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Abstract:

The Cyber Observable Expression (CybOX™) is a standardized language for encoding and communicating high-fidelity information about cyber observables, whether dynamic events or stateful measures that are observable in the operational cyber domain. By specifying a common structured schematic mechanism for these cyber observables, the intent is to enable the potential for detailed automatable sharing, mapping, detection, and analysis heuristics. This specification document defines the Win Memory Page Region Object data model, which is one of the Object data models for CybOX content.

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Notices

Table of Contents

1 Introduction

[All text is normative unless otherwise labeled.]

The Cyber Observable Expression (CybOX™) Language provides a common structure for representing cyber observables across and among the operational areas of enterprise cyber security. CybOX improves the consistency, efficiency, and interoperability of deployed tools and processes, and it increases overall situational awareness by enabling the potential for detailed automatable sharing, mapping, detection, and analysis heuristics.

This document serves as the specification for the CybOX Win Memory Page Region Object Version 2.1.1 data model, which is one of eighty-eight CybOX Object data models.

In Section **1.1** we discuss additional specification documents, in Section **1.2** we provide document conventions, and in Section **1.3** we provide terminology. References are given in Section **1.4**. In Section **2**, we give background information necessary to fully understand the Win Memory Page Region Object data model. We present the Win Memory Page Region Object data model specification details in Section **3** and conformance information in Section **4**.

1.1 CybOX™ Specification Documents

The CybOX specification consists of a formal UML model and a set of textual specification documents that explain the UML model. Specification documents have been written for each of the individual data models that compose the full CybOX UML model.

CybOX has a modular design comprising two fundamental data models and a collection of Object data models. The fundamental data models – CybOX Core and CybOX Common – provide essential CybOX structure and functionality. The CybOX Objects, defined in individual data models, are precise characterizations of particular types of observable cyber entities (e.g., HTTP session, Windows registry key, DNS query).

Use of the CybOX Core and Common data models is required; however, use of the CybOX Object data models is purely optional: users select and use only those Objects and corresponding data models that are needed. Importing the entire CybOX suite of data models is not necessary.

The *CybOX™ Version 2.1.1 Part 1: Overview* document provides a comprehensive overview of the full set of CybOX data models, which in addition to the Core, Common, and numerous Object data models, includes various extension data models and a vocabularies data model, which contains a set of default controlled vocabularies. *CybOX™ Version 2.1.1 Part 1: Overview* also summarizes the relationship of CybOX to other languages, and outlines general CybOX data model conventions.

1.2 Document Conventions

The following conventions are used in this document.

1.2.1 Fonts

The following font and font style conventions are used in the document:

- Capitalization is used for CybOX high-level concepts, which are defined in *CybOX™ Version 2.1.1 Part 1: Overview*.

Examples: Action, Object, Event, Property

- The `Courier New` font is used for writing UML objects.

  Examples: `ActionType`, `cyboxCommon:BaseObjectPropertyType`

  Note that all high-level concepts have a corresponding UML object. For example, the Action high-level concept is associated with a UML class named, `ActionType`.

- The '*italic*' font (with single quotes) is used for noting actual, explicit values for CybOX Language properties. The *italic* font (without quotes) is used for noting example values.

  Example: *'HashNameVocab-1.0,' high, medium, low*

1.2.2 UML Package References

Each CybOX data model is captured in a different UML package (e.g., Core package) where the packages together compose the full CybOX UML model. To refer to a particular class of a specific package, we use the format `package_prefix:class`, where `package_prefix` corresponds to the appropriate UML package.

The package_prefix for the Windows Memory Page Region File data model is `WinMemoryPageRegionObj`. Note that in this specification document, we do not explicitly specify the package prefix for any classes that originate from the Win Memory Page Region Object data model.

1.2.3 UML Diagrams

This specification makes use of UML diagrams to visually depict relationships between CybOX Language constructs. Note that the diagrams have been extracted directly from the full UML model for CybOX; they have not been constructed purely for inclusion in the specification documents. Typically, diagrams are included for the primary class of a data model, and for any other class where the visualization of its relationships between other classes would be useful. This implies that there will be very few diagrams for classes whose only properties are either a data type or a class from the CybOX Common data model. Other diagrams that are included correspond to classes that specialize a superclass and abstract or generalized classes that are extended by one or more subclasses.

In UML diagrams, classes are often presented with their attributes elided, to avoid clutter. The fully described class can usually be found in a related diagram. A class presented with an empty section at the bottom of the icon indicates that there are no attributes other than those that are visualized using associations.

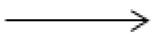
1.2.3.1 Class Properties

Generally, a class property can be shown in a UML diagram as either an attribute or an association (i.e., the distinction between attributes and associations is somewhat subjective). In order to make the size of UML diagrams in the specifications manageable, we have chosen to capture most properties as attributes and to capture only higher-level properties as associations, especially in the main top-level component diagrams. In particular, we will always capture properties of UML data types as attributes.

1.2.3.2 Diagram Icons and Arrow Types

Diagram icons are used in a UML diagram to indicate whether a shape is a class, enumeration, or a data type, and decorative icons are used to indicate whether an element is an attribute of a class or an enumeration literal. In addition, two different arrow styles indicate either a directed association relationship (regular arrowhead) or a generalization relationship (triangle-shaped arrowhead). The icons and arrow styles we use are shown and described in **Table 1-1**.

Table 1-1. UML diagram icons

Icon	Description
	This diagram icon indicates a class. If the name is in italics, it is an abstract class.
	This diagram icon indicates an enumeration.
	This diagram icon indicates a data type.
	This decorator icon indicates an attribute of a class. The green circle means its visibility is public. If the circle is red or yellow, it means its visibility is private or protected.
	This decorator icon indicates an enumeration literal.
	This arrow type indicates a directed association relationship.
	This arrow type indicates a generalization relationship.

1.2.4 Property Table Notation

Throughout Section **3**, tables are used to describe the properties of each data model class. Each property table consists of a column of names to identify the property, a type column to reflect the datatype of the property, a multiplicity column to reflect the allowed number of occurrences of the property, and a description column that describes the property. Package prefixes are provided for classes outside of the Win Memory Page Region Object data model (see Section **1.2.2**).

Note that if a class is a specialization of a superclass, only the properties that constitute the specialization are shown in the property table (i.e., properties of the superclass will not be shown). However, details of the superclass may be shown in the UML diagram.

1.2.5 Property and Class Descriptions

Each class and property defined in CybOX is described using the format, “The X property verb Y.” For example, in the specification for the CybOX Core data model, we write, “The `id` property specifies a globally unique identifier for the Action.” In fact, the verb “specifies” could have been replaced by any number of alternatives: “defines,” “describes,” “contains,” “references,” etc.

However, we thought that using a wide variety of verb phrases might confuse a reader of a specification document because the meaning of each verb could be interpreted slightly differently. On the other hand, we didn’t want to use a single, generic verb, such as “describes,” because although the different verb choices may or may not be meaningful from an implementation standpoint, a distinction could be useful to those interested in the modeling aspect of CybOX.

Consequently, we have preferred to use the three verbs, defined as follows, in class and property descriptions:

Verb	CybOX Definition
captures	Used to record and preserve information without implying anything about the structure of a class or property. Often used for properties that encompass general content. This is the least precise of the three verbs.
	Examples: The `Observable_Source` property characterizes the source of the Observable information. Examples of details captured include identifying characteristics, time-related attributes, and a list of the tools used to collect the information. The `Description` property captures a textual description of the Action.
characterizes	Describes the distinctive nature or features of a class or property. Often used to describe classes and properties that themselves comprise one or more other properties.
	Examples: The `Action` property characterizes a cyber observable Action. The `Obfuscation_Technique` property characterizes a technique an attacker could potentially leverage to obfuscate the Observable.
specifies	Used to clearly and precisely identify particular instances or values associated with a property. Often used for properties that are defined by a controlled vocabulary or enumeration; typically used for properties that take on only a single value.
	Example: The `cybox_major_version` property specifies the major version of the CybOX Language used for the set of Observables.

1.3 Terminology

The key words “MUST”, “MUST NOT”, “REQUIRED”, “SHALL”, “SHALL NOT”, “SHOULD”, “SHOULD NOT”, “RECOMMENDED”, “MAY”, and “OPTIONAL” in this document are to be interpreted as described in **[RFC2119]**.

1.4 Normative References

[RFC2119] Bradner, S., “Key words for use in RFCs to Indicate Requirement Levels”, BCP 14, RFC 2119, March 1997. http://www.ietf.org/rfc/rfc2119.txt.

2 Background Information

In this section, we provide high-level information about the Win Memory Page Region Object data model that is necessary to fully understand the specification details given in Section **3**.

2.1 Cyber Observables

A cyber observable is a dynamic event or a stateful property that occurs, or may occur, in the operational cyber domain. Examples of stateful properties include the value of a registry key, the MD5 hash of a file, and an IP address. Examples of events include the deletion of a file, the receipt of an HTTP GET request, and the creation of a remote thread.

A cyber observable is different than a cyber indicator. A cyber observable is a statement of fact, capturing what was observed or could be observed in the cyber operational domain. Cyber indicators are cyber observable patterns, such as a registry key value associated with a known bad actor or a spoofed email address used on a particular date.

2.2 Objects

Cyber observable objects (Files, IP Addresses, etc) in CybOX are characterized with a combination of two levels of data models.

The first level is the Object data model which specifies a base set of properties universal to all types of Objects and enables them to integrate with the overall cyber observable framework specified in the CybOX Core data model.

The second level are the object property models which specify the properties of a particular type of Object via individual data models each focused on a particular cyber entity, such as a Windows registry key, or an Email Message. Accordingly, each release of the CybOX language includes a particular set of Objects that are part of the release. The data model for each of these Objects is defined by its own specification that describes the context-specific classes and properties that compose the Object.

Any specific instance of an Object is represented utilizing the particular object properties data model within the general Object data model.

3 Data Model

3.1 WindowsMemoryPageRegionObjectType Class

The `WindowsMemoryPageRegionObjectType` class is intended to characterize Windows memory page regions. The UML diagram corresponding to the `WindowsMemoryPageRegionObjectType` class is shown in **Figure 3-1**.

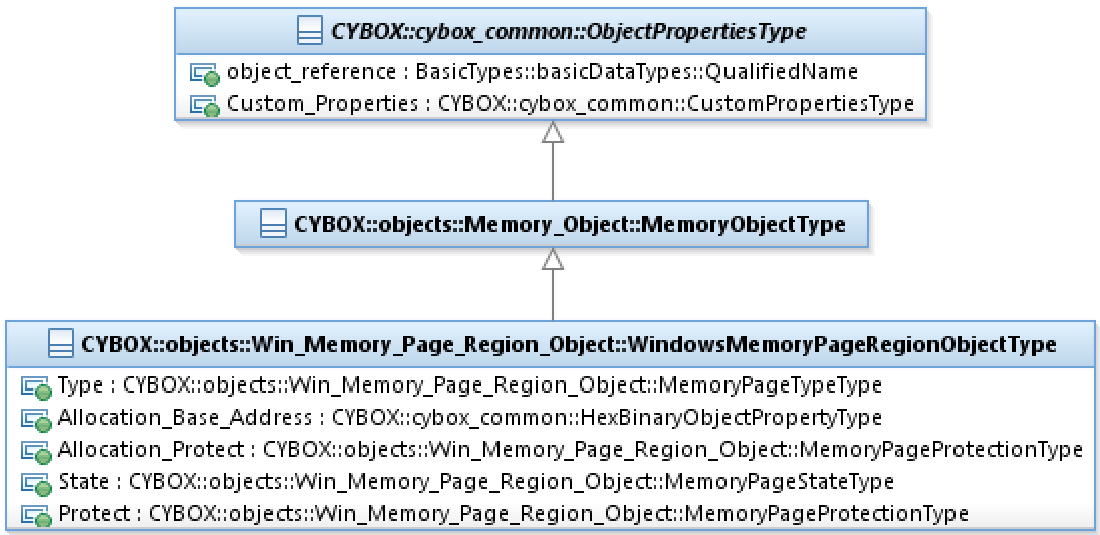


Figure 3-1. UML diagram of the `WindowsMemoryPageRegionObjectType` class

The property table of the `WindowsMemoryPageRegionObjectType` class is given in **Table 3-1**.

Table 3-1. Properties of the `WindowsMemoryPageRegionObjectType` class

Name	Type	Multiplicity	Description
Type	`MemoryPageTypeType`	0..1	The `Type` property specifies the type of pages in the

			memory page region.
Allocation_Base_Address	cyboxCommon: HexBinaryObjectPropertyType	0..1	The Allocation_Base_Address property specifies the base address of the memory page region when the region was first allocated.
Allocation_Protect	MemoryPageProtectionType	0..1	The Allocation_Protect property specifies the memory protection option for the memory page region when the region was initially allocated.
State	MemoryPageStateType	0..1	The State property specifies the state of the memory pages in the region.
Protect	MemoryPageProtectionType	0..1	The Protect property specifies the access protection of the memory pages in the region.

3.2 MemoryPageProtectionType Data Type

The MemoryPageProtectionType data type specifies memory protection constant type. Its core value SHOULD be a literal from the MemoryPageProtectionEnum enumeration. It extends the BaseObjectPropertyType data type, in order to permit complex (i.e., regular-expression based) specifications.

3.3 MemoryPageStateType Data Type

The MemoryPageStateType data type specifies the memory protection state. Its core value SHOULD be a literal from the MemoryPageStateEnum enumeration. It extends the BaseObjectPropertyType data type, in order to permit complex (i.e., regular-expression based) specifications.

3.4 MemoryPageTypeType Data Type

The MemoryPageTypeType data type specifies the memory protection type. Its core value SHOULD be a literal from the MemoryPageTypeEnum enumeration. It extends the BaseObjectPropertyType data type, in order to permit complex (i.e., regular-expression based) specifications.

3.5 MemoryPageProtectionEnum Enumeration

The literals of the `MemoryPageProtectionEnum` enumeration are given in **Table 3-2**.

Also see: https://msdn.microsoft.com/en-us/library/windows/desktop/aa366786%28v=vs.85%29.aspx.

Table 3-2. Literals of the `MemoryPageProtectionEnum` enumeration

Enumeration Literal	Description
PAGE_EXECUTE	Enables execute access to the committed region of pages. An attempt to read from or write to the committed region results in an access violation.
PAGE_EXECUTE_READ	Enables execute or read-only access to the committed region of pages. An attempt to write to the committed region results in an access violation.
PAGE_EXECUTE_READWRITE	Enables execute, read-only, or read/write access to the committed region of pages.
PAGE_EXECUTE_WRITECOPY	Enables execute, read-only, or copy-on-write access to a mapped view of a file mapping object. An attempt to write to a committed copy-on-write page results in a private copy of the page being made for the process. The private page is marked as PAGE_EXECUTE_READWRITE, and the change is written to the new page.
PAGE_NOACCESS	Disables all access to the committed region of pages. An attempt to read from, write to, or execute the committed region results in an access violation.
PAGE_READONLY	Enables read-only access to the committed region of pages. An attempt to write to the committed region results in an access

	violation. If Data Execution Prevention is enabled, an attempt to execute code in the committed region results in an access violation.
PAGE_READWRITE	Enables read-only or read/write access to the committed region of pages. If Data Execution Prevention is enabled, attempting to execute code in the committed region results in an access violation.
PAGE_WRITECOPY	Enables read-only or copy-on-write access to a mapped view of a file mapping object. An attempt to write to a committed copy-on-write page results in a private copy of the page being made for the process. The private page is marked as PAGE_READWRITE, and the change is written to the new page. If Data Execution Prevention is enabled, attempting to execute code in the committed region results in an access violation.

3.6 MemoryPageStateEnum Enumeration

The literals of the `MemoryPageStateEnum` enumeration are given in **Table 3-3**.

Also, see: https://msdn.microsoft.com/en-us/library/windows/desktop/aa366775%28v=vs.85%29.aspx.

Table 3-3. Literals of the `MemoryPageStateEnum` enumeration

Enumeration Literal	Description
MEM_COMMIT	Indicates committed pages for which physical storage has been allocated, either in memory or in the paging file on disk.
MEM_FREE	Indicates free pages not accessible to the calling process and available to be allocated. For free pages, the information in the AllocationBase, AllocationProtect, Protect, and Type members is undefined.

MEM_RESERVE	Indicates reserved pages where a range of the process's virtual address space is reserved without any physical storage being allocated. For reserved pages, the information in the Protect member is undefined.

3.7 MemoryPageTypeEnum Enumeration

The literals of the `MemoryPageTypeEnum` enumeration are given in **Table 3-4**.

Also, see: https://msdn.microsoft.com/en-us/library/windows/desktop/aa366775%28v=vs.85%29.aspx.

Table 3-4. Literals of the `MemoryPageTypeEnum` enumeration

Enumeration Literal	Description
MEM_IMAGE	Indicates that the memory pages within the region are mapped into the view of an image section.
MEM_MAPPED	Indicates that the memory pages within the region are mapped into the view of a section.
MEM_PRIVATE	Indicates that the memory pages within the region are private (that is, not shared by other processes).

4 Conformance

Implementations have discretion over which parts (components, properties, extensions, controlled vocabularies, etc.) of CybOX they implement (e.g., Observable/Object).

[1] Conformant implementations must conform to all normative structural specifications of the UML model or additional normative statements within this document that apply to the portions of CybOX they implement (e.g., implementers of the entire Observable class must conform to all normative structural specifications of the UML model regarding the Observable class or additional normative statements contained in the document that describes the Observable class).

[2] Conformant implementations are free to ignore normative structural specifications of the UML model or additional normative statements within this document that do not apply to the portions of CybOX they implement (e.g., non-implementers of any particular properties of the Observable class are free to ignore all normative structural specifications of the UML model regarding those properties of the Observable class or additional normative statements contained in the document that describes the Observable class).

The conformance section of this document is intentionally broad and attempts to reiterate what already exists in this document.

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