericRelationshipList` documentation
for more information.

Attributes:

scope (str): The scope of the items. Can be set to ``"inclusive"``
or ``"exclusive"``. See
:class:`stix.common.related.GenericRelationshipList` documentation
for more information.

```

"""
__namespace = "http://stix.mitre.org/Indicator-2"
__binding = indicator_binding
__binding_class = indicator_binding.RelatedIndicatorsType
__binding_var = "Related_Indicator"
__contained_type = RelatedIndicator
__inner_name = "related_indicators"

```

```
def __init__(self, related_indicators=None, scope=None):
    super(RelatedIndicators, self).__init__(scope, related_indicators)
```

```
class Indicator(stix.BaseCoreComponent):
    """Implementation of the STIX Indicator.
```

Args:

```
id_ (optional): An identifier. If ``None``, a value will be generated
via ``mixbox.idgen.create_id()``. If set, this will unset the
``idref`` property.
idref (optional): An identifier reference. If set this will unset the
``id`` property.
title (optional): A string title.
timestamp (optional): A timestamp value. Can be an instance of
``datetime.datetime`` or ``str``.
description (optional): A string description.
short_description (optional): A string short description.
```

```
"""
```

```
    _binding = indicator_binding
    _binding_class = indicator_binding.IndicatorType
    _namespace = 'http://stix.mitre.org/Indicator-2'
    _version = "2.2"
    _ALL_VERSIONS = ("2.0", "2.0.1", "2.1", "2.1.1", "2.2")
    _ALLOWED_COMPOSITION_OPERATORS = ('AND', 'OR')
    _ID_PREFIX = "indicator"
```

```
def __init__(self, id_=None, idref=None, timestamp=None, title=None,
             description=None, short_description=None):
```

```
    super(Indicator, self).__init__(
        id=id_,
        idref=idref,
        timestamp=timestamp,
        title=title,
        description=description,
        short_description=short_description
    )
```

```
    self.producer = None
    self.observables = None
    self.indicator_types = IndicatorTypes()
    self.confidence = None
    self.indicated_ttps = _IndicatedTTPs()
    self.test_mechanisms = TestMechanisms()
    self.alternative_id = None
    self.suggested_coas = SuggestedCOAs()
    self.sightings = Sightings()
    self.composite_indicator_expression = None
    self.kill_chain_phases = KillChainPhasesReference()
    self.valid_time_positions = _ValidTimePositions()
    self.related_indicators = None
    self.related_campaigns = RelatedCampaignRefs()
    self.observable_composition_operator = "OR"
    self.likely_impact = None
    self.negate = None
    self.related_packages = RelatedPackageRefs()
```

```
@property
```

```
def producer(self):
    """Contains information about the source of the :class:`Indicator`.
```

```
    Default Value: ``None``
```

```
Returns:
```

```
    An instance of
    :class:`stix.common.information_source.InformationSource`
```

```
Raises:
    ValueError: If set to a value that is not ``None`` and not an
        instance of
        :class:`stix.common.information_source.InformationSource`

"""
return self._producer

@producer.setter
def producer(self, value):
    self._set_var(InformationSource, try_cast=False, producer=value)

@property
def observable(self):
    """A convenience property for accessing or setting the only
    ``cybox.core.Observable`` instance held by this Indicator.

    Default Value: Empty ``list``.

    Setting this property results in the ``observables`` property being
    reinitialized to an empty ``list`` and appending the input value,
    resulting in a ``list`` containing one value.

    Note:
        If the ``observables`` list contains more than one item, this
        property will only return the first item in the list.

    Returns:
        An instance of ``cybox.core.Observable``.

    Raises:
        ValueError: If set to a value that cannot be converted to an
            instance of ``cybox.core.Observable``.

"""
if self.observables:
    return self.observables[0]
else:
    return None

@observable.setter
def observable(self, observable):
    self._observables = _Observables(observable)

@property
def observables(self):
    """A list of ``cybox.core.Observable`` instances. This can be set to
    a single object instance or a list of objects.

    Note:
        If the input value or values are not instance(s) of
        ``cybox.core.Observable``, an attempt will be made to
        convert the value to an instance of ``cybox.core.Observable``.

    Default Value: Empty ``list``

    Returns:
        A ``list`` of ``cybox.core.Observable`` instances.

    Raises:
        ValueError: If set to a value that cannot be converted to an
            instance of ``cybox.core.Observable``.

"""
return self._observables

@observables.setter
def observables(self, value):
```

```

self._observables = _Observables(value)

def add_observable(self, observable):
    """Adds an observable to the ``observables`` list property of the
    :class:`Indicator`.

    If the ``observable`` parameter is ``None``, no item will be added
    to the ``observables`` list.

    Note:
        The STIX Language dictates that an :class:`Indicator` can have only
        one ``Observable`` under it. Because of this, the ``to_xml()``
        method will convert the ``observables`` list into an
        ``cybox.core.ObservableComposition`` instance, in which each item
        in the ``observables`` list will be added to the composition. By
        default, the ``operator`` of the composition layer will be set to
        ``"OR"``. The ``operator`` value can be changed via the
        ``observable_composition_operator`` property.

    Args:
        observable: An instance of ``cybox.core.Observable`` or an object
            type that can be converted into one.

    Raises:
        ValueError: If the ``observable`` param cannot be converted into an
            instance of ``cybox.core.Observable``.

    """
    self.observables.append(observable)

@property
def alternative_id(self):
    """An alternative identifier for this :class:`Indicator`.

    This property can be set to a single string identifier or a list of
    identifiers. If set to a single object, the object will be inserted
    into an empty list internally.

    Default Value: Empty ``list``

    Returns:
        A list of alternative ids.

    """
    return self._alternative_id

@alternative_id.setter
def alternative_id(self, value):
    self._alternative_id = []
    if not value:
        return
    elif utils.is_sequence(value):
        self._alternative_id.extend(x for x in value if x)
    else:
        self._alternative_id.append(value)

def add_alternative_id(self, value):
    """Adds an alternative id to the ``alternative_id`` list property.

    Note:
        If ``None`` is passed in no value is added to the
        ``alternative_id`` list property.

    Args:
        value: An identifier value.

    """
    if not value:

```

```
        return

        self.alternative_id.append(value)

    @property
    def valid_time_positions(self):
        """A list of valid time positions for this :class:`Indicator`.

        This property can be set to a single instance or a list of
        :class:`stix.indicator.valid_time.ValidTime` instances. If set to a
        single instance, that object is converted into a list containing
        one item.

        Default Value: Empty ``list``

        Returns:
            A list of
            :class:`stix.indicator.valid_time.ValidTime` instances.

        """
        return self._valid_time_positions

    @valid_time_positions.setter
    def valid_time_positions(self, value):
        self._valid_time_positions = _ValidTimePositions(value)

    def add_valid_time_position(self, value):
        """Adds an valid time position to the ``valid_time_positions`` property
        list.

        If `value` is ``None``, no item is added to the ``value_time_positions``
        list.

        Args:
            value: An instance of :class:`stix.indicator.valid_time.ValidTime`.

        Raises:
            ValueError: If the `value` argument is not an instance of
            :class:`stix.indicator.valid_time.ValidTime`.

        """
        self.valid_time_positions.append(value)

    @property
    def indicator_types(self):
        """A list of indicator types for this :class:`Indicator`.

        This property can be set to lists or single instances of ``str``
        or :class:`stix.common.vocabs.VocabString` or an instance
        of :class:`IndicatorTypes`.

        Note:
            If an instance of ``str`` is passed in (or a ``list`` containing
            ``str`` values) an attempt will be made to convert that string
            value to an instance of :class:`stix.common.vocabs.IndicatorType`.

        Default Value: An empty ``IndicatorTypes`` instance.

        See Also:
            Documentation for :class:`IndicatorTypes`.

        Returns:
            An instance of ``IndicatorTypes``.

        """
        return self._indicator_types

    @indicator_types.setter
    def indicator_types(self, value):
```

```
self._indicator_types = IndicatorTypes(value)

def add_indicator_type(self, value):
    """Adds a value to the ``indicator_types`` list property.

    The `value` parameter can be a ``str`` or an instance of
    :class:`stix.common.vocabs.VocabString`.

    Note:
    If the `value` parameter is a ``str`` instance, an attempt will be
    made to convert it into an instance of
    :class:`stix.common.vocabs.IndicatorType`.

    Args:
    value: An instance of :class:`stix.common.vocabs.VocabString`
    or ``str``.

    Raises:
    ValueError: If the `value` param is a ``str`` instance that cannot
    be converted into an instance of
    :class:`stix.common.vocabs.IndicatorType`.
    """
    self.indicator_types.append(value)

@property
def confidence(self):
    """The confidence for this :class:`Indicator`.

    This property can be set to an instance of ``str``,
    :class:`stix.common.vocabs.VocabString`, or
    :class:`stix.common.confidence.Confidence`.

    Default Value: ``None``

    Note:
    If set to an instance of ``str`` or
    :class:`stix.common.vocabs.VocabString`, that value will be wrapped
    in an instance of
    :class:`stix.common.confidence.Confidence`.

    Returns:
    An instance of of
    :class:`stix.common.confidence.Confidence`.

    Raises:
    ValueError: If set to a ``str`` value that cannot be converted into
    an instance of :class:`stix.common.confidence.Confidence`.

    """
    return self._confidence

@confidence.setter
def confidence(self, value):
    self._set_var(Confidence, confidence=value)

@property
def indicated_ttps(self):
    return self._indicated_ttps

@indicated_ttps.setter
def indicated_ttps(self, value):
    self._indicated_ttps = _IndicatedTTPs(value)

def add_indicated_ttp(self, v):
    """Adds an Indicated TTP to the ``indicated_ttps`` list property
    of this :class:`Indicator`.

    The `v` parameter must be an instance of
    :class:`stix.common.related.RelatedTTP` or :class:`stix.ttp.TTP`.
```

If the `v` parameter is ``None``, no item will be added to the ``indicated_ttps`` list property.

Note:

If the `v` parameter is not an instance of :class:`stix.common.related.RelatedTTP` an attempt will be made to convert it to one.

Args:

v: An instance of :class:`stix.common.related.RelatedTTP` or :class:`stix.ttp.TTP`.

Raises:

ValueError: If the `v` parameter cannot be converted into an instance of :class:`stix.common.related.RelatedTTP`

"""

```
self.indicated_ttps.append(v)
```

@property

```
def test_mechanisms(self):
    return self._test_mechanisms
```

@test_mechanisms.setter

```
def test_mechanisms(self, value):
    self._test_mechanisms = TestMechanisms(value)
```

def add_test_mechanism(self, tm):

"""Adds an Test Mechanism to the ``test_mechanisms`` list property of this :class:`Indicator`.

The `tm` parameter must be an instance of a :class:`stix.indicator.test_mechanism._BaseTestMechanism` implementation.

If the `tm` parameter is ``None``, no item will be added to the ``test_mechanisms`` list property.

See Also:

Test Mechanism implementations are found under the :mod:`stix.extensions.test_mechanism` package.

Args:

tm: An instance of a :class:`stix.indicator.test_mechanism._BaseTestMechanism` implementation.

Raises:

ValueError: If the `tm` parameter is not an instance of :class:`stix.indicator.test_mechanism._BaseTestMechanism`

"""

```
self.test_mechanisms.append(tm)
```

@property

```
def related_indicators(self):
    return self._related_indicators
```

@related_indicators.setter

```
def related_indicators(self, value):
    if isinstance(value, RelatedIndicators):
        self._related_indicators = value
    else:
        self._related_indicators = RelatedIndicators(value)
```

def add_related_indicator(self, indicator):

"""Adds an Related Indicator to the ``related_indicators`` list property of this :class:`Indicator`.

The `indicator` parameter must be an instance of `stix.common.related.RelatedIndicator` or `Indicator`.

If the `indicator` parameter is `None`, no item will be added to the `related_indicators` list property.

Calling this method is the same as calling `append()` on the `related_indicators` property.

See Also:

The `RelatedIndicators` documentation.

Note:

If the `tm` parameter is not an instance of `stix.common.related.RelatedIndicator` an attempt will be made to convert it to one.

Args:

`indicator`: An instance of `Indicator` or `stix.common.related.RelatedIndicator`.

Raises:

`ValueError`: If the `indicator` parameter cannot be converted into an instance of `stix.common.related.RelatedIndicator`

```
"""
```

```
self.related_indicators.append(indicator)
```

```
@property
```

```
def related_campaigns(self):  
    return self._related_campaigns
```

```
@related_campaigns.setter
```

```
def related_campaigns(self, value):  
    if isinstance(value, RelatedCampaignRefs):  
        self._related_campaigns = value  
    else:  
        self._related_campaigns = RelatedCampaignRefs(value)
```

```
def add_related_campaign(self, value):
```

```
    """Adds a Related Campaign to this Indicator.
```

The `value` parameter must be an instance of `RelatedCampaignRef` or `CampaignRef`.

If the `value` parameter is `None`, no item will be added to the `related_campaigns` collection.

Calling this method is the same as calling `append()` on the `related_campaigns` property.

See Also:

The `RelatedCampaignRef` documentation.

Note:

If the `value` parameter is not an instance of `RelatedCampaignRef` an attempt will be made to convert it to one.

Args:

`value`: An instance of `RelatedCampaignRef` or `Campaign`.

Raises:

`ValueError`: If the `value` parameter cannot be converted into an instance of `RelatedCampaignRef`

```
"""
self.related_campaigns.append(value)

@property
def observable_composition_operator(self):
    return self._observable_composition_operator

@observable_composition_operator.setter
def observable_composition_operator(self, value):
    if value in self._ALLOWED_COMPOSITION_OPERATORS:
        self._observable_composition_operator = value
        return

    error = "observable_composition_operator must one of {0}"
    error = error.format(self._ALLOWED_COMPOSITION_OPERATORS)
    raise ValueError(error)

@property
def likely_impact(self):
    return self._likely_impact

@likely_impact.setter
def likely_impact(self, value):
    self._set_var(Statement, likely_impact=value)

@property
def negate(self):
    return self._negate

@negate.setter
def negate(self, value):
    self._negate = utils.xml_bool(value)

@property
def kill_chain_phases(self):
    return self._kill_chain_phases

@kill_chain_phases.setter
def kill_chain_phases(self, value):
    self._kill_chain_phases = KillChainPhasesReference(value)

def add_kill_chain_phase(self, value):
    """Add a new Kill Chain Phase reference to this Indicator.

    Args:
        value: a :class: `stix.common.kill_chains.KillChainPhase` or a `str`
            representing the phase_id of. Note that you if you are defining
            a custom Kill Chain, you need to add it to the STIX package
            separately.
    """
    self.kill_chain_phases.append(value)

@property
def related_packages(self):
    return self._related_packages

@related_packages.setter
def related_packages(self, value):
    self._related_packages = RelatedPackageRefs(value)

def add_related_package(self, value):
    self.related_packages.append(value)

def set_producer_identity(self, identity):
    """Sets the name of the producer of this indicator.

    This is the same as calling
    `indicator.producer.identity.name = identity`.
    """
```

If the ``producer`` property is ``None``, it will be initialized to an instance of
`:class:'stix.common.information_source.InformationSource'`.

If the ``identity`` property of the ``producer`` instance is ``None``, it will be initialized to an instance of
`:class:'stix.common.identity.Identity'`.

Note:

if the ``identity`` parameter is not an instance
`:class:'stix.common.identity.Identity'` an attempt will be made to convert it to one.

Args:

identity: An instance of ``str`` or
`'stix.common.identity.Identity'`.

"""

```
def unset_producer_identity():
    try:
        self.producer.identity.name = None
    except AttributeError:
        pass
```

```
if not identity:
    unset_producer_identity()
    return
```

```
if not self.producer:
    self.producer = InformationSource()
```

```
if isinstance(identity, Identity):
    self.producer.identity = identity
    return
```

```
if not self.producer.identity:
    self.producer.identity = Identity()
```

```
self.producer.identity.name = str(identity)
```

```
def set_produced_time(self, produced_time):
    """Sets the ``produced_time`` property of the ``producer`` property instance fo ``produced_time``.
```

This is the same as calling
```indicator.producer.time.produced_time = produced_time```.

The ``produced\_time`` parameter must be an instance of ``str``,  
```datetime.datetime```, or ```cybox.common.DateTimeWithPrecision```.

Note:

If ``produced_time`` is a ``str`` or ```datetime.datetime``` instance an attempt will be made to convert it into an instance of ```cybox.common.DateTimeWithPrecision```.

Args:

produced_time: An instance of ``str``,
```datetime.datetime```, or ```cybox.common.DateTimeWithPrecision```.

"""

```
if not self.producer:
 self.producer = InformationSource()
```

```
if not self.producer.time:
 self.producer.time = Time()
```

```
self.producer.time.produced_time = produced_time
```

```
def get_produced_time(self):
```

```
"""Gets the produced time for this :class:`Indicator`.

This is the same as calling
`produced_time = indicator.producer.time.produced_time`.

Returns:
 ``None`` or an instance of ``cybox.common.DateTimeWithPrecision``.

"""
try:
 return self.producer.time.produced_time
except AttributeError:
 return None

def set_received_time(self, received_time):
 """Sets the received time for this :class:`Indicator`.

 This is the same as calling
 `indicator.producer.time.produced_time = produced_time`.

 The `received_time` parameter must be an instance of ``str``,
 ``datetime.datetime``, or ``cybox.common.DateTimeWithPrecision``.

 Args:
 received_time: An instance of ``str``,
 ``datetime.datetime``, or ``cybox.common.DateTimeWithPrecision``.

 Note:
 If `received_time` is a ``str`` or ``datetime.datetime`` instance
 an attempt will be made to convert it into an instance of
 ``cybox.common.DateTimeWithPrecision``.

"""
if not self.producer:
 self.producer = InformationSource()

if not self.producer.time:
 self.producer.time = Time()

self.producer.time.received_time = received_time

def get_received_time(self):
 """Gets the received time for this :class:`Indicator`.

 This is the same as calling
 `received_time = indicator.producer.time.received_time`.

Returns:
 ``None`` or an instance of ``cybox.common.DateTimeWithPrecision``.

"""
try:
 return self.producer.time.received_time
except AttributeError:
 return None

def _merge_observables(self, observables):
 observable_composition = ObservableComposition()
 observable_composition.operator = self.observable_composition_operator

 for observable in observables:
 observable_composition.add(observable)

 root_observable = Observable()
 root_observable.observable_composition = observable_composition

 return root_observable

def add_object(self, object_):
```

"""Adds a python-cybox Object instance to the ``observables`` list property.

This is the same as calling ``indicator.add\_observable(object\_)``.

Note:

If the `object` param is not an instance of ``cybox.core.Object`` an attempt will be made to convert it into one before wrapping it in an ``cybox.core.Observable`` layer.

Args:

object\_ : An instance of ``cybox.core.Object`` or an object that can be converted into an instance of ``cybox.core.Observable``

Raises:

ValueError: if the `object\_` param cannot be converted to an instance of ``cybox.core.Observable``.

"""

```
if not object_:
 return
```

```
observable = Observable(object_)
self.add_observable(observable)
```

```
def to_obj(self, return_obj=None, ns_info=None):
 if not return_obj:
 return_obj = self._binding_class()

 super(Indicator, self).to_obj(return_obj=return_obj, ns_info=ns_info)

 return_obj.negate = True if self.negate else None

 if self.confidence:
 return_obj.Confidence = self.confidence.to_obj(ns_info=ns_info)
 if self.indicator_types:
 return_obj.Type = self.indicator_types.to_obj(ns_info=ns_info)
 if self.indicated_ttps:
 return_obj.Indicated_TTP = self.indicated_ttps.to_obj(ns_info=ns_info)
 if self.producer:
 return_obj.Producer = self.producer.to_obj(ns_info=ns_info)
 if self.test_mechanisms:
 return_obj.Test_Mechanisms = self.test_mechanisms.to_obj(ns_info=ns_info)
 if self.likely_impact:
 return_obj.Likely_Impact = self.likely_impact.to_obj(ns_info=ns_info)
 if self.alternative_id:
 return_obj.Alternative_ID = self.alternative_id
 if self.valid_time_positions:
 return_obj.Valid_Time_Position = self.valid_time_positions.to_obj(ns_info=ns_info)
 if self.suggested_coas:
 return_obj.Suggested_COAs = self.suggested_coas.to_obj(ns_info=ns_info)
 if self.sightings:
 return_obj.Sightings = self.sightings.to_obj(ns_info=ns_info)
 if self.composite_indicator_expression:
 return_obj.Composite_Indicator_Expression = self.composite_indicator_expression.to_obj(ns_info=ns_info)
 if self.kill_chain_phases:
 return_obj.Kill_Chain_Phases = self.kill_chain_phases.to_obj(ns_info=ns_info)
 if self.related_indicators:
 return_obj.Related_Indicators = self.related_indicators.to_obj(ns_info=ns_info)
 if self.related_campaigns:
 return_obj.Related_Campaigns = self.related_campaigns.to_obj(ns_info=ns_info)
 if self.related_packages:
 return_obj.Related_Packages = self.related_packages.to_obj(ns_info=ns_info)
 if self.observables:
 if len(self.observables) > 1:
 root_observable = self._merge_observables(self.observables)
 else:
 root_observable = self.observables[0]
 return_obj.Observable = root_observable.to_obj(ns_info=ns_info)
```

```

return return_obj

@classmethod
def from_obj(cls, obj, return_obj=None):
 if not obj:
 return None
 if not return_obj:
 return_obj = cls()

 super(Indicator, cls).from_obj(obj, return_obj=return_obj)

 if isinstance(obj, cls._binding_class):
 return_obj.negate = obj.negate
 return_obj.producer = InformationSource.from_obj(obj.Producer)
 return_obj.confidence = Confidence.from_obj(obj.Confidence)
 return_obj.sightings = Sightings.from_obj(obj.Sightings)
 return_obj.composite_indicator_expression = CompositeIndicatorExpression.from_obj(obj.Composite_Indicator_Expression)
 return_obj.kill_chain_phases = KillChainPhasesReference.from_obj(obj.Kill_Chain_Phases)
 return_obj.related_indicators = RelatedIndicators.from_obj(obj.Related_Indicators)
 return_obj.likely_impact = Statement.from_obj(obj.Likely_Impact)
 return_obj.indicator_types = IndicatorTypes.from_obj(obj.Type)
 return_obj.test_mechanisms = TestMechanisms.from_obj(obj.Test_Mechanisms)
 return_obj.suggested_coas = SuggestedCOAs.from_obj(obj.Suggested_COAs)
 return_obj.alternative_id = obj.Alternative_ID
 return_obj.indicated_ttps = _IndicatedTTPs.from_obj(obj.Indicated_TTP)
 return_obj.valid_time_positions = _ValidTimePositions.from_obj(obj.Valid_Time_Position)
 return_obj.observable = Observable.from_obj(obj.Observable)
 return_obj.related_campaigns = RelatedCampaignRefs.from_obj(obj.Related_Campaigns)
 return_obj.related_packages = RelatedPackageRefs.from_obj(obj.Related_Packages)

 return return_obj

def to_dict(self):
 keys = ('observables', 'observable_composition_operator', 'negate')
 d = utils.to_dict(self, skip=keys)

 if self.negate:
 d['negate'] = True

 if self.observables:
 if len(self.observables) == 1:
 d['observable'] = self.observables[0].to_dict()
 else:
 composite_observable = self._merge_observables(self.observables)
 d['observable'] = composite_observable.to_dict()

 return d

@classmethod
def from_dict(cls, dict_repr, return_obj=None):
 if not dict_repr:
 return None
 if not return_obj:
 return_obj = cls()

 super(Indicator, cls).from_dict(dict_repr, return_obj=return_obj)

 get = dict_repr.get
 return_obj.negate = get('negate')
 return_obj.alternative_id = get('alternative_id')
 return_obj.indicated_ttps = _IndicatedTTPs.from_dict(get('indicated_ttps'))
 return_obj.test_mechanisms = TestMechanisms.from_list(get('test_mechanisms'))
 return_obj.suggested_coas = SuggestedCOAs.from_dict(get('suggested_coas'))
 return_obj.sightings = Sightings.from_dict(get('sightings'))
 return_obj.composite_indicator_expression = CompositeIndicatorExpression.from_dict(get('composite_indicator_expression'))
 return_obj.kill_chain_phases = KillChainPhasesReference.from_dict(get('kill_chain_phases'))
 return_obj.related_indicators = RelatedIndicators.from_dict(get('related_indicators'))
 return_obj.likely_impact = Statement.from_dict(get('likely_impact'))

```

```

return_obj.indicator_types = IndicatorTypes.from_list(get('indicator_types'))
return_obj.confidence = Confidence.from_dict(get('confidence'))
return_obj.valid_time_positions = _ValidTimePositions.from_dict(get('valid_time_positions'))
return_obj.observable = Observable.from_dict(get('observable'))
return_obj.producer = InformationSource.from_dict(get('producer'))
return_obj.related_campaigns = RelatedCampaignRefs.from_dict(get('related_campaigns'))
return_obj.related_packages = RelatedPackageRefs.from_dict(get('related_packages'))

return return_obj

```

```

class CompositeIndicatorExpression(stix.EntityList):
 """Implementation of the STIX ``CompositeIndicatorExpressionType``.

```

The ``CompositeIndicatorExpression`` class implements methods found on ``collections.MutableSequence`` and as such can be interacted with as a ``list`` (e.g., ``append()``).

Note:

The ``append()`` method can only accept instances of :class:`Indicator`.

Examples:

Add a :class:`Indicator` instance to an instance of :class:`CompositeIndicatorExpression`:

```

>>> i = Indicator()
>>> comp = CompositeIndicatorExpression()
>>> comp.append(i)

```

Create a :class:`CompositeIndicatorExpression` from a list of :class:`Indicator` instances using ``\*args`` argument list:

```

>>> list_indicators = [Indicator() for i in xrange(10)]
>>> comp = CompositeIndicatorExpression(CompositeIndicatorExpression.OP_OR, *list_indicators)
>>> len(comp)
10

```

Args:

operator (str, optional): The logical composition operator. Must be ``"AND"`` or ``"OR"``.

\*args: Variable length argument list of :class:`Indicator` instances.

Attributes:

OP\_AND (str): String ``"AND"``

OP\_OR (str): String ``"OR"``

OPERATORS (tuple): Tuple of allowed ``operator`` values.

operator (str): The logical composition operator. Must be ``"AND"`` or ``"OR"``.

"""

```

 _binding = indicator_binding
 _binding_class = indicator_binding.CompositeIndicatorExpressionType
 _namespace = 'http://stix.mitre.org/Indicator-2'
 _contained_type = Indicator
 _binding_var = "Indicator"
 _inner_name = "indicators"

```

```

OP_AND = "AND"

```

```

OP_OR = "OR"

```

```

OPERATORS = (OP_AND, OP_OR)

```

```

def __init__(self, operator="OR", *args):
 super(CompositeIndicatorExpression, self).__init__(*args)
 self.operator = operator

```

```

@property

```

```

def operator(self):
 return self._operator

```

```
@operator.setter
def operator(self, value):
 if not value:
 raise ValueError("operator must not be None or empty")
 elif value not in self.OPERATORS:
 raise ValueError("operator must be one of: %s" % (self.OPERATORS,))
 else:
 self._operator = value

def __nonzero__(self):
 return super(CompositeIndicatorExpression, self).__nonzero__()

def to_obj(self, return_obj=None, ns_info=None):
 list_obj = super(CompositeIndicatorExpression, self).to_obj(return_obj=return_obj, ns_info=ns_info)
 list_obj.operator = self.operator
 return list_obj

def to_dict(self):
 d = super(CompositeIndicatorExpression, self).to_dict()
 if self.operator:
 d['operator'] = self.operator
 return d

@classmethod
def from_obj(cls, obj, return_obj=None):
 if not obj:
 return None
 if return_obj is None:
 return_obj = cls()

 super(CompositeIndicatorExpression, cls).from_obj(obj, return_obj=return_obj)
 return_obj.operator = obj.operator
 return return_obj

@classmethod
def from_dict(cls, dict_repr, return_obj=None):
 if not dict_repr:
 return None
 if return_obj is None:
 return_obj = cls()

 super(CompositeIndicatorExpression, cls).from_dict(dict_repr, return_obj=return_obj)
 return_obj.operator = dict_repr.get('operator')
 return return_obj

class RelatedCampaignRefs(GenericRelationshipList):
 _namespace = "http://stix.mitre.org/Indicator-2"
 _binding = indicator_binding
 _binding_class = _binding.RelatedCampaignReferencesType
 _binding_var = 'Related_Campaign'
 _contained_type = RelatedCampaignRef
 _inner_name = "related_campaigns"

 def __init__(self, related_campaign_refs=None, scope=None):
 super(RelatedCampaignRefs, self).__init__(scope, related_campaign_refs)

 def _fix_value(self, value):
 from stix.campaign import Campaign

 if isinstance(value, Campaign) and value.id_:
 return RelatedCampaignRef(CampaignRef(idref=value.id_))
 else:
 return super(RelatedCampaignRefs, self)._fix_value(value)

NOT ACTUAL STIX TYPES!
class IndicatorTypes(stix.TypedList):
 """A :class:`stix.common.vocabs.VocabString` collection which defaults to
```

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:class:`stix.common.vocabs.IndicatorType`. This class implements methods found on ``collections.MutableSequence`` and as such can be interacted with like a ``list``.

Note:

The ``append()`` method can accept ``str`` or :class:`stix.common.vocabs.VocabString` instances. If a ``str`` instance is passed in, an attempt will be made to convert it to an instance of :class:`stix.common.vocabs.IndicatorType`.

Examples:

Add an instance of :class:`stix.common.vocabs.IndicatorType`:

```
>>> from stix.common.vocabs import IndicatorType
>>> itypes = IndicatorTypes()
>>> type_ = IndicatorType(IndicatorType.TERM_IP_WATCHLIST)
>>> itypes.append(type_)
>>> print len(itypes)
1
```

Add a string value:

```
>>> from stix.common.vocabs import IndicatorType
>>> itypes = IndicatorTypes()
>>> type(IndicatorType.TERM_IP_WATCHLIST)
<type 'str'>
>>> itypes.append(IndicatorType.TERM_IP_WATCHLIST)
>>> print len(itypes)
1
```

Args:

\*args: Variable length argument list of strings or :class:`stix.common.vocabs.VocabString` instances.

"""

```
_namespace = "http://stix.mitre.org/Indicator-2"
_contained_type = VocabString
```

```
def _fix_value(self, value):
 return IndicatorType(value)
```

```
class _IndicatedTTPs(stix.TypedList):
 _contained_type = RelatedTTP
```

```
class _Observables(stix.TypedList):
 _contained_type = Observable
```

### 8.3. Python Source Code for LibTaxii – Base Code for TAXII Clients

The following script is by MITRE Corporation which is free to use according to their license. It has been included here so that the reader can readily study the code to better understand the technical details of TAXII.

```
Copyright (C) 2013 - The MITRE Corporation
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```

```
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```

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```

"""
Creating, handling, and parsing TAXII 1.0 messages.
"""

try:
 import simplejson as json
except ImportError:
 import json
import os
import StringIO
import warnings

from lxml import etree

from .common import (parse, parse_datetime_string, append_any_content_etree, TAXIIBase,
 get_required, get_optional, get_optional_text)
from .validation import do_check, uri_regex, check_timestamp_label, message_id_regex_10
from constants import *

def validate_xml(xml_string):
 """
 Note that this function has been deprecated. Please see
 libtaxii.validators.SchemaValidator.

 Validate XML with the TAXII XML Schema 1.0.

 Args:
 xml_string (str): The XML to validate.

 Example:
 .. code-block:: python

 is_valid = tm10.validate_xml(message.to_xml())
 """
 warnings.warn('Call to deprecated function: libtaxii.messages_10.validate_xml()',
 category=DeprecationWarning)

 if isinstance(xml_string, basestring):
 f = StringIO.StringIO(xml_string)
 else:
 f = xml_string

 etree_xml = parse(f)
 package_dir, package_filename = os.path.split(__file__)
 schema_file = os.path.join(package_dir, "xsd", "TAXII_XMLMessageBinding_Schema.xsd")
 taxii_schema_doc = parse(schema_file)
 xml_schema = etree.XMLSchema(taxii_schema_doc)
 valid = xml_schema.validate(etree_xml)
 if not valid:
 return xml_schema.error_log.last_error
 return valid

def get_message_from_xml(xml_string):
 """Create a TAXIIMessage object from an XML string.

 This function automatically detects which type of Message should be created
 based on the XML.

 Args:
 xml_string (str): The XML to parse into a TAXII message.

 Example:
 .. code-block:: python

 message_xml = message.to_xml()
 new_message = tm10.get_message_from_xml(message_xml)
 """

```

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```

"""
if isinstance(xml_string, basestring):
 f = StringIO.StringIO(xml_string)
else:
 f = xml_string

etree_xml = parse(f)
qn = etree.QName(etree_xml)
if qn.namespace != ns_map['taxii']:
 raise ValueError('Unsupported namespace: %s' % qn.namespace)

message_type = qn.localname

if message_type == MSG_DISCOVERY_REQUEST:
 return DiscoveryRequest.from_etree(etree_xml)
if message_type == MSG_DISCOVERY_RESPONSE:
 return DiscoveryResponse.from_etree(etree_xml)
if message_type == MSG_FEED_INFORMATION_REQUEST:
 return FeedInformationRequest.from_etree(etree_xml)
if message_type == MSG_FEED_INFORMATION_RESPONSE:
 return FeedInformationResponse.from_etree(etree_xml)
if message_type == MSG_POLL_REQUEST:
 return PollRequest.from_etree(etree_xml)
if message_type == MSG_POLL_RESPONSE:
 return PollResponse.from_etree(etree_xml)
if message_type == MSG_STATUS_MESSAGE:
 return StatusMessage.from_etree(etree_xml)
if message_type == MSG_INBOX_MESSAGE:
 return InboxMessage.from_etree(etree_xml)
if message_type == MSG_MANAGE_FEED_SUBSCRIPTION_REQUEST:
 return ManageFeedSubscriptionRequest.from_etree(etree_xml)
if message_type == MSG_MANAGE_FEED_SUBSCRIPTION_RESPONSE:
 return ManageFeedSubscriptionResponse.from_etree(etree_xml)

raise ValueError('Unknown message_type: %s' % message_type)

def get_message_from_dict(d):
 """Create a TAXIIMessage object from a dictionary.

 This function automatically detects which type of Message should be created
 based on the 'message_type' key in the dictionary.

 Args:
 d (dict): The dictionary to build the TAXII message from.

 Example:
 .. code-block:: python

 message_dict = message.to_dict()
 new_message = tm10.get_message_from_dict(message_dict)
 """
 if 'message_type' not in d:
 raise ValueError('message_type is a required field!')

 message_type = d['message_type']
 if message_type == MSG_DISCOVERY_REQUEST:
 return DiscoveryRequest.from_dict(d)
 if message_type == MSG_DISCOVERY_RESPONSE:
 return DiscoveryResponse.from_dict(d)
 if message_type == MSG_FEED_INFORMATION_REQUEST:
 return FeedInformationRequest.from_dict(d)
 if message_type == MSG_FEED_INFORMATION_RESPONSE:
 return FeedInformationResponse.from_dict(d)
 if message_type == MSG_POLL_REQUEST:
 return PollRequest.from_dict(d)
 if message_type == MSG_POLL_RESPONSE:
 return PollResponse.from_dict(d)
 if message_type == MSG_STATUS_MESSAGE:

```

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```

 return StatusMessage.from_dict(d)
if message_type == MSG_INBOX_MESSAGE:
 return InboxMessage.from_dict(d)
if message_type == MSG_MANAGE_FEED_SUBSCRIPTION_REQUEST:
 return ManageFeedSubscriptionRequest.from_dict(d)
if message_type == MSG_MANAGE_FEED_SUBSCRIPTION_RESPONSE:
 return ManageFeedSubscriptionResponse.from_dict(d)

raise ValueError('Unknown message_type: %s' % message_type)

def get_message_from_json(json_string):
 """Create a TAXIIMessage object from a JSON string.

 This function automatically detects which type of Message should be created
 based on the JSON.

 Args:
 json_string (str): The JSON to parse into a TAXII message.
 """
 return get_message_from_dict(json.loads(json_string))

class TAXIIBase10(TAXIIBase):
 version = VID_TAXII_XML_10

class DeliveryParameters(TAXIIBase10):
 """Delivery Parameters.

 Args:
 inbox_protocol (str): identifies the protocol to be used when pushing
 TAXII Data Feed content to a Consumer's TAXII Inbox Service
 implementation. **Required**
 inbox_address (str): identifies the address of the TAXII Daemon hosting
 the Inbox Service to which the Consumer requests content for this
 TAXII Data Feed to be delivered. **Required**
 delivery_message_binding (str): identifies the message binding to be
 used to send pushed content for this subscription. **Required**
 content_bindings (list of str): contains Content Binding IDs
 indicating which types of contents the Consumer requests to
 receive for this TAXII Data Feed. **Optional**
 """
 # TODO: Should the default arguments of these change? I'm not sure these are
 # actually optional

 def __init__(self, inbox_protocol=None, inbox_address=None,
 delivery_message_binding=None, content_bindings=None):
 self.inbox_protocol = inbox_protocol
 self.inbox_address = inbox_address
 self.delivery_message_binding = delivery_message_binding
 self.content_bindings = content_bindings or []

 @property
 def sort_key(self):
 return self.inbox_address

 @property
 def inbox_protocol(self):
 return self._inbox_protocol

 @inbox_protocol.setter
 def inbox_protocol(self, value):
 do_check(value, 'inbox_protocol', regex_tuple=(uri_regex))
 self._inbox_protocol = value

 @property

```

```
def inbox_address(self):
 return self._inbox_address

@inbox_address.setter
def inbox_address(self, value):
 # TODO: Can inbox_address be validated?
 self._inbox_address = value

@property
def delivery_message_binding(self):
 return self._delivery_message_binding

@delivery_message_binding.setter
def delivery_message_binding(self, value):
 do_check(value, 'delivery_message_binding', regex_tuple=uri_regex)
 self._delivery_message_binding = value

@property
def content_bindings(self):
 return self._content_bindings

@content_bindings.setter
def content_bindings(self, value):
 do_check(value, 'content_bindings', regex_tuple=uri_regex)
 self._content_bindings = value

def to_etree(self):
 xml = etree.Element('{%s}Push_Parameters' % ns_map['taxii'])

 if self.inbox_protocol is not None:
 pb = etree.SubElement(xml, '{%s}Protocol_Binding' % ns_map['taxii'])
 pb.text = self.inbox_protocol

 if self.inbox_address is not None:
 a = etree.SubElement(xml, '{%s}Address' % ns_map['taxii'])
 a.text = self.inbox_address

 if self.delivery_message_binding is not None:
 mb = etree.SubElement(xml, '{%s}Message_Binding' % ns_map['taxii'])
 mb.text = self.delivery_message_binding

 for binding in self.content_bindings:
 cb = etree.SubElement(xml, '{%s}Content_Binding' % ns_map['taxii'])
 cb.text = binding

 return xml

def to_dict(self):
 d = {}

 if self.inbox_protocol is not None:
 d['inbox_protocol'] = self.inbox_protocol

 if self.inbox_address is not None:
 d['inbox_address'] = self.inbox_address

 if self.delivery_message_binding is not None:
 d['delivery_message_binding'] = self.delivery_message_binding

 d['content_bindings'] = []
 for binding in self.content_bindings:
 d['content_bindings'].append(binding)

 return d

def to_text(self, line_prepend=""):
 s = line_prepend + "=== Push Parameters ===\n"
 s += line_prepend + " Inbox Protocol: %s\n" % self.inbox_protocol
 s += line_prepend + " Address: %s\n" % self.inbox_address
```

```

s += line_prepend + " Message Binding: %s\n" % self.delivery_message_binding
if len(self.content_bindings) > 0:
 s += line_prepend + " Content Bindings: Any Content\n"
 for cb in self.content_bindings:
 s += line_prepend + " Content Binding: %s\n" % str(cb)

return s

@staticmethod
def from_etree(etree_xml):

 inbox_protocol = get_optional_text(etree_xml, './taxii:Protocol_Binding', ns_map)
 inbox_address = get_optional_text(etree_xml, './taxii:Address', ns_map)
 delivery_message_binding = get_optional_text(etree_xml, './taxii:Message_Binding', ns_map)

 content_bindings = []
 for binding in etree_xml.xpath('./taxii:Content_Binding', namespaces=ns_map):
 content_bindings.append(binding.text)

 return DeliveryParameters(inbox_protocol, inbox_address, delivery_message_binding, content_bindings)

@staticmethod
def from_dict(d):
 return DeliveryParameters(**d)

class TAXIIMessage(TAXIIBase10):

 """Encapsulate properties common to all TAXII Messages (such as headers).

 This class is extended by each Message Type (e.g., DiscoveryRequest), with
 each subclass containing subclass-specific information
 """

 message_type = 'TAXIIMessage'

 def __init__(self, message_id, in_response_to=None, extended_headers=None):
 """Create a new TAXIIMessage

 Arguments:
 - message_id (string) - A value identifying this message.
 - in_response_to (string) - Contains the Message ID of the message to
 which this is a response.
 - extended_headers (dictionary) - A dictionary of name/value pairs for
 use as Extended Headers
 """
 self.message_id = message_id
 self.in_response_to = in_response_to
 if extended_headers is None:
 self.extended_headers = {}
 else:
 self.extended_headers = extended_headers

 @property
 def message_id(self):
 return self._message_id

 @message_id.setter
 def message_id(self, value):
 do_check(value, 'message_id', regex_tuple=message_id_regex_10)
 self._message_id = value

 @property
 def in_response_to(self):
 return self._in_response_to

 @in_response_to.setter
 def in_response_to(self, value):
 do_check(value, 'in_response_to', regex_tuple=message_id_regex_10, can_be_none=True)

```

```

self.in_response_to = value

@property
def extended_headers(self):
 return self._extended_headers

@extended_headers.setter
def extended_headers(self, value):
 do_check(value.keys(), 'extended_headers.keys()', regex_tuple=uri_regex)
 self._extended_headers = value

def to_etree(self):
 """Creates the base etree for the TAXII Message.

 Message-specific constructs must be added by each Message class. In
 general, when converting to XML, subclasses should call this method
 first, then create their specific XML constructs.
 """
 root_elt = etree.Element('{%s}%s' % (ns_map['taxii'], self.message_type), nsmap=ns_map)
 root_elt.attrib['message_id'] = str(self.message_id)

 if self.in_response_to is not None:
 root_elt.attrib['in_response_to'] = str(self.in_response_to)

 if len(self.extended_headers) > 0:
 eh = etree.SubElement(root_elt, '{%s}Extended_Headers' % ns_map['taxii'])

 for name, value in self.extended_headers.items():
 h = etree.SubElement(eh, '{%s}Extended_Header' % ns_map['taxii'])
 h.attrib['name'] = name
 append_any_content_etree(h, value)
 # h.text = value
 return root_elt

def to_xml(self, pretty_print=False):
 """Convert a message to XML.

 Subclasses shouldn't implement this method, as it is mainly a wrapper
 for cls.to_etree.
 """
 return etree.tostring(self.to_etree(), pretty_print=pretty_print)

def to_dict(self):
 """Create the base dictionary for the TAXII Message.

 Message-specific constructs must be added by each Message class. In
 general, when converting to dictionary, subclasses should call this
 method first, then create their specific dictionary constructs.
 """
 d = {}
 d['message_type'] = self.message_type
 d['message_id'] = self.message_id
 if self.in_response_to is not None:
 d['in_response_to'] = self.in_response_to
 d['extended_headers'] = {}
 for k, v in self.extended_headers.iteritems():
 if isinstance(v, etree._Element) or isinstance(v, etree._ElementTree):
 v = etree.tostring(v)
 elif not isinstance(v, basestring):
 v = str(v)
 d['extended_headers'][k] = v

 return d

def to_json(self):
 return json.dumps(self.to_dict())

def to_text(self, line_prepend=""):
 s = line_prepend + "Message Type: %s\n" % self.message_type

```

```

s += line_prepend + "Message ID: %s" % self.message_id
if self.in_response_to:
 s += "; In Response To: %s" % self.in_response_to
s += "\n"
for k, v in self.extended_headers.iteritems():
 s += line_prepend + "Extended Header: %s = %s" % (k, v)

return s

@classmethod
def from_etree(cls, src_etree, **kwargs):
 """Pulls properties of a TAXII Message from an etree.

 Message-specific constructs must be pulled by each Message class. In
 general, when converting from etree, subclasses should call this method
 first, then parse their specific XML constructs.
 """

 # Check namespace and element name of the root element
 expected_tag = '{%s}%s' % (ns_map['taxii'], cls.message_type)
 tag = src_etree.tag
 if tag != expected_tag:
 raise ValueError('%s != %s' % (tag, expected_tag))

 # Get the message ID
 message_id = get_required(src_etree, '/taxii:*/@message_id', ns_map)

 # Get in response to, if present
 in_response_to = get_optional(src_etree, '/taxii:*/@in_response_to', ns_map)
 if in_response_to:
 kwargs['in_response_to'] = in_response_to

 # Get the Extended headers
 extended_header_list = src_etree.xpath('/taxii:*/taxii:Extended_Headers/taxii:Extended_Header', namespaces=ns_map)
 extended_headers = {}
 for header in extended_header_list:
 eh_name = header.xpath('/@name')[0]
 # eh_value = header.text
 if len(header) == 0: # This has string content
 eh_value = header.text
 else: # This has XML content
 eh_value = header[0]

 extended_headers[eh_name] = eh_value

 return cls(message_id, extended_headers=extended_headers, **kwargs)

@classmethod
def from_xml(cls, xml):
 """Parse a Message from XML.

 Subclasses shouldn't implement this method, as it is mainly a wrapper
 for cls.from_etree.
 """
 if isinstance(xml, basestring):
 f = StringIO.StringIO(xml)
 else:
 f = xml

 etree_xml = parse(f)
 return cls.from_etree(etree_xml)

@classmethod
def from_dict(cls, d, **kwargs):
 """Pulls properties of a TAXII Message from a dictionary.

 Message-specific constructs must be pulled by each Message class. In
 general, when converting from dictionary, subclasses should call this

```

```

method first, then parse their specific dictionary constructs.
"""
message_type = d['message_type']
if message_type != cls.message_type:
 raise ValueError('%s != %s' % (message_type, cls.message_type))
message_id = d['message_id']
extended_headers = {}
for k, v in d['extended_headers'].iteritems():
 try:
 v = parse(v)
 except etree.XMLSyntaxError:
 pass
 extended_headers[k] = v

in_response_to = d.get('in_response_to')
if in_response_to:
 kwargs['in_response_to'] = in_response_to

return cls(message_id, extended_headers=extended_headers, **kwargs)

@classmethod
def from_json(cls, json_string):
 return cls.from_dict(json.loads(json_string))

class ContentBlock(TAXIIBase10):

 """A TAXII Content Block.

 Args:
 content_binding (str): a Content Binding ID or nesting expression
 indicating the type of content contained in the Content field of this
 Content Block. **Required**
 content (string or etree): a piece of content of the type specified
 by the Content Binding. **Required**
 timestamp_label (datetime): the Timestamp Label associated with this
 Content Block. **Optional**
 padding (string): an arbitrary amount of padding for this Content
 Block. **Optional**
 """

 NAME = 'Content_Block'

 def __init__(self, content_binding, content, timestamp_label=None, padding=None):
 self.content_binding = content_binding
 self.content, self.content_is_xml = self._stringify_content(content)
 self.timestamp_label = timestamp_label
 self.padding = padding

 @property
 def sort_key(self):
 return self.content[:25]

 @property
 def content_binding(self):
 return self._content_binding

 @content_binding.setter
 def content_binding(self, value):
 do_check(value, 'content_binding', regex_tuple=uri_regex)
 self._content_binding = value

 @property
 def content(self):
 if self.content_is_xml:
 return etree.tostring(self._content)
 else:
 return self._content

```

```
@content.setter
def content(self, value):
 do_check(value, 'content') # Just check for not None
 self._content, self.content_is_xml = self.stringify_content(value)

@property
def content_is_xml(self):
 return self._content_is_xml

@content_is_xml.setter
def content_is_xml(self, value):
 do_check(value, 'content_is_xml', value_tuple=(True, False))
 self._content_is_xml = value

@property
def timestamp_label(self):
 return self._timestamp_label

@timestamp_label.setter
def timestamp_label(self, value):
 value = check_timestamp_label(value, 'timestamp_label', can_be_none=True)
 self._timestamp_label = value

def stringify_content(self, content):
 """Always a string or raises an error.
 Returns the string representation and whether the data is XML.
 """
 # If it's an etree, it's definitely XML
 if isinstance(content, etree.ElementTree):
 return content.getroot(), True

 if isinstance(content, etree.Element):
 return content, True

 if hasattr(content, 'read'): # The content is file-like
 try: # Try to parse as XML
 xml = parse(content)
 return xml, True
 except etree.XMLSyntaxError: # Content is not well-formed XML; just treat as a string
 return content.read(), False
 else: # The Content is not file-like
 try: # Attempt to parse string as XML
 sio_content = StringIO.StringIO(content)
 xml = parse(sio_content)
 return xml, True
 except etree.XMLSyntaxError: # Content is not well-formed XML; just treat as a string
 if isinstance(content, basestring): # It's a string of some kind, unicode or otherwise
 return content, False
 else: # It's some other datatype that needs casting to string
 return str(content), False

def to_etree(self):
 block = etree.Element('{%s}Content_Block' % ns_map['taxii'], nsmap=ns_map)
 cb = etree.SubElement(block, '{%s}Content_Binding' % ns_map['taxii'])
 cb.text = self.content_binding
 c = etree.SubElement(block, '{%s}Content' % ns_map['taxii'])

 if self.content_is_xml:
 c.append(self._content)
 else:
 c.text = self._content

 if self.timestamp_label:
 tl = etree.SubElement(block, '{%s}Timestamp_Label' % ns_map['taxii'])
 tl.text = self.timestamp_label.isoformat()

 if self.padding is not None:
 p = etree.SubElement(block, '{%s}Padding' % ns_map['taxii'])
 p.text = self.padding
```

```

 return block

def to_dict(self):
 block = {}
 block['content_binding'] = self.content_binding

 if self.content_is_xml:
 block['content'] = etree.tostring(self._content)
 else:
 block['content'] = self._content
 block['content_is_xml'] = self.content_is_xml

 if self.timestamp_label:
 block['timestamp_label'] = self.timestamp_label.isoformat()

 if self.padding is not None:
 block['padding'] = self.padding

 return block

def to_json(self):
 return json.dumps(self.to_dict())

def to_text(self, line_prepend=""):
 s = line_prepend + "=== Content Block ===\n"
 s += line_prepend + " Content Binding: %s\n" % self.content_binding
 s += line_prepend + " Content Length: %s\n" % len(self.content)
 s += line_prepend + " (Only content length is shown for brevity)\n"
 if self.timestamp_label:
 s += line_prepend + " Timestamp Label: %s\n" % self.timestamp_label.isoformat()
 s += line_prepend + " Padding: %s\n" % self.padding

 return s

@staticmethod
def from_etree(etree_xml):
 kwargs = {}

 kwargs['content_binding'] = get_required(etree_xml, './taxii:Content_Binding', ns_map).text

 kwargs['padding'] = get_optional_text(etree_xml, './taxii:Padding', ns_map)

 ts_text = get_optional_text(etree_xml, './taxii:Timestamp_Label', ns_map)
 if ts_text:
 kwargs['timestamp_label'] = parse_datetime_string(ts_text)

 content = get_required(etree_xml, './taxii:Content', ns_map)

 if len(content) == 0: # This has string content
 kwargs['content'] = content.text
 else: # This has XML content
 kwargs['content'] = content[0]

 return ContentBlock(**kwargs)

@staticmethod
def from_dict(d):
 kwargs = {}
 kwargs['content_binding'] = d['content_binding']
 kwargs['padding'] = d.get('padding')

 if d.get('timestamp_label'):
 kwargs['timestamp_label'] = parse_datetime_string(d['timestamp_label'])

 is_xml = d.get('content_is_xml', False)
 if is_xml:
 #FIXME: to parse or not to parse the content - this should be configurable

```

```

 kwargs['content'] = parse(d['content'])
 else:
 kwargs['content'] = d['content']

 cb = ContentBlock(**kwargs)
 return cb

 @classmethod
 def from_json(cls, json_string):
 return cls.from_dict(json.loads(json_string))

TAXII Message Classes

class DiscoveryRequest(TAXIIMessage):
 """
 A TAXII Discovery Request message.

 Args:
 message_id (str): A value identifying this message. **Required**
 extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. **Optional**
 """

 message_type = MSG_DISCOVERY_REQUEST

 @TAXIIMessage.in_response_to.setter
 def in_response_to(self, value):
 if value:
 raise ValueError('in_response_to must be None')
 self.in_response_to = value

class DiscoveryResponse(TAXIIMessage):
 """
 A TAXII Discovery Response message.

 Args:
 message_id (str): A value identifying this message. **Required**
 in_response_to (str): Contains the Message ID of the message to
 which this is a response. **Optional**
 extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. **Optional**
 service_instances (list of `ServiceInstance`): a list of
 service instances that this response contains. **Optional**
 """

 message_type = MSG_DISCOVERY_RESPONSE

 def __init__(self, message_id, in_response_to, extended_headers=None, service_instances=None):
 super(DiscoveryResponse, self).__init__(message_id, in_response_to, extended_headers)
 self.service_instances = service_instances or []

 @TAXIIMessage.in_response_to.setter
 def in_response_to(self, value):
 do_check(value, 'in_response_to', regex_tuple=uri_regex)
 self.in_response_to = value

 @property
 def service_instances(self):
 return self._service_instances

 @service_instances.setter
 def service_instances(self, value):
 do_check(value, 'service_instances', type=ServiceInstance)
 self._service_instances = value

 def to_etree(self):

```

```

xml = super(DiscoveryResponse, self).to_etree()
for service_instance in self.service_instances:
 xml.append(service_instance.to_etree())
return xml

def to_dict(self):
 d = super(DiscoveryResponse, self).to_dict()
 d['service_instances'] = []
 for service_instance in self.service_instances:
 d['service_instances'].append(service_instance.to_dict())
 return d

def to_json(self):
 return json.dumps(self.to_dict())

def to_text(self, line_prepend=""):
 s = super(DiscoveryResponse, self).to_text(line_prepend)
 for si in self.service_instances:
 s += si.to_text(line_prepend + STD_INDENT)

 return s

@classmethod
def from_etree(cls, etree_xml):
 msg = super(DiscoveryResponse, cls).from_etree(etree_xml)
 msg.service_instances = []
 for service_instance in etree_xml.xpath('/taxii:Service_Instance', namespaces=ns_map):
 si = ServiceInstance.from_etree(service_instance)
 msg.service_instances.append(si)
 return msg

@classmethod
def from_dict(cls, d):
 msg = super(DiscoveryResponse, cls).from_dict(d)
 msg.service_instances = []
 for service_instance in d['service_instances']:
 si = ServiceInstance.from_dict(service_instance)
 msg.service_instances.append(si)
 return msg

class ServiceInstance(TAXIIBase10):
 """
 The Service Instance component of a TAXII Discovery Response Message.

 Args:
 service_type (string): identifies the Service Type of this
 Service Instance. **Required**
 services_version (string): identifies the TAXII Services
 Specification to which this Service conforms. **Required**
 protocol_binding (string): identifies the protocol binding
 supported by this Service. **Required**
 service_address (string): identifies the network address of the
 TAXII Daemon that hosts this Service. **Required**
 message_bindings (list of strings): identifies the message
 bindings supported by this Service instance. **Required**
 inbox_service_accepted_content (list of strings): identifies
 content bindings that this Inbox Service is willing to accept.
 Optional
 available (boolean): indicates whether the identity of the
 requester (authenticated or otherwise) is allowed to access this
 TAXII Service. **Optional**
 message (string): contains a message regarding this Service
 instance. **Optional**

 The ``message_bindings`` list must contain at least one value.
 """

```

```
def __init__(self, service_type, services_version, protocol_binding,
 service_address, message_bindings,
 inbox_service_accepted_content=None, available=None,
 message=None):
 self.service_type = service_type
 self.services_version = services_version
 self.protocol_binding = protocol_binding
 self.service_address = service_address
 self.message_bindings = message_bindings
 self.inbox_service_accepted_content = inbox_service_accepted_content or []
 self.available = available
 self.message = message

@property
def sort_key(self):
 return self.service_address

@property
def service_type(self):
 return self._service_type

@service_type.setter
def service_type(self, value):
 do_check(value, 'service_type', value_tuple=SVC_TYPES)
 self._service_type = value

@property
def services_version(self):
 return self._services_version

@services_version.setter
def services_version(self, value):
 do_check(value, 'services_version', regex_tuple=uri_regex)
 self._services_version = value

@property
def protocol_binding(self):
 return self._protocol_binding

@protocol_binding.setter
def protocol_binding(self, value):
 do_check(value, 'protocol_binding', regex_tuple=uri_regex)
 self._protocol_binding = value

@property
def service_address(self):
 return self._service_address

@service_address.setter
def service_address(self, value):
 self._service_address = value

@property
def message_bindings(self):
 return self._message_bindings

@message_bindings.setter
def message_bindings(self, value):
 do_check(value, 'message_bindings', regex_tuple=uri_regex)
 self._message_bindings = value

@property
def inbox_service_accepted_content(self):
 return self._inbox_service_accepted_content

@inbox_service_accepted_content.setter
def inbox_service_accepted_content(self, value):
 do_check(value, 'inbox_service_accepted_content', regex_tuple=uri_regex)
 self._inbox_service_accepted_content = value
```

```

@property
def available(self):
 return self._available

@available.setter
def available(self, value):
 do_check(value, 'available', value_tuple=(True, False), can_be_none=True)
 self._available = value

def to_etree(self):
 si = etree.Element('{%s}Service_Instance' % ns_map['taxii'])
 si.attrib['service_type'] = self.service_type
 si.attrib['service_version'] = self.services_version
 if self.available:
 si.attrib['available'] = str(self.available).lower()

 protocol_binding = etree.SubElement(si, '{%s}Protocol_Binding' % ns_map['taxii'])
 protocol_binding.text = self.protocol_binding

 service_address = etree.SubElement(si, '{%s}Address' % ns_map['taxii'])
 service_address.text = self.service_address

 for mb in self.message_bindings:
 message_binding = etree.SubElement(si, '{%s}Message_Binding' % ns_map['taxii'])
 message_binding.text = mb

 for cb in self.inbox_service_accepted_content:
 content_binding = etree.SubElement(si, '{%s}Content_Binding' % ns_map['taxii'])
 content_binding.text = cb

 if self.message is not None:
 message = etree.SubElement(si, '{%s}Message' % ns_map['taxii'])
 message.text = self.message

 return si

def to_dict(self):
 d = {}
 d['service_type'] = self.service_type
 d['services_version'] = self.services_version
 d['protocol_binding'] = self.protocol_binding
 d['service_address'] = self.service_address
 d['message_bindings'] = self.message_bindings
 d['inbox_service_accepted_content'] = self.inbox_service_accepted_content
 d['available'] = self.available
 d['message'] = self.message
 return d

def to_text(self, line_prepend=""):
 s = line_prepend + "=== Service Instance===\n"
 s += line_prepend + " Service Type: %s\n" % self.service_type
 s += line_prepend + " Services Version: %s\n" % self.services_version
 s += line_prepend + " Protocol Binding: %s\n" % self.protocol_binding
 s += line_prepend + " Address: %s\n" % self.service_address
 for mb in self.message_bindings:
 s += line_prepend + " Message Binding: %s\n" % mb
 if len(self.inbox_service_accepted_content) == 0:
 s += line_prepend + " Inbox Service Accepts: %s\n" % None
 for isac in self.inbox_service_accepted_content:
 s += line_prepend + " Inbox Service Accepts: %s\n" % isac
 s += line_prepend + " Available: %s\n" % self.available
 s += line_prepend + " Message: %s\n" % self.message

 return s

@classmethod
def from_etree(cls, etree_xml): # Expects a taxii:Service_Instance element
 service_type = etree_xml.attrib['service_type']

```

```

services_version = etree_xml.attrib['service_version']
available = None
if etree_xml.attrib.get('available'):
 tmp_available = etree_xml.attrib['available']
 available = tmp_available.lower() == 'true'

protocol_binding = get_required(etree_xml, './taxii:Protocol_Binding', ns_map).text
service_address = get_required(etree_xml, './taxii:Address', ns_map).text

message_bindings = []
for mb in etree_xml.xpath('./taxii:Message_Binding', namespaces=ns_map):
 message_bindings.append(mb.text)

inbox_service_accepted_contents = []
for cb in etree_xml.xpath('./taxii:Content_Binding', namespaces=ns_map):
 inbox_service_accepted_contents.append(cb.text)

message = get_optional_text(etree_xml, './taxii:Message', ns_map)

return ServiceInstance(service_type, services_version, protocol_binding,
 service_address, message_bindings, inbox_service_accepted_contents,
 available, message)

@staticmethod
def from_dict(d):
 return ServiceInstance(**d)

class FeedInformationRequest(TAXIIMessage):
 """
 A TAXII Feed Information Request message.

 Args:
 message_id (str): A value identifying this message. **Required**
 extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. **Optional**
 """
 message_type = MSG_FEED_INFORMATION_REQUEST

 @TAXIIMessage.in_response_to.setter
 def in_response_to(self, value):
 if value:
 raise ValueError('in_response_to must be None')
 self.in_response_to = value

class FeedInformationResponse(TAXIIMessage):
 """
 A TAXII Feed Information Response message.

 Args:
 message_id (str): A value identifying this message. **Required**
 in_response_to (str): Contains the Message ID of the message to
 which this is a response. **Required**
 extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. **Optional**
 feed_informations (list of FeedInformation): A list
 of FeedInformation objects to be contained in this response.
 Optional
 """
 message_type = MSG_FEED_INFORMATION_RESPONSE

 def __init__(self, message_id, in_response_to, extended_headers=None, feed_informations=None):
 super(FeedInformationResponse, self).__init__(message_id, in_response_to, extended_headers=extended_headers)
 self.feed_informations = feed_informations or []

```

```

@TAXIIMessage.in_response_to.setter
def in_response_to(self, value):
 do_check(value, 'in_response_to', regex_tuple=message_id_regex_10)
 self.in_response_to = value

@property
def feed_informations(self):
 return self._feed_informations

@feed_informations.setter
def feed_informations(self, value):
 do_check(value, 'feed_informations', type=FeedInformation)
 self._feed_informations = value

def to_etree(self):
 xml = super(FeedInformationResponse, self).to_etree()
 for feed in self.feed_informations:
 xml.append(feed.to_etree())
 return xml

def to_dict(self):
 d = super(FeedInformationResponse, self).to_dict()
 d['feed_informations'] = []
 for feed in self.feed_informations:
 d['feed_informations'].append(feed.to_dict())
 return d

def to_text(self, line_prepend=""):
 s = super(FeedInformationResponse, self).to_text(line_prepend)
 for feed in self.feed_informations:
 s += feed.to_text(line_prepend + STD_INDENT)

 return s

@classmethod
def from_etree(cls, etree_xml):
 msg = super(FeedInformationResponse, cls).from_etree(etree_xml)
 msg.feed_informations = []
 feed_informations = etree_xml.xpath('/taxii:Feed', namespaces=ns_map)
 for feed in feed_informations:
 msg.feed_informations.append(FeedInformation.from_etree(feed))
 return msg

@classmethod
def from_dict(cls, d):
 msg = super(FeedInformationResponse, cls).from_dict(d)
 msg.feed_informations = []
 for feed in d['feed_informations']:
 msg.feed_informations.append(FeedInformation.from_dict(feed))
 return msg

class FeedInformation(TAXIIBase10):
 """
 The Feed Information component of a TAXII Feed Information Response
 Message.

 Arguments:
 feed_name (str): the name by which this TAXII Data Feed is
 identified. **Required**
 feed_description (str): a prose description of this TAXII
 Data Feed. **Required**
 supported_contents (list of str): Content Binding IDs
 indicating which types of content are currently expressed in this
 TAXII Data Feed. **Required**
 available (boolean): whether the identity of the requester
 (authenticated or otherwise) is allowed to access this TAXII
 Service. **Optional** Default: ``None``, indicating "unknown"

```

push\_methods (list of PushMethod objects): the protocols that can be used to push content via a subscription. **\*\*Optional\*\***

polling\_service\_instances (list of PollingServiceInstance objects): the bindings and address a Consumer can use to interact with a Poll Service instance that supports this TAXII Data Feed. **\*\*Optional\*\***

subscription\_methods (list of SubscriptionMethod objects): the protocol and address of the TAXII Daemon hosting the Feed Management Service that can process subscriptions for this TAXII Data Feed. **\*\*Optional\*\***

The absence of ``push\_methods`` indicates no push methods. The absence of ``polling\_service\_instances`` indicates no polling services. At least one of ``push\_methods`` and ``polling\_service\_instances`` must not be empty. The absence of ``subscription\_methods`` indicates no subscription services.

```

"""
def __init__(self, feed_name, feed_description, supported_contents,
 available=None, push_methods=None,
 polling_service_instances=None, subscription_methods=None):

 self.feed_name = feed_name
 self.available = available
 self.feed_description = feed_description
 self.supported_contents = supported_contents
 self.push_methods = push_methods or []
 self.polling_service_instances = polling_service_instances or []
 self.subscription_methods = subscription_methods or []

@property
def sort_key(self):
 return self.feed_name

@property
def feed_name(self):
 return self._feed_name

@feed_name.setter
def feed_name(self, value):
 do_check(value, 'feed_name', regex_tuple=uri_regex)
 self._feed_name = value

@property
def available(self):
 return self._available

@available.setter
def available(self, value):
 do_check(value, 'available', value_tuple=(True, False), can_be_none=True)
 self._available = value

@property
def supported_contents(self):
 return self._supported_contents

@supported_contents.setter
def supported_contents(self, value):
 do_check(value, 'supported_contents', regex_tuple=uri_regex)
 self._supported_contents = value

@property
def push_methods(self):
 return self._push_methods

@push_methods.setter
def push_methods(self, value):
 do_check(value, 'push_methods', type=PushMethod)
 self._push_methods = value

```

```
@property
def polling_service_instances(self):
 return self._polling_service_instances

@polling_service_instances.setter
def polling_service_instances(self, value):
 do_check(value, 'polling_service_instances', type=PollingServiceInstance)
 self._polling_service_instances = value

@property
def subscription_methods(self):
 return self._subscription_methods

@subscription_methods.setter
def subscription_methods(self, value):
 do_check(value, 'subscription_methods', type=SubscriptionMethod)
 self._subscription_methods = value

def to_etree(self):
 f = etree.Element('{%s}Feed' % ns_map['taxii'])
 f.attrib['feed_name'] = self.feed_name
 if self.available:
 f.attrib['available'] = str(self.available).lower()
 feed_description = etree.SubElement(f, '{%s}Description' % ns_map['taxii'])
 feed_description.text = self.feed_description

 for binding in self.supported_contents:
 cb = etree.SubElement(f, '{%s}Content_Binding' % ns_map['taxii'])
 cb.text = binding

 for push_method in self.push_methods:
 f.append(push_method.to_etree())

 for polling_service in self.polling_service_instances:
 f.append(polling_service.to_etree())

 for subscription_method in self.subscription_methods:
 f.append(subscription_method.to_etree())

 return f

def to_dict(self):
 d = {}
 d['feed_name'] = self.feed_name
 if self.available:
 d['available'] = self.available
 d['feed_description'] = self.feed_description
 d['supported_contents'] = self.supported_contents
 d['push_methods'] = []
 for push_method in self.push_methods:
 d['push_methods'].append(push_method.to_dict())
 d['polling_service_instances'] = []
 for polling_service in self.polling_service_instances:
 d['polling_service_instances'].append(polling_service.to_dict())
 d['subscription_methods'] = []
 for subscription_method in self.subscription_methods:
 d['subscription_methods'].append(subscription_method.to_dict())
 return d

def to_text(self, line_prepend=""):
 s = line_prepend + "==== Data Feed ====\n"
 s += line_prepend + " Feed Name: %s\n" % self.feed_name
 if self.available:
 s += line_prepend + " Available: %s\n" % self.available
 s += line_prepend + " Feed Description: %s\n" % self.feed_description
 for sc in self.supported_contents:
 s += line_prepend + " Supported Content: %s\n" % sc
 for pm in self.push_methods:
```

```

 s += pm.to_text(line_prepend + STD_INDENT)
for ps in self.polling_service_instances:
 s += ps.to_text(line_prepend + STD_INDENT)
for sm in self.subscription_methods:
 s += sm.to_text(line_prepend + STD_INDENT)

return s

@staticmethod
def from_etree(etree_xml):
 kwargs = {}
 kwargs['feed_name'] = etree_xml.attrib['feed_name']
 kwargs['available'] = None
 if 'available' in etree_xml.attrib:
 tmp = etree_xml.attrib['available']
 kwargs['available'] = tmp.lower() == 'true'

 kwargs['feed_description'] = get_required(etree_xml, './taxii:Description', ns_map).text

 kwargs['supported_contents'] = []
 for binding_elt in etree_xml.xpath('./taxii:Content_Binding', namespaces=ns_map):
 kwargs['supported_contents'].append(binding_elt.text)

 kwargs['push_methods'] = []
 for push_method_elt in etree_xml.xpath('./taxii:Push_Method', namespaces=ns_map):
 kwargs['push_methods'].append(PushMethod.from_etree(push_method_elt))

 kwargs['polling_service_instances'] = []
 for polling_elt in etree_xml.xpath('./taxii:Polling_Service', namespaces=ns_map):
 kwargs['polling_service_instances'].append(PollingServiceInstance.from_etree(polling_elt))

 kwargs['subscription_methods'] = []
 for subscription_elt in etree_xml.xpath('./taxii:Subscription_Service', namespaces=ns_map):
 kwargs['subscription_methods'].append(SubscriptionMethod.from_etree(subscription_elt))

 return FeedInformation(**kwargs)

@staticmethod
def from_dict(d):
 kwargs = {}
 kwargs['feed_name'] = d['feed_name']
 kwargs['available'] = d.get('available')

 kwargs['feed_description'] = d['feed_description']
 kwargs['supported_contents'] = []
 for binding in d.get('supported_contents', []):
 kwargs['supported_contents'].append(binding)

 kwargs['push_methods'] = []
 for push_method in d.get('push_methods', []):
 kwargs['push_methods'].append(PushMethod.from_dict(push_method))

 kwargs['polling_service_instances'] = []
 for polling in d.get('polling_service_instances', []):
 kwargs['polling_service_instances'].append(PollingServiceInstance.from_dict(polling))

 kwargs['subscription_methods'] = []
 for subscription_method in d.get('subscription_methods', []):
 kwargs['subscription_methods'].append(SubscriptionMethod.from_dict(subscription_method))

 return FeedInformation(**kwargs)

class PushMethod(TAXIIBaseI0):
 """
 The Push Method component of a TAXII Feed Information
 component.

```

```

Args:
 push_protocol (str): a protocol binding that can be used
 to push content to an Inbox Service instance. **Required**
 push_message_bindings (list of str): the message bindings that
 can be used to push content to an Inbox Service instance
 using the protocol identified in the Push Protocol field.
 Required
"""

def __init__(self, push_protocol, push_message_bindings):
 self.push_protocol = push_protocol
 self.push_message_bindings = push_message_bindings

@property
def sort_key(self):
 return self.push_protocol

@property
def push_protocol(self):
 return self._push_protocol

@push_protocol.setter
def push_protocol(self, value):
 do_check(value, 'push_protocol', regex_tuple=uri_regex)
 self._push_protocol = value

@property
def push_message_bindings(self):
 return self._push_message_bindings

@push_message_bindings.setter
def push_message_bindings(self, value):
 do_check(value, 'push_message_bindings', regex_tuple=uri_regex)
 self._push_message_bindings = value

def to_etree(self):
 x = etree.Element('{%s}Push_Method' % ns_map['taxii'])
 proto_bind = etree.SubElement(x, '{%s}Protocol_Binding' % ns_map['taxii'])
 proto_bind.text = self.push_protocol
 for binding in self.push_message_bindings:
 b = etree.SubElement(x, '{%s}Message_Binding' % ns_map['taxii'])
 b.text = binding
 return x

def to_dict(self):
 d = {}
 d['push_protocol'] = self.push_protocol
 d['push_message_bindings'] = []
 for binding in self.push_message_bindings:
 d['push_message_bindings'].append(binding)
 return d

def to_text(self, line_prepend=""):
 s = line_prepend + "=== Push Method ===\n"
 s += line_prepend + " Protocol Binding: %s\n" % self.push_protocol
 for mb in self.push_message_bindings:
 s += line_prepend + " Message Binding: %s\n" % mb

 return s

@staticmethod
def from_etree(etree_xml):
 kwargs = {}
 kwargs['push_protocol'] = get_required(etree_xml, './taxii:Protocol_Binding', ns_map).text
 kwargs['push_message_bindings'] = []
 for message_binding in etree_xml.xpath('./taxii:Message_Binding', namespaces=ns_map):
 kwargs['push_message_bindings'].append(message_binding.text)
 return PushMethod(**kwargs)

```

```

@staticmethod
def from_dict(d):
 return PushMethod(**d)

class PollingServiceInstance(TAXIIBase10):
 """
 The Polling Service Instance component of a TAXII Feed
 Information component.

 Args:
 poll_protocol (str): the protocol binding supported by
 this Poll Service instance. **Required**
 poll_address (str): the address of the TAXII Daemon
 hosting this Poll Service instance. **Required**
 poll_message_bindings (list of str): the message bindings
 supported by this Poll Service instance. **Required**
 """
 NAME = 'Polling_Service'

 def __init__(self, poll_protocol, poll_address, poll_message_bindings):
 self.poll_protocol = poll_protocol
 self.poll_address = poll_address
 self.poll_message_bindings = poll_message_bindings

 @property
 def sort_key(self):
 return self.poll_address

 @property
 def poll_protocol(self):
 return self._poll_protocol

 @poll_protocol.setter
 def poll_protocol(self, value):
 do_check(value, 'poll_protocol', regex_tuple=uri_regex)
 self._poll_protocol = value

 @property
 def poll_message_bindings(self):
 return self._poll_message_bindings

 @poll_message_bindings.setter
 def poll_message_bindings(self, value):
 do_check(value, 'poll_message_bindings', regex_tuple=uri_regex)
 self._poll_message_bindings = value

 def to_etree(self):
 x = etree.Element('{%s}Polling_Service' % ns_map['taxii'])
 proto_bind = etree.SubElement(x, '{%s}Protocol_Binding' % ns_map['taxii'])
 proto_bind.text = self.poll_protocol
 address = etree.SubElement(x, '{%s}Address' % ns_map['taxii'])
 address.text = self.poll_address
 for binding in self.poll_message_bindings:
 b = etree.SubElement(x, '{%s}Message_Binding' % ns_map['taxii'])
 b.text = binding
 return x

 def to_dict(self):
 d = {}
 d['poll_protocol'] = self.poll_protocol
 d['poll_address'] = self.poll_address
 d['poll_message_bindings'] = []
 for binding in self.poll_message_bindings:
 d['poll_message_bindings'].append(binding)
 return d

 def to_text(self, line_prepend=""):

```

```

s = line_prepend + "=== Poll Service Instance ===\n"
s += line_prepend + " Protocol Binding: %s\n" % self.poll_protocol
s += line_prepend + " Address: %s\n" % self.poll_address
for mb in self.poll_message_bindings:
 s += line_prepend + " Message Binding: %s\n" % mb

return s

@classmethod
def from_etree(cls, etree_xml):
 protocol = get_required(etree_xml, './taxii:Protocol_Binding', ns_map).text
 addr = get_required(etree_xml, './taxii:Address', ns_map).text

 bindings = []
 for message_binding in etree_xml.xpath('./taxii:Message_Binding', namespaces=ns_map):
 bindings.append(message_binding.text)
 return cls(protocol, addr, bindings)

@classmethod
def from_dict(cls, d):
 return cls(**d)

class SubscriptionMethod(TAXIIBase10):
 """
 The Subscription Method component of a TAXII Feed Information
 component.

 Args:
 subscription_protocol (str): the protocol binding supported by
 this Feed Management Service instance. **Required**
 subscription_address (str): the address of the TAXII Daemon
 hosting this Feed Management Service instance.
 Required.
 subscription_message_bindings (list of str): the message
 bindings supported by this Feed Management Service
 Instance. **Required**
 """
 NAME = 'Subscription_Service'

 def __init__(self, subscription_protocol, subscription_address,
 subscription_message_bindings):
 self.subscription_protocol = subscription_protocol
 self.subscription_address = subscription_address
 self.subscription_message_bindings = subscription_message_bindings

 @property
 def sort_key(self):
 return self.subscription_address

 @property
 def subscription_protocol(self):
 return self._subscription_protocol

 @subscription_protocol.setter
 def subscription_protocol(self, value):
 do_check(value, 'subscription_protocol', regex_tuple=uri_regex)
 self._subscription_protocol = value

 @property
 def subscription_message_bindings(self):
 return self._subscription_message_bindings

 @subscription_message_bindings.setter
 def subscription_message_bindings(self, value):
 do_check(value, 'subscription_message_bindings', regex_tuple=uri_regex)
 self._subscription_message_bindings = value

```

```

def to_etree(self):
 x = etree.Element('{%s}%s' % (ns_map['taxii'], self.NAME))
 proto_bind = etree.SubElement(x, '{%s}Protocol_Binding' % ns_map['taxii'])
 proto_bind.text = self.subscription_protocol
 address = etree.SubElement(x, '{%s}Address' % ns_map['taxii'])
 address.text = self.subscription_address
 for binding in self.subscription_message_bindings:
 b = etree.SubElement(x, '{%s}Message_Binding' % ns_map['taxii'])
 b.text = binding
 return x

def to_dict(self):
 d = {}
 d['subscription_protocol'] = self.subscription_protocol
 d['subscription_address'] = self.subscription_address
 d['subscription_message_bindings'] = []
 for binding in self.subscription_message_bindings:
 d['subscription_message_bindings'].append(binding)
 return d

def to_text(self, line_prepend=""):
 s = line_prepend + "==== Subscription Method ====\n"
 s += line_prepend + " Protocol Binding: %s\n" % self.subscription_protocol
 s += line_prepend + " Address: %s\n" % self.subscription_address
 for mb in self.subscription_message_bindings:
 s += line_prepend + " Message Binding: %s\n" % mb

 return s

@classmethod
def from_etree(cls, etree_xml):
 protocol = get_required(etree_xml, './taxii:Protocol_Binding', ns_map).text
 addr = get_required(etree_xml, './taxii:Address', ns_map).text
 bindings = []
 for message_binding in etree_xml.xpath('./taxii:Message_Binding', namespaces=ns_map):
 bindings.append(message_binding.text)
 return cls(protocol, addr, bindings)

@classmethod
def from_dict(cls, d):
 return cls(**d)

class PollRequest(TAXIIMessage):
 """
 A TAXII Poll Request message.

 Arguments:
 message_id (str): A value identifying this message. Required
 extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. Optional
 feed_name (str): the name of the TAXII Data Feed that is being
 polled. Required
 exclusive_begin_timestamp_label (datetime): a Timestamp Label
 indicating the beginning of the range of TAXII Data Feed content the
 requester wishes to receive. Optional
 inclusive_end_timestamp_label (datetime): a Timestamp Label
 indicating the end of the range of TAXII Data Feed content the
 requester wishes to receive. Optional
 subscription_id (str): the existing subscription the Consumer
 wishes to poll. Optional
 content_bindings (list of str): the type of content that is
 requested in the response to this poll. Optional, defaults to
 accepting all content bindings.
 """
 message_type = MSG_POLL_REQUEST

 def __init__(self, message_id, extended_headers=None,

```

```
 feed_name=None, exclusive_begin_timestamp_label=None,
 inclusive_end_timestamp_label=None, subscription_id=None,
 content_bindings=None):
 super(PollRequest, self).__init__(message_id, extended_headers=extended_headers)
 self.feed_name = feed_name
 self.exclusive_begin_timestamp_label = exclusive_begin_timestamp_label
 self.inclusive_end_timestamp_label = inclusive_end_timestamp_label
 self.subscription_id = subscription_id
 self.content_bindings = content_bindings or []

 @TAXIIMessage.in_response_to.setter
 def in_response_to(self, value):
 if value:
 raise ValueError('in_response_to must be None')
 self._in_response_to = value

 @property
 def feed_name(self):
 return self._feed_name

 @feed_name.setter
 def feed_name(self, value):
 do_check(value, 'feed_name', regex_tuple=uri_regex)
 self._feed_name = value

 @property
 def exclusive_begin_timestamp_label(self):
 return self._exclusive_begin_timestamp_label

 @exclusive_begin_timestamp_label.setter
 def exclusive_begin_timestamp_label(self, value):
 value = check_timestamp_label(value, 'exclusive_begin_timestamp_label', can_be_none=True)
 self._exclusive_begin_timestamp_label = value

 @property
 def inclusive_end_timestamp_label(self):
 return self._inclusive_end_timestamp_label

 @inclusive_end_timestamp_label.setter
 def inclusive_end_timestamp_label(self, value):
 value = check_timestamp_label(value, 'inclusive_end_timestamp_label', can_be_none=True)
 self._inclusive_end_timestamp_label = value

 @property
 def subscription_id(self):
 return self._subscription_id

 @subscription_id.setter
 def subscription_id(self, value):
 do_check(value, 'subscription_id', regex_tuple=uri_regex, can_be_none=True)
 self._subscription_id = value

 @property
 def content_bindings(self):
 return self._content_bindings

 @content_bindings.setter
 def content_bindings(self, value):
 do_check(value, 'content_bindings', regex_tuple=uri_regex)
 self._content_bindings = value

 def to_etree(self):
 xml = super(PollRequest, self).to_etree()
 xml.attrib['feed_name'] = self.feed_name
 if self.subscription_id is not None:
 xml.attrib['subscription_id'] = self.subscription_id

 if self.exclusive_begin_timestamp_label:
 ebt = etree.SubElement(xml, '{%s}Exclusive_Begin_Timestamp' % ns_map['taxii'])
```

```

 # TODO: Add TZ Info
 ebt.text = self.exclusive_begin_timestamp_label.isoformat()

 if self.inclusive_end_timestamp_label:
 iet = etree.SubElement(xml, '{%s}Inclusive_End_Timestamp' % ns_map['taxii'])
 # TODO: Add TZ Info
 iet.text = self.inclusive_end_timestamp_label.isoformat()

 for binding in self.content_bindings:
 b = etree.SubElement(xml, '{%s}Content_Binding' % ns_map['taxii'])
 b.text = binding

 return xml

def to_dict(self):
 d = super(PollRequest, self).to_dict()
 d['feed_name'] = self.feed_name
 if self.subscription_id is not None:
 d['subscription_id'] = self.subscription_id
 if self.exclusive_begin_timestamp_label: # TODO: Add TZ Info
 d['exclusive_begin_timestamp_label'] = self.exclusive_begin_timestamp_label.isoformat()
 if self.inclusive_end_timestamp_label: # TODO: Add TZ Info
 d['inclusive_end_timestamp_label'] = self.inclusive_end_timestamp_label.isoformat()
 d['content_bindings'] = []
 for bind in self.content_bindings:
 d['content_bindings'].append(bind)
 return d

def to_text(self, line_prepend=""):
 s = super(PollRequest, self).to_text(line_prepend)
 s += line_prepend + " Feed Name: %s\n" % self.feed_name
 if self.subscription_id:
 s += line_prepend + " Subscription ID: %s\n" % self.subscription_id

 if self.exclusive_begin_timestamp_label:
 s += line_prepend + " Excl. Begin Timestamp Label: %s\n" % self.exclusive_begin_timestamp_label.isoformat()
 else:
 s += line_prepend + " Excl. Begin Timestamp Label: %s\n" % None

 if self.inclusive_end_timestamp_label:
 s += line_prepend + " Incl. End Timestamp Label: %s\n" % self.inclusive_end_timestamp_label.isoformat()
 else:
 s += line_prepend + " Incl. End Timestamp Label: %s\n" % None

 if len(self.content_bindings) == 0:
 s += line_prepend + " Content Binding: Any Content\n"

 for cb in self.content_bindings:
 s += line_prepend + " Content Binding: %s\n" % cb

 return s

@classmethod
def from_etree(cls, etree_xml):
 kwargs = {}
 kwargs['feed_name'] = get_required(etree_xml, './@feed_name', ns_map)
 kwargs['subscription_id'] = get_optional(etree_xml, './@subscription_id', ns_map)

 ebt_text = get_optional_text(etree_xml, './taxii:Exclusive_Begin_Timestamp', ns_map)
 if ebt_text:
 kwargs['exclusive_begin_timestamp_label'] = parse_datetime_string(ebt_text)

 iet_text = get_optional_text(etree_xml, './taxii:Inclusive_End_Timestamp', ns_map)
 if iet_text:
 kwargs['inclusive_end_timestamp_label'] = parse_datetime_string(iet_text)

 kwargs['content_bindings'] = []
 for binding in etree_xml.xpath('./taxii:Content_Binding', namespaces=ns_map):
 kwargs['content_bindings'].append(binding.text)

```

```

msg = super(PollRequest, cls).from_etree(etree_xml, **kwargs)
return msg

@classmethod
def from_dict(cls, d):
 kwargs = {}
 kwargs['feed_name'] = d['feed_name']

 kwargs['subscription_id'] = d.get('subscription_id')

 kwargs['exclusive_begin_timestamp_label'] = None
 if d.get('exclusive_begin_timestamp_label'):
 kwargs['exclusive_begin_timestamp_label'] = parse_datetime_string(d['exclusive_begin_timestamp_label'])

 kwargs['inclusive_end_timestamp_label'] = None
 if d.get('inclusive_end_timestamp_label'):
 kwargs['inclusive_end_timestamp_label'] = parse_datetime_string(d['inclusive_end_timestamp_label'])

 kwargs['content_bindings'] = d.get('content_bindings', [])

 msg = super(PollRequest, cls).from_dict(d, **kwargs)
 return msg

```

```
class PollResponse(TAXIIMessage):
```

```
 """
```

```
 A TAXII Poll Response message.
```

```
 Args:
```

```

message_id (str): A value identifying this message. **Required**
in_response_to (str): Contains the Message ID of the message to
 which this is a response. **Required**
extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. **Optional**
feed_name (str): the name of the TAXII Data Feed that was polled.
 Required
inclusive_begin_timestamp_label (datetime): a Timestamp Label
 indicating the beginning of the range this response covers.
 Optional
inclusive_end_timestamp_label (datetime): a Timestamp Label
 indicating the end of the range this response covers. **Required**
subscription_id (str): the Subscription ID for which this content
 is being provided. **Optional**
message (str): additional information for the message recipient.
 Optional
content_blocks (list of ContentBlock): piece of content
 and additional information related to the content. **Optional**

```

```
 """
```

```
message_type = MSG_POLL_RESPONSE
```

```

def __init__(self, message_id, in_response_to, extended_headers=None,
 feed_name=None, inclusive_begin_timestamp_label=None,
 inclusive_end_timestamp_label=None, subscription_id=None,
 message=None, content_blocks=None):
 super(PollResponse, self).__init__(message_id, in_response_to, extended_headers)
 self.feed_name = feed_name
 self.inclusive_end_timestamp_label = inclusive_end_timestamp_label
 self.inclusive_begin_timestamp_label = inclusive_begin_timestamp_label
 self.subscription_id = subscription_id
 self.message = message
 self.content_blocks = content_blocks or []

```

```
@TAXIIMessage.in_response_to.setter
```

```

def in_response_to(self, value):
 do_check(value, 'in_response_to', regex_tuple=uri_regex)
 self.in_response_to = value

```

```
@property
def feed_name(self):
 return self._feed_name

@feed_name.setter
def feed_name(self, value):
 do_check(value, 'feed_name', regex_tuple=uri_regex)
 self._feed_name = value

@property
def inclusive_end_timestamp_label(self):
 return self._inclusive_end_timestamp_label

@inclusive_end_timestamp_label.setter
def inclusive_end_timestamp_label(self, value):
 value = check_timestamp_label(value, 'inclusive_end_timestamp_label')
 self._inclusive_end_timestamp_label = value

@property
def inclusive_begin_timestamp_label(self):
 return self._inclusive_begin_timestamp_label

@inclusive_begin_timestamp_label.setter
def inclusive_begin_timestamp_label(self, value):
 value = check_timestamp_label(value, 'inclusive_begin_timestamp_label', can_be_none=True)
 self._inclusive_begin_timestamp_label = value

@property
def subscription_id(self):
 return self._subscription_id

@subscription_id.setter
def subscription_id(self, value):
 do_check(value, 'subscription_id', regex_tuple=uri_regex, can_be_none=True)
 self._subscription_id = value

@property
def content_blocks(self):
 return self._content_blocks

@content_blocks.setter
def content_blocks(self, value):
 do_check(value, 'content_blocks', type=ContentBlock)
 self._content_blocks = value

def to_etree(self):
 xml = super(PollResponse, self).to_etree()
 xml.attrib['feed_name'] = self.feed_name
 if self.subscription_id is not None:
 xml.attrib['subscription_id'] = self.subscription_id

 if self.message is not None:
 m = etree.SubElement(xml, '{%s}Message' % ns_map['taxii'])
 m.text = self.message

 if self.inclusive_begin_timestamp_label:
 ibt = etree.SubElement(xml, '{%s}Inclusive_Begin_Timestamp' % ns_map['taxii'])
 ibt.text = self.inclusive_begin_timestamp_label.isoformat()

 iet = etree.SubElement(xml, '{%s}Inclusive_End_Timestamp' % ns_map['taxii'])
 iet.text = self.inclusive_end_timestamp_label.isoformat()

 for block in self.content_blocks:
 xml.append(block.to_etree())

 return xml

def to_dict(self):
 d = super(PollResponse, self).to_dict()
```

```

d['feed_name'] = self.feed_name
if self.subscription_id is not None:
 d['subscription_id'] = self.subscription_id
if self.message is not None:
 d['message'] = self.message
if self.inclusive_begin_timestamp_label:
 d['inclusive_begin_timestamp_label'] = self.inclusive_begin_timestamp_label.isoformat()
d['inclusive_end_timestamp_label'] = self.inclusive_end_timestamp_label.isoformat()
d['content_blocks'] = []
for block in self.content_blocks:
 d['content_blocks'].append(block.to_dict())

return d

def to_text(self, line_prepend=""):
 s = super(PollResponse, self).to_text(line_prepend)
 s += line_prepend + " Feed Name: %s\n" % self.feed_name
 if self.subscription_id:
 s += line_prepend + " Subscription ID: %s\n" % self.subscription_id
 s += line_prepend + " Message: %s\n" % self.message

 if self.inclusive_begin_timestamp_label:
 s += line_prepend + " Incl. Begin Timestamp Label: %s\n" % self.inclusive_begin_timestamp_label.isoformat()
 else:
 s += line_prepend + " Incl. Begin Timestamp Label: %s\n" % None

 s += line_prepend + " Incl. End Timestamp Label: %s\n" % self.inclusive_end_timestamp_label.isoformat()

 for cb in self.content_blocks:
 s += cb.to_text(line_prepend + STD_INDENT)

 return s

@classmethod
def from_etree(cls, etree_xml):
 kwargs = {}

 kwargs['feed_name'] = get_required(etree_xml, './@feed_name', ns_map)
 kwargs['subscription_id'] = get_optional(etree_xml, './@subscription_id', ns_map)
 kwargs['message'] = get_optional_text(etree_xml, './taxii:Message', ns_map)

 ibts_text = get_optional_text(etree_xml, './taxii:Inclusive_Begin_Timestamp', ns_map)
 if ibts_text:
 kwargs['inclusive_begin_timestamp_label'] = parse_datetime_string(ibts_text)

 iets_text = get_required(etree_xml, './taxii:Inclusive_End_Timestamp', ns_map).text
 kwargs['inclusive_end_timestamp_label'] = parse_datetime_string(iets_text)

 kwargs['content_blocks'] = []
 blocks = etree_xml.xpath('./taxii:Content_Block', namespaces=ns_map)
 for block in blocks:
 kwargs['content_blocks'].append(ContentBlock.from_etree(block))

 msg = super(PollResponse, cls).from_etree(etree_xml, **kwargs)
 return msg

@classmethod
def from_dict(cls, d):
 kwargs = {}
 kwargs['feed_name'] = d['feed_name']

 kwargs['message'] = d.get('message')
 kwargs['subscription_id'] = d.get('subscription_id')

 kwargs['inclusive_begin_timestamp_label'] = None
 if d.get('inclusive_begin_timestamp_label'):
 kwargs['inclusive_begin_timestamp_label'] = parse_datetime_string(d['inclusive_begin_timestamp_label'])

```

```

kwargs['inclusive_end_timestamp_label'] = parse_datetime_string(d['inclusive_end_timestamp_label'])

kwargs['content_blocks'] = []
for block in d['content_blocks']:
 kwargs['content_blocks'].append(ContentBlock.from_dict(block))
msg = super(PollResponse, cls).from_dict(d, **kwargs)
return msg

class StatusMessage(TAXIIMessage):
 """
 A TAXII Status message.

 Args:
 message_id (str): A value identifying this message. **Required**
 in_response_to (str): Contains the Message ID of the message to
 which this is a response. **Required**
 extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. **Optional**
 status_type (str): One of the defined Status Types or a third-party-
 defined Status Type. **Required**
 status_detail (str): A field for additional information about
 this status in a machine-readable format. **Optional or Prohibited**
 depending on ``status_type``. See TAXII Specification for details.
 message (str): Additional information for the status. There is no
 expectation that this field be interpretable by a machine; it is
 instead targeted to a human operator. **Optional**
 """
 message_type = MSG_STATUS_MESSAGE

 def __init__(self, message_id, in_response_to, extended_headers=None,
 status_type=None, status_detail=None, message=None):
 super(StatusMessage, self).__init__(message_id, in_response_to, extended_headers=extended_headers)
 self.status_type = status_type
 self.status_detail = status_detail
 self.message = message

 @TAXIIMessage.in_response_to.setter
 def in_response_to(self, value):
 do_check(value, 'in_response_to', regex_tuple=uri_regex)
 self.in_response_to = value

 @property
 def status_type(self):
 return self._status_type

 @status_type.setter
 def status_type(self, value):
 do_check(value, 'status_type')
 self._status_type = value

 # TODO: is it possible to check the status detail?

 def to_etree(self):
 xml = super(StatusMessage, self).to_etree()
 xml.attrib['status_type'] = self.status_type

 if self.status_detail is not None:
 sd = etree.SubElement(xml, '{%s}Status_Detail' % ns_map['taxii'])
 sd.text = self.status_detail

 if self.message is not None:
 m = etree.SubElement(xml, '{%s}Message' % ns_map['taxii'])
 m.text = self.message

 return xml

 def to_dict(self):

```

```

 d = super(StatusMessage, self).to_dict()
 d['status_type'] = self.status_type
 if self.status_detail is not None:
 d['status_detail'] = self.status_detail
 if self.message is not None:
 d['message'] = self.message

 return d

def to_text(self, line_prepend=""):
 s = super(StatusMessage, self).to_text(line_prepend)
 s += line_prepend + " Status Type: %s\n" % self.status_type
 if self.status_detail:
 s += line_prepend + " Status Detail: %s\n" % self.status_detail
 s += line_prepend + " Status Message: %s\n" % self.message
 return s

@classmethod
def from_etree(cls, etree_xml):
 kwargs = dict(
 status_type = etree_xml.attrib['status_type'],
 status_detail = get_optional_text(etree_xml, './taxii:Status_Detail', ns_map),
 message = get_optional_text(etree_xml, './taxii:Message', ns_map),
)

 msg = super(StatusMessage, cls).from_etree(etree_xml, **kwargs)
 return msg

@classmethod
def from_dict(cls, d):
 kwargs = dict(
 status_type = d['status_type'],
 status_detail = d.get('status_detail'),
 message = d.get('message')
)

 msg = super(StatusMessage, cls).from_dict(d, **kwargs)
 return msg

class InboxMessage(TAXIIMessage):
 """
 A TAXII Inbox message.

 Args:
 message_id (str): A value identifying this message. **Required**
 extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. **Optional**
 message (str): prose information for the message recipient. **Optional**
 subscription_information (SubscriptionInformation): This
 field is only present if this message is being sent to provide
 content in accordance with an existing TAXII Data Feed
 subscription. **Optional**
 content_blocks (list of ContentBlock): Inbox content. **Optional**
 """

 message_type = MSG_INBOX_MESSAGE

 def __init__(self, message_id, in_response_to=None, extended_headers=None,
 message=None, subscription_information=None,
 content_blocks=None):

 super(InboxMessage, self).__init__(message_id, extended_headers=extended_headers)
 self.subscription_information = subscription_information
 self.message = message
 self.content_blocks = content_blocks or []

 @TAXIIMessage.in_response_to.setter

```

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```
def in_response_to(self, value):
 if value:
 raise ValueError('in_response_to must be None')
 self._in_response_to = value

@property
def subscription_information(self):
 return self._subscription_information

@subscription_information.setter
def subscription_information(self, value):
 do_check(value, 'subscription_information', type=SubscriptionInformation, can_be_none=True)
 self._subscription_information = value

@property
def content_blocks(self):
 return self._content_blocks

@content_blocks.setter
def content_blocks(self, value):
 do_check(value, 'content_blocks', type=ContentBlock)
 self._content_blocks = value

def to_etree(self):
 xml = super(InboxMessage, self).to_etree()
 if self.message is not None:
 m = etree.SubElement(xml, '{%s}Message' % ns_map['taxii'])
 m.text = self.message

 if self.subscription_information:
 xml.append(self.subscription_information.to_etree())

 for block in self.content_blocks:
 xml.append(block.to_etree())

 return xml

def to_dict(self):
 d = super(InboxMessage, self).to_dict()
 if self.message is not None:
 d['message'] = self.message

 if self.subscription_information:
 d['subscription_information'] = self.subscription_information.to_dict()

 d['content_blocks'] = []
 for block in self.content_blocks:
 d['content_blocks'].append(block.to_dict())

 return d

def to_text(self, line_prepend=""):
 s = super(InboxMessage, self).to_text(line_prepend)
 s += line_prepend + " Message: %s\n" % self.message
 if self.subscription_information:
 s += self.subscription_information.to_text(line_prepend + STD_INDENT)
 s += line_prepend + " Message has %s Content Blocks\n" % len(self.content_blocks)
 for cb in self.content_blocks:
 s += cb.to_text(line_prepend + STD_INDENT)

 return s

@classmethod
def from_etree(cls, etree_xml):
 msg = super(InboxMessage, cls).from_etree(etree_xml)

 msg.message = get_optional_text(etree_xml, './taxii:Message', ns_map)

 subs_info = get_optional(etree_xml, './taxii:Source_Subscription', ns_map)
```

```

if subs_info is not None:
 msg.subscription_information = SubscriptionInformation.from_etree(subs_info)

content_blocks = etree_xml.xpath('/.taxii:Content_Block', namespaces=ns_map)
msg.content_blocks = []
for block in content_blocks:
 msg.content_blocks.append(ContentBlock.from_etree(block))

return msg

@classmethod
def from_dict(cls, d):
 msg = super(InboxMessage, cls).from_dict(d)

 msg.message = d.get('message')

 msg.subscription_information = None
 if 'subscription_information' in d:
 msg.subscription_information = SubscriptionInformation.from_dict(d['subscription_information'])

 msg.content_blocks = []
 for block in d['content_blocks']:
 msg.content_blocks.append(ContentBlock.from_dict(block))

 return msg

class SubscriptionInformation(TAXIIBase10):
 """
 The Subscription Information component of a TAXII Inbox message.

 Arguments:
 feed_name (str): the name of the TAXII Data Feed from
 which this content is being provided. **Required**
 subscription_id (str): the Subscription ID for which this
 content is being provided. **Required**
 inclusive_begin_timestamp_label (datetime): a Timestamp Label
 indicating the beginning of the time range this Inbox Message
 covers. **Optional**
 inclusive_end_timestamp_label (datetime): a Timestamp Label
 indicating the end of the time range this Inbox Message covers.
 Optional
 """

 def __init__(self, feed_name, subscription_id,
 inclusive_begin_timestamp_label,
 inclusive_end_timestamp_label):
 self.feed_name = feed_name
 self.subscription_id = subscription_id
 self.inclusive_begin_timestamp_label = inclusive_begin_timestamp_label
 self.inclusive_end_timestamp_label = inclusive_end_timestamp_label

 @property
 def feed_name(self):
 return self._feed_name

 @feed_name.setter
 def feed_name(self, value):
 do_check(value, 'feed_name', regex_tuple=uri_regex)
 self._feed_name = value

 @property
 def subscription_id(self):
 return self._subscription_id

 @subscription_id.setter
 def subscription_id(self, value):
 do_check(value, 'subscription_id', regex_tuple=uri_regex)

```

```

self._subscription_id = value

@property
def inclusive_begin_timestamp_label(self):
 return self._inclusive_begin_timestamp_label

@inclusive_begin_timestamp_label.setter
def inclusive_begin_timestamp_label(self, value):
 value = check_timestamp_label(value, 'inclusive_begin_timestamp_label')
 self._inclusive_begin_timestamp_label = value

@property
def inclusive_end_timestamp_label(self):
 return self._inclusive_end_timestamp_label

@inclusive_end_timestamp_label.setter
def inclusive_end_timestamp_label(self, value):
 value = check_timestamp_label(value, 'inclusive_end_timestamp_label')
 self._inclusive_end_timestamp_label = value

def to_etree(self):
 xml = etree.Element('{%s}Source_Subscription' % ns_map['taxii'])
 xml.attrib['feed_name'] = self.feed_name
 xml.attrib['subscription_id'] = self.subscription_id

 ibtl = etree.SubElement(xml, '{%s}Inclusive_Begin_Timestamp' % ns_map['taxii'])
 ibtl.text = self.inclusive_begin_timestamp_label.isoformat()

 ietl = etree.SubElement(xml, '{%s}Inclusive_End_Timestamp' % ns_map['taxii'])
 ietl.text = self.inclusive_end_timestamp_label.isoformat()

 return xml

def to_dict(self):
 d = {}
 d['feed_name'] = self.feed_name
 d['subscription_id'] = self.subscription_id
 d['inclusive_begin_timestamp_label'] = self.inclusive_begin_timestamp_label.isoformat()
 d['inclusive_end_timestamp_label'] = self.inclusive_end_timestamp_label.isoformat()
 return d

def to_text(self, line_prepend=""):
 s = line_prepend + "==== Subscription Information ====\n"
 s += line_prepend + " Feed Name: %s\n" % self.feed_name
 s += line_prepend + " Subscription ID: %s\n" % self.subscription_id
 s += line_prepend + " Incl. Begin TS Label: %s\n" % self.inclusive_begin_timestamp_label.isoformat()
 s += line_prepend + " Incl. End TS Label: %s\n" % self.inclusive_end_timestamp_label.isoformat()
 return s

@staticmethod
def from_etree(etree_xml):
 feed_name = etree_xml.attrib['feed_name']
 subscription_id = etree_xml.attrib['subscription_id']

 ibtl = parse_datetime_string(get_required(etree_xml, './taxii:Inclusive_Begin_Timestamp', ns_map).text)
 ietl = parse_datetime_string(get_required(etree_xml, './taxii:Inclusive_End_Timestamp', ns_map).text)

 return SubscriptionInformation(feed_name, subscription_id, ibtl, ietl)

@staticmethod
def from_dict(d):
 feed_name = d['feed_name']
 subscription_id = d['subscription_id']

 ibtl = parse_datetime_string(d['inclusive_begin_timestamp_label'])
 ietl = parse_datetime_string(d['inclusive_end_timestamp_label'])

 return SubscriptionInformation(feed_name, subscription_id, ibtl, ietl)

```

```

class ManageFeedSubscriptionRequest(TAXIIMessage):
 """
 A TAXII Manage Feed Subscription Request message.

 Args:
 message_id (str): A value identifying this message. **Required**
 extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. **Optional**
 feed_name (str): the name of the TAXII Data Feed to which the
 action applies. **Required**
 action (str): the requested action to take. **Required**
 subscription_id (str): the ID of a previously created subscription.
 Required if ``action==``:py:data:``ACT_UNSUBSCRIBE``, else
 Prohibited.
 delivery_parameters (list of DeliveryParameters): the delivery parameters
 for this request. **Optional** Absence means delivery is not requested.
 """

 message_type = MSG_MANAGE_FEED_SUBSCRIPTION_REQUEST

 def __init__(self, message_id, extended_headers=None,
 feed_name=None, action=None, subscription_id=None,
 delivery_parameters=None):
 super(ManageFeedSubscriptionRequest, self).__init__(message_id, extended_headers=extended_headers)
 self.feed_name = feed_name
 self.action = action
 self.subscription_id = subscription_id
 self.delivery_parameters = delivery_parameters

 @TAXIIMessage.in_response_to.setter
 def in_response_to(self, value):
 if value:
 raise ValueError('in_response_to must be None')
 self._in_response_to = value

 @property
 def feed_name(self):
 return self._feed_name

 @feed_name.setter
 def feed_name(self, value):
 do_check(value, 'feed_name', regex_tuple=uri_regex)
 self._feed_name = value

 @property
 def action(self):
 return self._action

 @action.setter
 def action(self, value):
 do_check(value, 'action', value_tuple=ACT_TYPES)
 self._action = value

 @property
 def subscription_id(self):
 return self._subscription_id

 @subscription_id.setter
 def subscription_id(self, value):
 do_check(value, 'subscription_id', regex_tuple=uri_regex, can_be_none=True)
 self._subscription_id = value

 @property
 def delivery_parameters(self):
 return self._delivery_parameters

 @delivery_parameters.setter

```

```

def delivery_parameters(self, value):
 do_check(value, 'delivery_parameters', type=DeliveryParameters, can_be_none=True)
 self._delivery_parameters = value

def to_etree(self):
 xml = super(ManageFeedSubscriptionRequest, self).to_etree()
 xml.attrib['feed_name'] = self.feed_name
 xml.attrib['action'] = self.action
 if self.subscription_id is not None:
 xml.attrib['subscription_id'] = self.subscription_id

 if self.delivery_parameters:
 xml.append(self.delivery_parameters.to_etree())
 return xml

def to_dict(self):
 d = super(ManageFeedSubscriptionRequest, self).to_dict()
 d['feed_name'] = self.feed_name
 d['action'] = self.action
 d['subscription_id'] = self.subscription_id
 d['delivery_parameters'] = None
 if self.delivery_parameters:
 d['delivery_parameters'] = self.delivery_parameters.to_dict()
 return d

def to_text(self, line_prepend=""):
 s = super(ManageFeedSubscriptionRequest, self).to_text(line_prepend)
 s += line_prepend + " Feed Name: %s\n" % self.feed_name
 s += line_prepend + " Action: %s\n" % self.action
 s += line_prepend + " Subscription ID: %s\n" % self.subscription_id
 if self.delivery_parameters:
 s += self.delivery_parameters.to_text(line_prepend + STD_INDENT)
 return s

@classmethod
def from_etree(cls, etree_xml):
 kwargs = dict(
 feed_name = get_required(etree_xml, './@feed_name', ns_map),
 action = get_required(etree_xml, './@action', ns_map),

 # subscription_id is not required for action 'SUBSCRIBE'
 subscription_id = get_optional(etree_xml, './@subscription_id', ns_map),
)

 # marked as required in spec but as optional is XSD
 delivery = get_optional(etree_xml, './taxii:Push_Parameters', ns_map)
 if delivery is not None:
 kwargs['delivery_parameters'] = DeliveryParameters.from_etree(delivery)

 msg = super(ManageFeedSubscriptionRequest, cls).from_etree(etree_xml, **kwargs)
 return msg

@classmethod
def from_dict(cls, d):
 kwargs = dict(
 feed_name = d['feed_name'],
 action = d['action'],
 subscription_id = d['subscription_id'],
 delivery_parameters = DeliveryParameters.from_dict(d['delivery_parameters'])
)

 msg = super(ManageFeedSubscriptionRequest, cls).from_dict(d, **kwargs)
 return msg

```

```
class ManageFeedSubscriptionResponse(TAXIIMessage):
```

```
 """
```

```
 A TAXII Manage Feed Subscription Response message.
```

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```

Args:
 message_id (str): A value identifying this message. **Required**
 in_response_to (str): Contains the Message ID of the message to
 which this is a response. **Required**
 extended_headers (dict): A dictionary of name/value pairs for
 use as Extended Headers. **Optional**
 feed_name (str): the name of the TAXII Data Feed to which
 the action applies. **Required**
 message (str): additional information for the message recipient.
 Optional
 subscription_instances (list of SubscriptionInstance): **Optional**
"""

message_type = MSG_MANAGE_FEED_SUBSCRIPTION_RESPONSE

def __init__(self, message_id, in_response_to, extended_headers=None,
 feed_name=None, message=None, subscription_instances=None):
 super(ManageFeedSubscriptionResponse, self).__init__(message_id, in_response_to, extended_headers=extended_headers)
 self.feed_name = feed_name
 self.message = message
 self.subscription_instances = subscription_instances or []

 @TAXIIMessage.in_response_to.setter
 def in_response_to(self, value):
 do_check(value, 'in_response_to', regex_tuple=uri_regex)
 self._in_response_to = value

 @property
 def feed_name(self):
 return self._feed_name

 @feed_name.setter
 def feed_name(self, value):
 do_check(value, 'feed_name', regex_tuple=uri_regex)
 self._feed_name = value

 @property
 def subscription_instances(self):
 return self._subscription_instances

 @subscription_instances.setter
 def subscription_instances(self, value):
 do_check(value, 'subscription_instances', type=SubscriptionInstance)
 self._subscription_instances = value

 def to_etree(self):
 xml = super(ManageFeedSubscriptionResponse, self).to_etree()
 xml.attrib['feed_name'] = self.feed_name
 if self.message is not None:
 m = etree.SubElement(xml, '{%s}Message' % ns_map['taxii'])
 m.text = self.message

 for subscription_instance in self.subscription_instances:
 xml.append(subscription_instance.to_etree())

 return xml

 def to_dict(self):
 d = super(ManageFeedSubscriptionResponse, self).to_dict()
 d['feed_name'] = self.feed_name
 if self.message is not None:
 d['message'] = self.message
 d['subscription_instances'] = []
 for subscription_instance in self.subscription_instances:
 d['subscription_instances'].append(subscription_instance.to_dict())

 return d

```

```

def to_text(self, line_prepend=""):
 s = super(ManageFeedSubscriptionResponse, self).to_text(line_prepend)
 s += line_prepend + " Feed Name: %s\n" % self.feed_name
 s += line_prepend + " Message: %s\n" % self.message
 for si in self.subscription_instances:
 s += si.to_text(line_prepend + STD_INDENT)
 return s

@classmethod
def from_etree(cls, etree_xml):
 kwargs = {}
 kwargs['feed_name'] = etree_xml.attrib['feed_name']

 kwargs['message'] = get_optional_text(etree_xml, './taxii:Message', ns_map)

 kwargs['subscription_instances'] = []
 for si in etree_xml.xpath('./taxii:Subscription', namespaces=ns_map):
 kwargs['subscription_instances'].append(SubscriptionInstance.from_etree(si))

 msg = super(ManageFeedSubscriptionResponse, cls).from_etree(etree_xml, **kwargs)
 return msg

@classmethod
def from_dict(cls, d):
 kwargs = {}
 kwargs['feed_name'] = d['feed_name']
 kwargs['message'] = d.get('message')

 kwargs['subscription_instances'] = []
 for instance in d['subscription_instances']:
 kwargs['subscription_instances'].append(SubscriptionInstance.from_dict(instance))

 msg = super(ManageFeedSubscriptionResponse, cls).from_dict(d, **kwargs)
 return msg

class SubscriptionInstance(TAXIIBase10):
 """
 The Subscription Instance component of the Manage Feed Subscription
 Response message.

 Args:
 subscription_id (str): the id of the subscription. **Required**
 delivery_parameters (DeliveryParameters): the parameters
 for this subscription. **Required** if responding to message
 with ``action==``:py:data:ACT_STATUS``, otherwise **Prohibited**
 poll_instances (list of PollInstance): Each Poll
 Instance represents an instance of a Poll Service that can be
 contacted to retrieve content associated with the new
 Subscription. **Optional**
 """
 def __init__(self, subscription_id, delivery_parameters=None,
 poll_instances=None):
 self.subscription_id = subscription_id
 self.delivery_parameters = delivery_parameters
 self.poll_instances = poll_instances or []

 @property
 def sort_key(self):
 return self.subscription_id

 @property
 def subscription_id(self):
 return self._subscription_id

 @subscription_id.setter
 def subscription_id(self, value):

```

```

do_check(value, 'subscription_id', regex_tuple=uri_regex)
self._subscription_id = value

@property
def delivery_parameters(self):
 return self._delivery_parameters

@delivery_parameters.setter
def delivery_parameters(self, value):
 do_check(value, 'delivery_parameters', type=DeliveryParameters, can_be_none=True)
 self._delivery_parameters = value

@property
def poll_instances(self):
 return self._poll_instances

@poll_instances.setter
def poll_instances(self, value):
 do_check(value, 'poll_instances', type=PollInstance, can_be_none=False)
 self._poll_instances = value

def to_etree(self):
 xml = etree.Element('{%s}Subscription' % ns_map['taxii'])
 xml.attrib['subscription_id'] = self.subscription_id

 if self.delivery_parameters:
 xml.append(self.delivery_parameters.to_etree())

 for poll_instance in self.poll_instances:
 xml.append(poll_instance.to_etree())

 return xml

def to_dict(self):
 d = {}
 d['subscription_id'] = self.subscription_id

 if self.delivery_parameters:
 d['delivery_parameters'] = self.delivery_parameters.to_dict()
 else:
 d['delivery_parameters'] = None

 d['poll_instances'] = []
 for poll_instance in self.poll_instances:
 d['poll_instances'].append(poll_instance.to_dict())

 return d

def to_text(self, line_indent=""):
 s = line_indent + "=== Subscription Instance ===\n"
 s += line_indent + " Subscription ID: %s\n" % self.subscription_id
 if self.delivery_parameters:
 s += self.delivery_parameters.to_text(line_indent + STD_INDENT)
 for pi in self.poll_instances:
 s += pi.to_text(line_indent + STD_INDENT)
 return s

@staticmethod
def from_etree(etree_xml):
 subscription_id = etree_xml.attrib['subscription_id']

 _delivery_parameters = get_optional(etree_xml, './taxii:Push_Parameters', ns_map)
 if _delivery_parameters:
 delivery_parameters = DeliveryParameters.from_etree(_delivery_parameters)
 else:
 delivery_parameters = None

 poll_instances = []
 for poll_instance in etree_xml.xpath('./taxii:Poll_Instance', namespaces=ns_map):

```

```

 poll_instances.append(PollInstance.from_etree(poll_instance))

 return SubscriptionInstance(subscription_id, delivery_parameters, poll_instances)

 @staticmethod
 def from_dict(d):
 subscription_id = d['subscription_id']

 if d.get('delivery_parameters'):
 delivery_parameters = DeliveryParameters.from_dict(d['delivery_parameters'])
 else:
 delivery_parameters = None

 poll_instances = []
 for poll_instance in d['poll_instances']:
 poll_instances.append(PollInstance.from_dict(poll_instance))

 return SubscriptionInstance(subscription_id, delivery_parameters, poll_instances)

class PollInstance(TAXIIBase10):
 """
 The Poll Instance component of the Manage Feed Subscription
 Response message.

 Args:
 poll_protocol (str): The protocol binding supported by this
 instance of a Polling Service. **Required**
 poll_address (str): the address of the TAXII Daemon hosting
 this Poll Service. **Required**
 poll_message_bindings (list of str): one or more message bindings
 that can be used when interacting with this Poll Service
 instance. **Required**
 """

 def __init__(self, poll_protocol, poll_address, poll_message_bindings=None):
 self.poll_protocol = poll_protocol
 self.poll_address = poll_address
 self._poll_message_bindings = poll_message_bindings or []

 @property
 def sort_key(self):
 return self.poll_address

 @property
 def poll_protocol(self):
 return self._poll_protocol

 @poll_protocol.setter
 def poll_protocol(self, value):
 do_check(value, 'poll_protocol', regex_tuple=(uri_regex))
 self._poll_protocol = value

 @property
 def poll_message_bindings(self):
 return self._poll_message_bindings

 @poll_message_bindings.setter
 def poll_message_bindings(self, value):
 do_check(value, 'poll_message_bindings', regex_tuple=(uri_regex))
 self._poll_message_bindings = value

 def to_etree(self):
 xml = etree.Element('{%s}Poll_Instance' % ns_map['taxii'])

 pb = etree.SubElement(xml, '{%s}Protocol_Binding' % ns_map['taxii'])
 pb.text = self.poll_protocol

```

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```

a = etree.SubElement(xml, '{%s}Address' % ns_map['taxii'])
a.text = self.poll_address

for binding in self.poll_message_bindings:
 b = etree.SubElement(xml, '{%s}Message_Binding' % ns_map['taxii'])
 b.text = binding

return xml

def to_dict(self):
 d = {}

 d['poll_protocol'] = self.poll_protocol
 d['poll_address'] = self.poll_address
 d['poll_message_bindings'] = []
 for binding in self.poll_message_bindings:
 d['poll_message_bindings'].append(binding)

 return d

def to_text(self, line_prepend=""):
 s = line_prepend + "==== Poll Instance ====\n"
 s += line_prepend + " Protocol Binding: %s\n" % self.poll_protocol
 s += line_prepend + " Address: %s\n" % self.poll_address
 for mb in self.poll_message_bindings:
 s += line_prepend + " Message Binding: %s\n" % mb
 return s

@staticmethod
def from_etree(etree_xml):
 poll_protocol = get_required(etree_xml, './taxii:Protocol_Binding', ns_map).text
 address = get_required(etree_xml, './taxii:Address', ns_map).text

 poll_message_bindings = []
 for b in etree_xml.xpath('./taxii:Message_Binding', namespaces=ns_map):
 poll_message_bindings.append(b.text)

 return PollInstance(poll_protocol, address, poll_message_bindings)

@staticmethod
def from_dict(d):
 return PollInstance(**d)

#####
EVERYTHING BELOW HERE IS FOR BACKWARDS COMPATIBILITY
#####

Add top-level classes as nested classes for backwards compatibility
DiscoveryResponse.ServiceInstance = ServiceInstance
FeedInformationResponse.FeedInformation = FeedInformation
FeedInformation.PushMethod = PushMethod
FeedInformation.PollingServiceInstance = PollingServiceInstance
FeedInformation.SubscriptionMethod = SubscriptionMethod
ManageFeedSubscriptionResponse.PollInstance = PollInstance
ManageFeedSubscriptionResponse.SubscriptionInstance = SubscriptionInstance
InboxMessage.SubscriptionInformation = SubscriptionInformation

Constants not imported in `from constants import *`
MSG_TYPES = MSG_TYPES_10
ST_TYPES = ST_TYPES_10
ACT_TYPES = ACT_TYPES_10
SVC_TYPES = SVC_TYPES_10

from common import (generate_message_id)

```