Leveraging CybOX to Standardize Representation and Exchange of Digital Forensic Information

By

Eoghan Casey, Greg Back, and Sean Barnum

DFAX: Digital Forensic Analysis eXpression

Leveraging CybOX^{TM} to Standardize Representation and Exchange of Digital Forensic Information

Eoghan Casey, Greg Back, Sean Barnum

MITRE

Outline

- Motivation
- Related work
- DFAX ontology
- Introduce a Unified Cyber Ontology (UCO)
- Using CybOX to represent digital evidence
- Provenance
- Actions, Action Patterns, Action Lifecycle
- Next steps

Motivation

- Share digital forensic information
  - Investigations involving 2+ jurisdictions/agencies
- Share digital forensic knowledge
  - Distinctive behavioral patterns to search for
- Combine results from multiple forensic tools
- Compare results from multiple forensic tools
  - Automate tool validation & verification
- Structured data enables more advanced analysis
  - high timelines, graph queries, behavioral analysis

CybOX™

- What is a Cyber Observable?
  - a *measurable event* or *stateful property* in the cyber domain
  - measurable events: registry key is created, file is deleted
  - stateful properties: MD5 hash of a file, value of a registry key
- How these observables relate (patterns)
- Actions (context and tool provenance)
- Already used in digital forensics (intrusions, malware, IoC)
  - Autopsy, Volatility

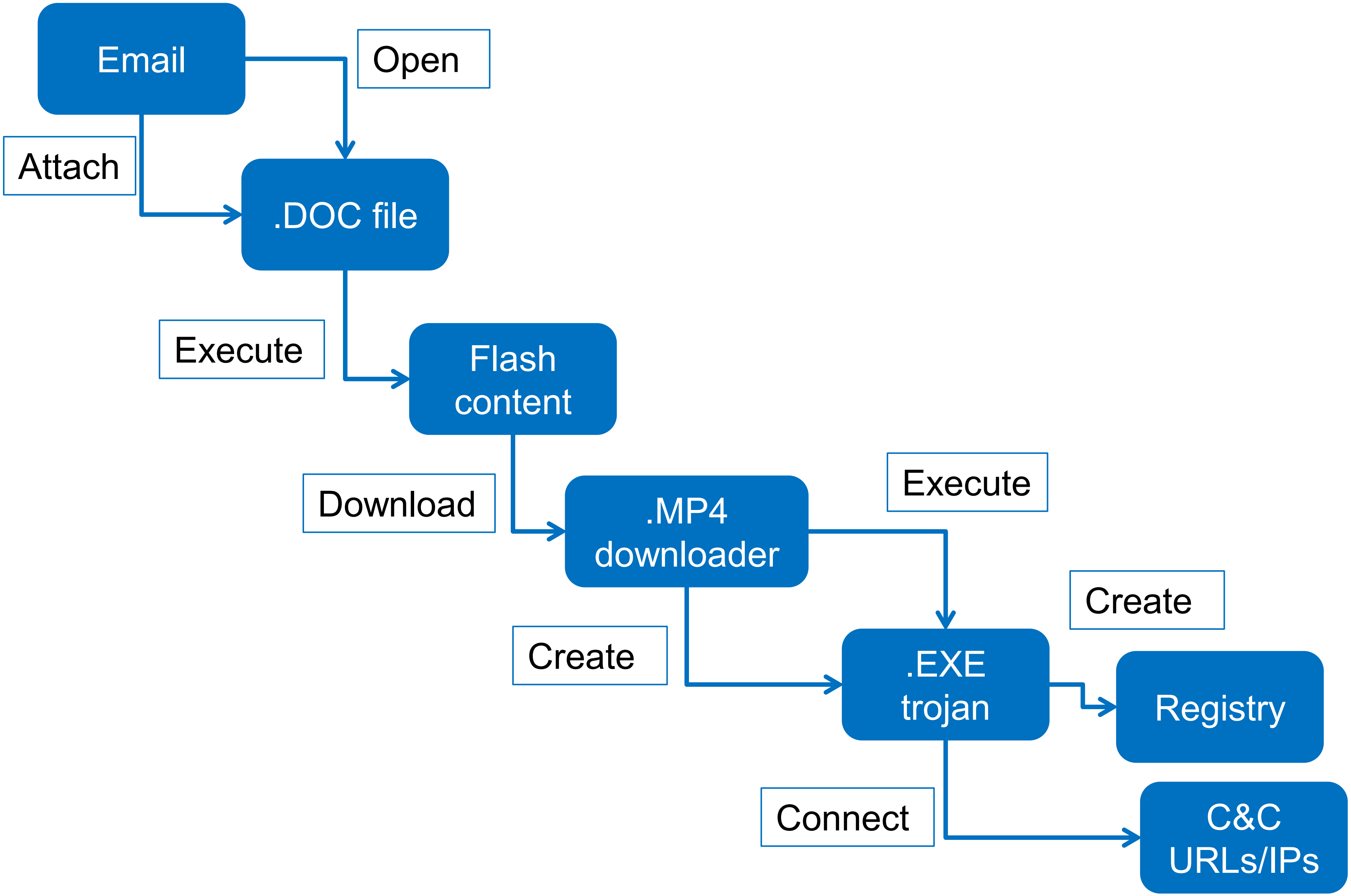
Various Defined Object Schemas

- Account
- Address
- API
- Code
- Device
- Disk
- Disk Partition
- DNS Cache
- DNS_Record
- Email Message
- File
- GUI
- GUI Dialog Box
- GUI Window
- Library
- Linux Package
- Memory
- Mutex
- Network Flow
- Network Packet
- Network Route Entry
- Network Route
- Network Subnet
- Pipe
- Port
- Process
- Product
- Semaphore
- Socket
- System
- Unix File
- Unix Network Route Entry
- Unix Pipe
- Unix Process
- Unix User Account
- Unix Volume
- URI
- User Account
- User Session
- Volume
- Win Computer Account
- Win Critical Section
- Win Driver
- Win Event
- Win Event Log
- Win Executable File
- Win File
- Win Kernel
- Win Kernel Hook
- Win Handle
- Win Mailslot
- Win Mutex
- Win Pipe
- Win Network Route Entry
- Win Network Share
- Win Pipe
- Win Prefetch
- Win Process
- Win Registry Key
- Win Semaphore
- Win Service
- Win System
- Win System Restore
- Win Task
- Win Thread
- Win User Account
- Win Volume
- Win Waitable Timer
- X509 Certificate

…

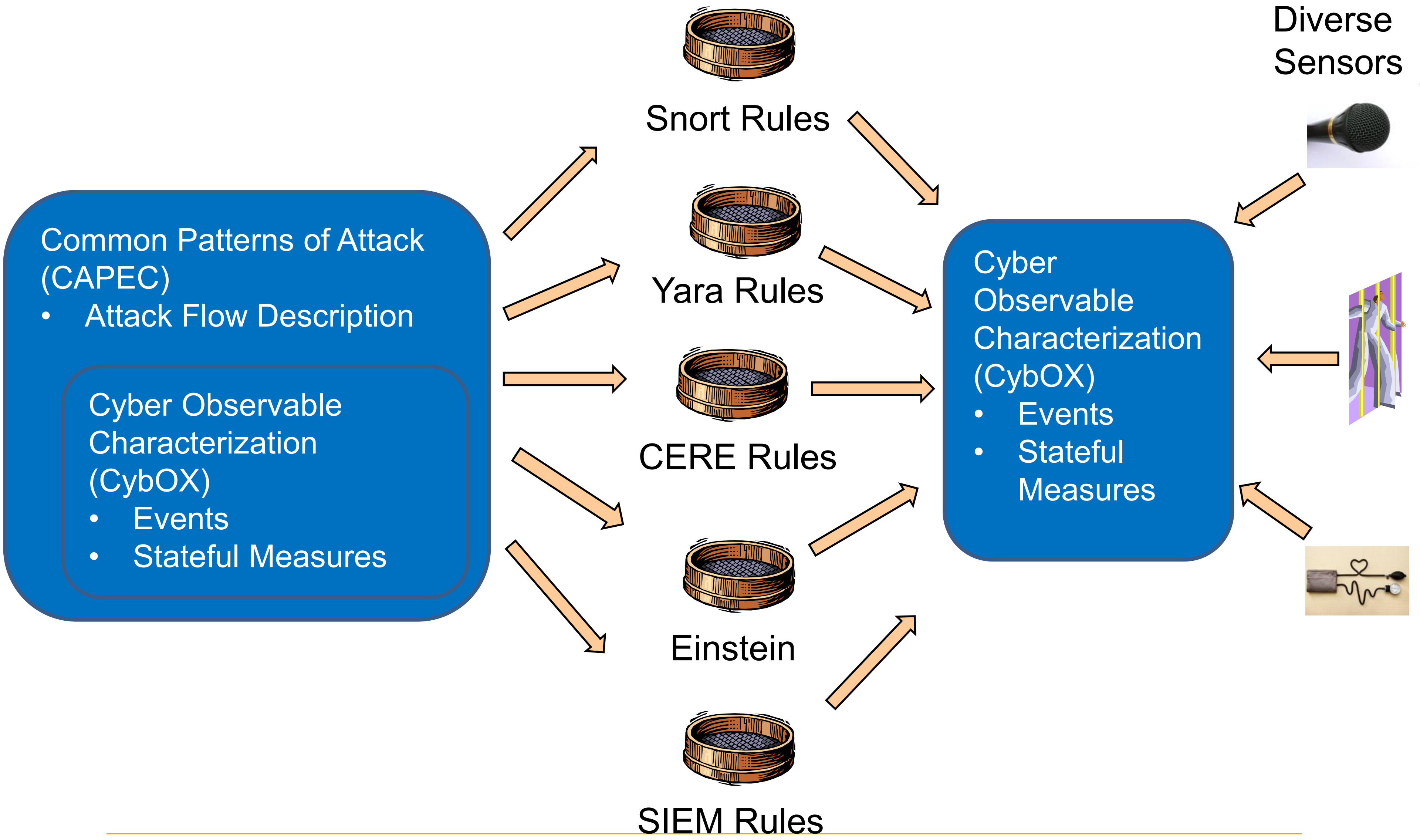
(more on the way)

Disk (Contains)



MITRE

Use Case: Detect Malicious Activity



Common Patterns of Attack (CAPEC)

- Attack Flow Description

Cyber Observable Characterization (CybOX)

- Events
- Stateful Measures

Snort Rules

Yara Rules

CERE Rules

Einstein

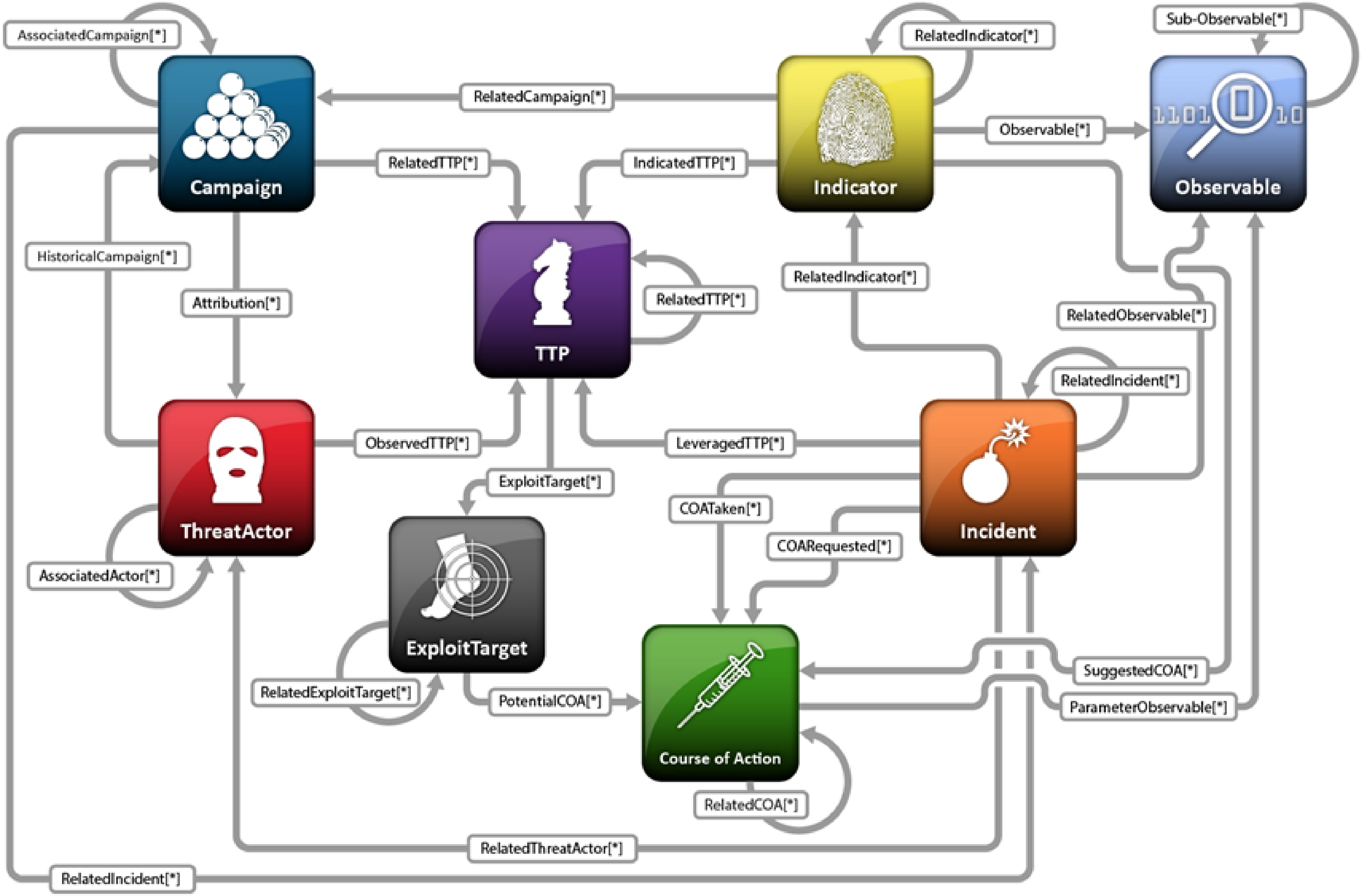
SIEM Rules

Cyber Observable Characterization (CybOX)

- Events
- Stateful Measures

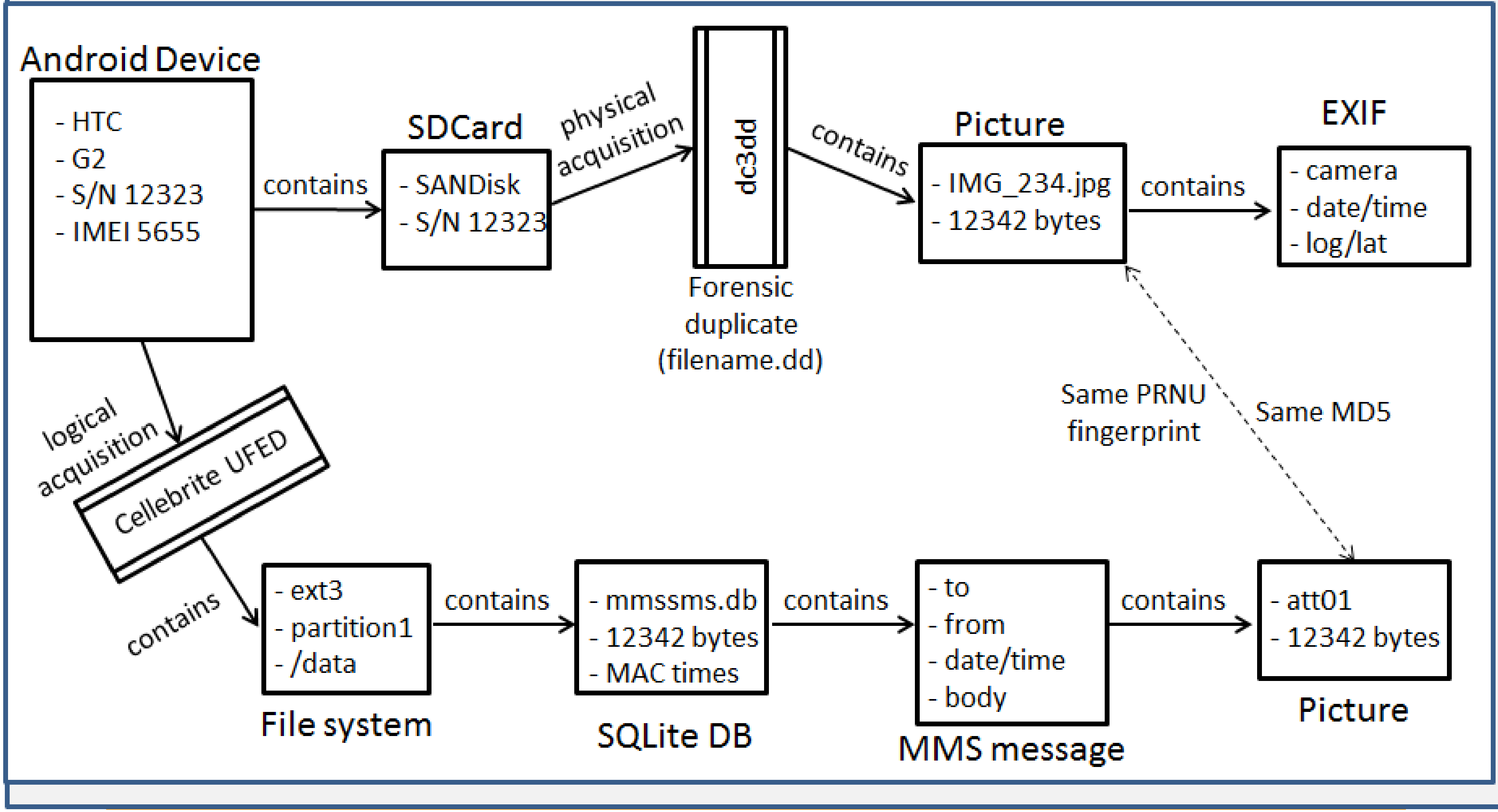
Diverse Sensors

STIX: Structured Threat Information eXpressions



Android Example

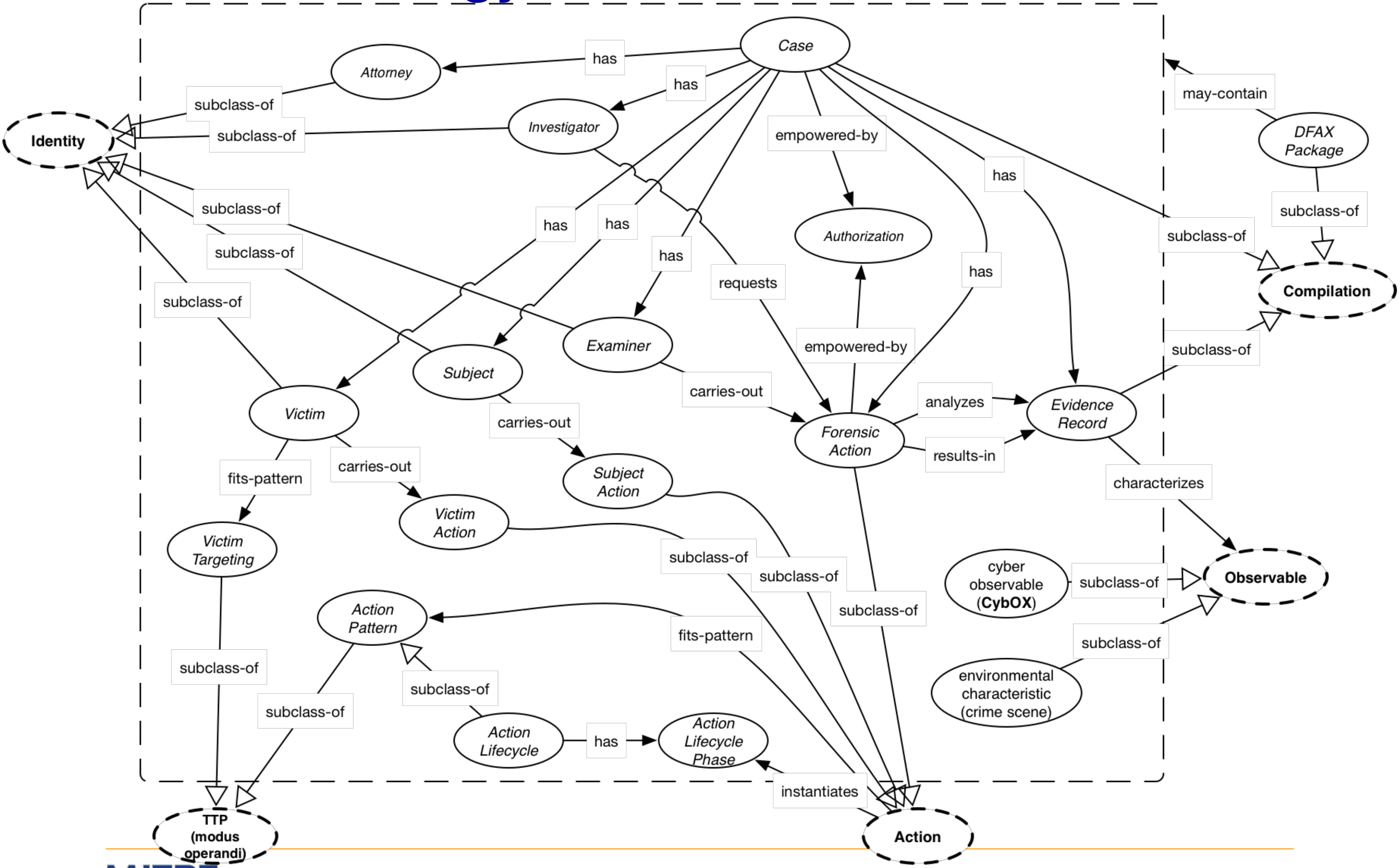
Case Details (reference #, organization, people)



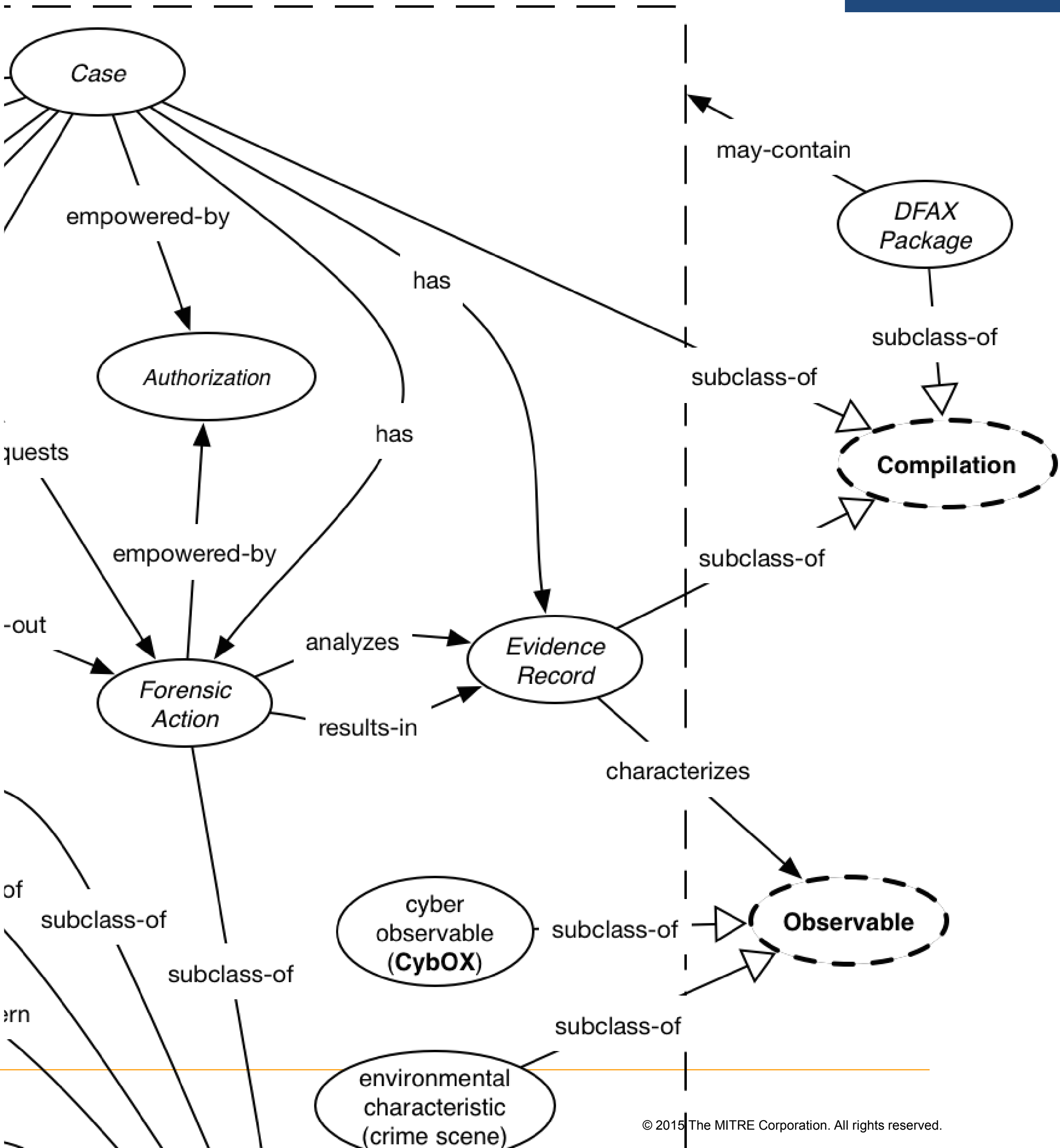
Related Work

	Digital Evidence Bags (DEB)	XIRAF	RDF	Digital Evidence Exchange (DEX)	Digital Forensic XML (DFXML)	AFF4	DFAX
	Turner, 2005	Alink et al, 2006	Schatz, 2007	Levine & Liberatore, 2009	Garfinkel, 2009	Cohen, et al 2009	Open Source (DHS/MITRE)
Open source	Y	N	N/A	Y	Y	Y	Y
Case Information	Y	Y	N	N	N	Y	Y
Integrity assurance	Y	Y	Y	Y	Y	Y	Y
Chain of custody	Y	N	P	N	N	Y	Y
Evidence details	Y	Y	Y	N	N	Y	Y
Tool details	Y	Y	Y	Y	Y	Y	Y
Storage media contents	Y	Y	Y	N	Y	Y	Y
Mobile device contents	Y	Y	N	N	N	N	Y
Assign object multiple types	Y	Y	Y	N	N	Y	Y
Parent-child relationships	Y	Y	Y	Y	Y	N	Y
Non-hierarchical relationships	N	N	Y	N	N	Y	Y
Actions	N	N	Y	N	N	N	Y
Action Lifecycles	N	N	N	N	N	N	Y
Action Patterns	N	N	N	N	N	N	Y

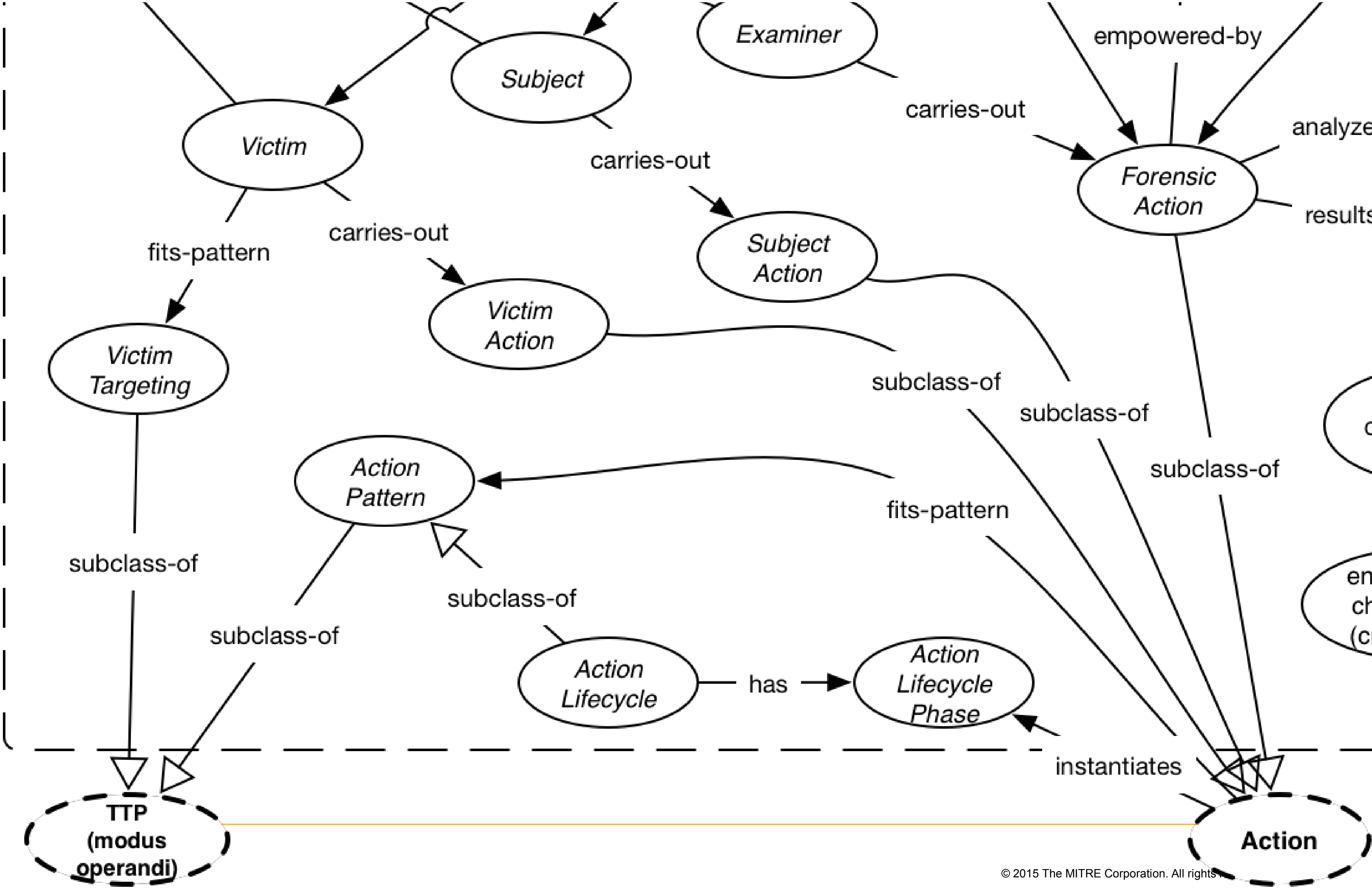
DFAX Ontology



DFAX Ontology



DFAX Ontology



Digital Evidence in CybOX

- **Traces of wiping (Observable or Pattern)**

```
<ProductObj:Product>Secure Delete</ProductObj:Product>

<FileObj:File_Name>sdelete.exe</FileObj:File_Name>
<cybox:Relationship>Characterizes</cybox:Relationship>


<WinRegistryKeyObj:Key>Software\Sysinternal\SDelete</WinRegist
<cybox:Relationship>Created</cybox:Relationship>


<FileObj:File_Name
condition="FitsPattern">Z+.Z+</FileObj:File_Name>
<cybox:Relationship">Renamed_By</cybox:Relationship>
```

Provenance

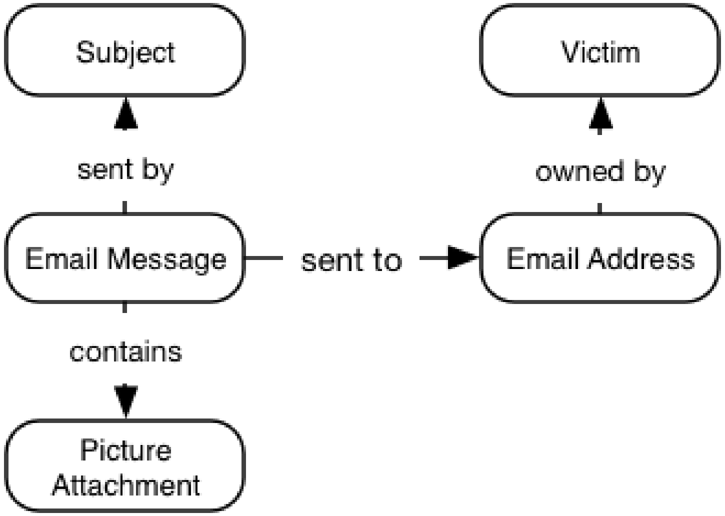
- Evidence source and handling
  - Continuity of possession / Chain of custody

- Evidence processing
  - Tools and transformations

- Evidence analysis
  - Evaluation of source
  - Need to expand CybOX (e.g., PRNU and ENF)

Provenance in DFAX/CybOX

- Evidence source and handling
  - `dfax:Evidence Record`
  - `dfax:Forensic Action`
- Evidence processing
  - `cyboxCommon:Tool`
- Evidence analysis
  - Defined relationships



MITRE

Action Lifecycle: Forensic Process

- **Different groups define process differently**

Forensic Process 1	Forensic Process 2	Forensic Process 3	Forensic Process 4
		Authorization	
	Planning	Planning	Preparation
Identification	Identification	Notification	
Preservation	Reconnaissance	Search	Incident Response
Collection	Transport & Storage	Collection	Data Collection
Examination		Transport	
Analysis	Analysis	Storage	Data Analysis
Presentation	Proof and Defense	Examination	Presentation of Findings
	Archive Storage	Presentation	
		Proof/defense	Incident Closure
		Dissemination	

Action Lifecycle: Subject

Grooming (Sexual Assault)	Kill Chain (Intrusion)
Victim selection	Reconnaissance
Establish trust	Development
Desensitization to sexual activity/abuse	Delivery
Maintain secrecy (persuasion/threats)	Exploitation
Arrange meeting	Configuration
Conceal evidence	Beaconing and C2

Actions {Subject, Victim, System}

- **Action = `USB Device Connected`**
- **Represent & search structured characteristics**

```
FileObj:File_Name = setupapi.log
IN
FileObj:File_Path = C:\Windows\setupapi.log
CONTAINS
cyboxCommon:String_Value =
“\DISK&VEN_KINGSTON&PROD_DATATRAVELER_3.0&REV_PMAP\8606E6D418ABE6077179
FAE&0]
OR
WinRegistryKeyObj:Name = HardwareID
IN
WinRegistryKeyObj:Hive = HKEY_LOCAL_MACHINE
WinRegistryKeyObj:Key = “\SYSTEM\CurrentControlSet\Enum\USBSTOR\
Disk&Ven_Kingston&Prod_DataTraveler_3.0&Rev_PMAP\08606E6D418ABE6077179F
AE&0”
CONTAINS
WinRegistryKeyObj:Data = “USBSTOR\DiskKingstonDataTraveler_3.0PMAP”
```

Note: Plaso

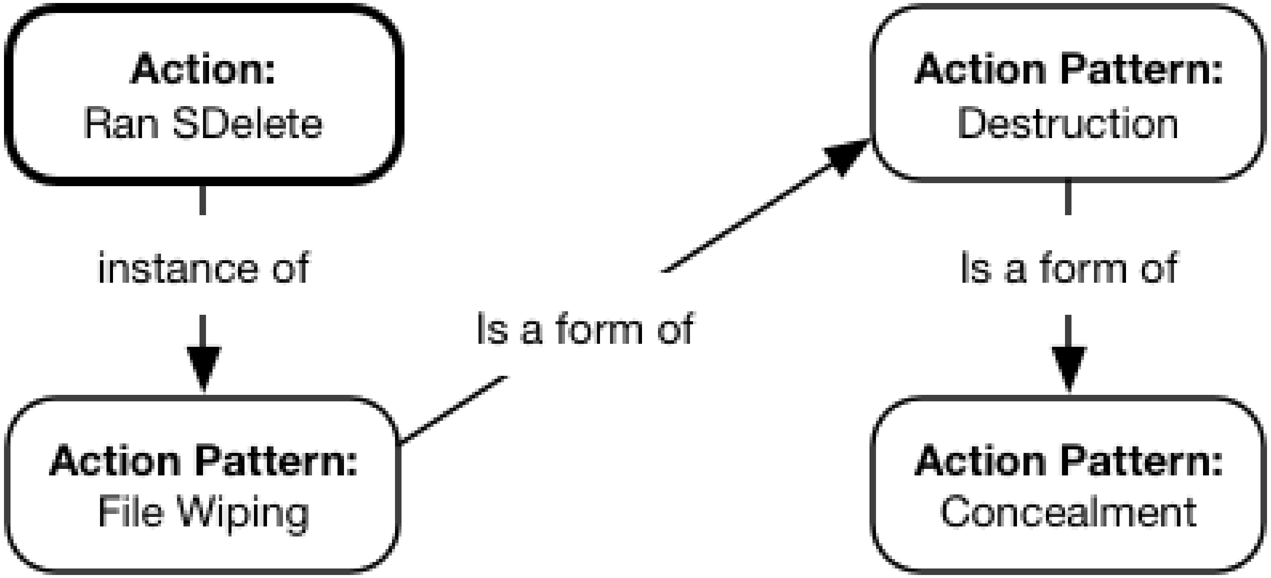
- Categorizes related “events” using “tags”
  - Plaso events map to cybOX:Observables
  - Plaso tags map to dfax:Actions

- Plaso “Application Execution” tag includes:
  - windows:prefetch:execution
  - windows:lnk AND path contains ‘.exe’
  - winreg AND userassist or mru
  - winevt source = Security AND eventID = 592

MITRE

Action Patterns

- Higher level, human understandable terms
  - Reflect behaviors and objectives
  - Assist in establishing modus operandi (a.k.a. TTP)



MITRE

Representing Changes

NIST Diskprint (before and after comparison)

http://www.nsrl.nist.gov/dskprt/DPexample.html

- CybOX Actions
  - Install program
  - Execute program
  - Use program
  - Uninstall program

Next steps

- Community involvement
  - https://github.com/dfax/dfax
- DFAX/CybOX Python library
- Periodic Mobile Forensics
- Plaso
- Abstract concepts common across cyber domains
  - Tools
  - Actions & Action Lifecycle