



INTERNATIONAL STANDARD

OPC unified architecture - Part 3: Address Space Model

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

FOREWORD	10
1 Scope	12
2 Normative references	12
3 Terms, definitions, abbreviations and conventions	13
3.1 Terms and definitions	13
3.2 Abbreviated terms	14
3.3 Conventions	14
3.3.1 Conventions for AddressSpace figures	14
3.3.2 Conventions for defining NodeClasses	15
4 AddressSpace concepts	16
4.1 Overview	16
4.2 URIs	17
4.3 Object Model	18
4.4 Node Model	18
4.4.1 General	18
4.4.2 NodeClasses	19
4.4.3 Attributes	19
4.4.4 References	19
4.5 Variables	20
4.5.1 General	20
4.5.2 Properties	20
4.5.3 DataVariables	20
4.6 TypeDefinitionNodes	21
4.6.1 General	21
4.6.2 Complex TypeDefinitionNodes and their InstanceDeclarations	21
4.6.3 Subtyping	22
4.6.4 Instantiation of complex TypeDefinitionNodes	23
4.7 Event Model	24
4.7.1 General	24
4.7.2 EventTypes	24
4.7.3 Event Categorization	25
4.8 Methods	25
4.9 Roles	25
4.9.1 Overview	25
4.9.2 Well Known Roles	26
4.9.3 Evaluating Permissions with Roles	27
4.10 Interfaces and AddIns for Objects	29
4.10.1 Overview	29
4.10.2 Interface Model	29
4.10.3 AddIn model	33
5 Standard NodeClasses	34
5.1 Overview	34
5.2 Base NodeClass	35
5.2.1 General	35
5.2.2 NodeId	35
5.2.3 NodeClass	35

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

5.2.5	DisplayName	36
5.2.6	Description	36
5.2.7	WriteMask	36
5.2.8	UserWriteMask	36
5.2.9	RolePermissions.....	37
5.2.10	UserRolePermissions	38
5.2.11	AccessRestrictions	38
5.3	ReferenceType NodeClass	38
5.3.1	General	38
5.3.2	Attributes.....	39
5.3.3	References.....	41
5.4	View NodeClass.....	41
5.5	Objects	43
5.5.1	Object NodeClass.....	43
5.5.2	ObjectType NodeClass	44
5.5.3	Standard ObjectType FolderType	46
5.5.4	Client-side creation of Objects of an ObjectType	46
5.6	Variables	47
5.6.1	General	47
5.6.2	Variable NodeClass	47
5.6.3	Properties.....	51
5.6.4	DataVariable.....	52
5.6.5	VariableType NodeClass	53
5.6.6	Client-side creation of Variables of an VariableType	55
5.7	Methods.....	55
5.7.1	Method NodeClass	55
5.7.2	HasArgumentDescription ReferenceType.....	59
5.7.3	HasOptionalInputArgumentDescription ReferenceType.....	59
5.8	DataTypes	59
5.8.1	DataType Model	59
5.8.2	Encoding Rules for different kinds of DataTypes.....	60
5.8.3	DataType NodeClass	61
5.8.4	DataTypeEncoding and Encoding Information.....	64
5.9	Summary of Attributes of the NodeClasses	64
6	Type Model for ObjectTypes and VariableTypes	65
6.1	Overview	65
6.2	Definitions	66
6.2.1	InstanceDeclaration	66
6.2.2	Instances without ModellingRules	66
6.2.3	InstanceDeclarationHierarchy	66
6.2.4	Similar Node of InstanceDeclaration	66
6.2.5	BrowsePath.....	66
6.2.6	BrowseName within a TypeDefinitionNode.....	66
6.2.7	Attribute Handling of InstanceDeclarations	66
6.2.8	Attribute Handling of Variable and VariableTypes	67
6.2.9	NodeIds of InstanceDeclarations	67
6.3	Subtyping of ObjectTypes and VariableTypes	67
6.3.1	Overview	67

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

6.3.3	InstanceDeclarations	67
6.4	Instances of ObjectTypes and VariableTypes	72
6.4.1	Overview	72
6.4.2	Creating an Instance	72
6.4.3	Constraints on an Instance	73
6.4.4	ModellingRules	74
6.5	Changing Type Definitions that are already used	82
7	Standard ReferenceTypes	83
7.1	General.....	83
7.2	References ReferenceType.....	83
7.3	HierarchicalReferences ReferenceType	84
7.4	NonHierarchicalReferences ReferenceType	84
7.5	HasChild ReferenceType	84
7.6	Aggregates ReferenceType.....	84
7.7	HasComponent ReferenceType	85
7.8	HasProperty ReferenceType	85
7.9	HasOrderedComponent ReferenceType.....	85
7.10	HasSubtype ReferenceType.....	85
7.11	Organizes ReferenceType	86
7.12	HasModellingRule ReferenceType	86
7.13	HasTypeDefinition ReferenceType.....	86
7.14	HasEncoding ReferenceType.....	86
7.15	GeneratesEvent.....	87
7.16	AlwaysGeneratesEvent	87
7.17	HasEventSource	87
7.18	HasNotifier.....	88
7.19	HasInterface ReferenceType.....	89
7.20	HasAddIn ReferenceType	89
7.21	IsDeprecated ReferenceType.....	90
7.22	HasStructuredComponent ReferenceType	90
7.22.1	Overview	90
7.22.2	Differences between HasStructuredComponent and ExposesItsArray	91
7.23	AssociatedWith ReferenceType	92
8	Standard DataTypes.....	92
8.1	General.....	92
8.2	NodeId.....	92
8.2.1	General	92
8.2.2	NamespaceIndex.....	93
8.2.3	IdType	93
8.2.4	Identifier value.....	94
8.3	QualifiedName	94
8.4	LocaleId.....	94
8.5	LocalizedText	95
8.6	Argument.....	95
8.7	BaseDataType	96
8.8	Boolean	96
8.9	Byte.....	96
8.10	ByteString.....	96

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

8.12	Double	97
8.13	Duration	97
8.14	Enumeration	97
8.15	Float	97
8.16	Guid	97
8.17	Sbyte	97
8.18	IdType	97
8.19	Image	97
8.20	ImageBMP	97
8.21	ImageGIF	98
8.22	ImageJPG	98
8.23	ImagePNG	98
8.24	Integer	98
8.25	Int16	98
8.26	Int32	98
8.27	Int64	98
8.28	TimeZoneDataType	98
8.29	NodeClass	98
8.30	Number	99
8.31	String	99
8.32	Structure	99
8.33	UInteger	99
8.34	UInt16	99
8.35	UInt32	99
8.36	UInt64	99
8.37	UtcTime	100
8.38	XmlElement	100
8.39	EnumValueType	100
8.40	OptionSet	100
8.41	Union	101
8.42	DateString	102
8.43	DecimalString	102
8.44	DurationString	102
8.45	NormalizedString	102
8.46	TimeString	103
8.47	DataTypeDefinition	103
8.48	StructureDefinition	103
8.49	StructureType	104
8.50	EnumDefinition	104
8.51	StructureField	104
8.52	EnumField	105
8.53	AudioDataType	106
8.54	Decimal	106
8.55	PermissionType	106
8.56	AccessRestrictionType	107
8.57	AccessLevelType	108
8.58	AccessLevelExType	108
8.59	EventNotifierType	110

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

8.61	CurrencyUnitType	111
9	Standard EventTypes	112
9.1	General.....	112
9.2	BaseEventType.....	113
9.3	SystemEventType	113
9.4	ProgressEventType.....	113
9.5	AuditEventType	114
9.6	AuditSecurityEventType	115
9.7	AuditChannelEventType.....	115
9.8	AuditOpenSecureChannelEventType	115
9.9	AuditSessionEventType	115
9.10	AuditCreateSessionEventType.....	116
9.11	AuditUrlMismatchEventType	116
9.12	AuditActivateSessionEventType.....	116
9.13	AuditCancelEventType.....	116
9.14	AuditCertificateEventType.....	116
9.15	AuditCertificateDataMismatchEventType.....	116
9.16	AuditCertificateExpiredEventType	116
9.17	AuditCertificateInvalidEventType	116
9.18	AuditCertificateUntrustedEventType.....	116
9.19	AuditCertificateRevokedEventType	117
9.20	AuditCertificateMismatchEventType.....	117
9.21	AuditNodeManagementEventType	117
9.22	AuditAddNodesEventType	117
9.23	AuditDeleteNodesEventType.....	117
9.24	AuditAddReferencesEventType.....	117
9.25	AuditDeleteReferencesEventType.....	117
9.26	AuditUpdateEventType	117
9.27	AuditWriteUpdateEventType	117
9.28	AuditHistoryUpdateEventType	117
9.29	AuditUpdateMethodEventType	117
9.30	DeviceFailureEventType	118
9.31	SystemStatusChangeEventType	118
9.32	ModelChangeEvents	118
9.32.1	General	118
9.32.2	NodeVersion Property	118
9.32.3	Views	118
9.32.4	Event compression	118
9.32.5	BaseModelChangeEventType	119
9.32.6	GeneralModelChangeEventType	119
9.32.7	Guidelines for ModelChangeEvents	119
9.33	SemanticChangeEventType	119
9.33.1	General	119
9.33.2	ViewVersion and NodeVersion Properties.....	119
9.33.3	Views	120
9.33.4	Event compression	120
Annex A (informative)	How to use the Address Space Model	121
A.1	Overview	121

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

A.3	ObjectTypes	121
A.4	VariableTypes	122
A.4.1	General	122
A.4.2	Properties or DataVariables	122
A.4.3	Many Variables and / or Structured DataTypes	122
A.5	Views	123
A.6	Methods	123
A.7	Defining ReferenceTypes	123
A.8	Defining ModellingRules	123
Annex B	(informative) OPC UA Meta Model in UML	124
B.1	Background	124
B.2	Notation	124
B.3	Meta Model	125
B.3.1	Base	125
B.3.2	ReferenceType	126
B.3.3	Predefined ReferenceTypes	127
B.3.4	Attributes	127
B.3.5	Object and ObjectType	128
B.3.6	EventNotifier	129
B.3.7	Variable and VariableType	129
B.3.8	Method	130
B.3.9	DataType	131
B.3.10	View	132
Annex C	(normative) Graphical notation	133
C.1	General	133
C.2	Notation	133
C.2.1	Overview	133
C.2.2	Simple notation	133
C.2.3	Extended notation	135
Bibliography	138
Figure 1	– AddressSpace Node diagrams	15
Figure 2	– OPC UA Object Model	18
Figure 3	– AddressSpace Node Model	19
Figure 4	– Reference Model	20
Figure 5	– Example of a Variable defined by a VariableType	21
Figure 6	– Example of a Complex TypeDefinition	22
Figure 7	– Object and its Components defined by an ObjectType	23
Figure 8	– Examples of Interfaces	31
Figure 9	– Example: Interface application to an ObjectType	31
Figure 10	– Example: One Interface applied to an ObjectType another one to the instance	32
Figure 11	– Example: Interface Hierarchy	32
Figure 12	– Example of AddIn with default BrowseName	33
Figure 13	– Example of AddIn applied to an instance	34
Figure 14	– Permissions in the Address Space	38

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

Figure 16 – Method Metadata Example	58
Figure 17 – Variables, VariableTypes and their DataTypes	59
Figure 18 – DataType Model.....	60
Figure 19 – Example of DataType Modelling	64
Figure 20 – Subtyping TypeDefinitionNodes.....	68
Figure 21 – The Fully-Inherited InstanceDeclarationHierarchy for BetaType	71
Figure 22 – An Instance and its TypeDefinitionNode	72
Figure 23 – Example for several References between InstanceDeclarations	74
Figure 24 – Example on changing instances based on InstanceDeclarations	75
Figure 25 – Example on changing InstanceDeclarations based on an InstanceDeclaration	76
Figure 26 – Use of the Standard ModellingRule Mandatory.....	77
Figure 27 – Example using the Standard ModellingRules Optional and Mandatory.....	78
Figure 28 – Example on using ExposesItsArray	79
Figure 29 – Complex example on using ExposesItsArray	79
Figure 30 – Example using OptionalPlaceholder with an Object and Variable	80
Figure 31 – Example using OptionalPlaceholder with a Method.....	81
Figure 32 – Example on using MandatoryPlaceholder for Object and Variable	82
Figure 33 – Standard ReferenceType Hierarchy.....	83
Figure 34 – Event Reference Example	88
Figure 35 – Complex Event Reference Example	89
Figure 36 – Example of using HasStructuredComponent ReferencyType	91
Figure 37 – Difference between HasStructuredComponent and ExposesItsArray	92
Figure 38 – Standard EventType Hierarchy.....	113
Figure 39 – Audit Behaviour of a Server	114
Figure 40 – Audit Behaviour of an Aggregating Server.....	115
Figure B.1 – Background of OPC UA Meta Model	124
Figure B.2 – Notation (I)	124
Figure B.3 – Notation (II)	125
Figure B.4 – Base	126
Figure B.5 – Reference and ReferenceType	126
Figure B.6 – Predefined ReferenceTypes.....	127
Figure B.7 – Attributes	128
Figure B.8 – Object and ObjectType	129
Figure B.9 – EventNotifier.....	129
Figure B.10 – Variable and VariableType.....	130
Figure B.11 – Method	131
Figure B.12 – DataType	131
Figure B.13 – View	132
Figure C.1 – Example of a Reference connecting two Nodes	134
Figure C.2 – Example of using a TypeDefinition inside a Node	136
Figure C.3 – Example of exposing Attributes.....	136

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

Table 1 – NodeClass Table Conventions	15
Table 2 – Well-Known Roles	26
Table 3 – Example Roles	27
Table 4 – Example Nodes	28
Table 5 – Example Role Assignment.....	28
Table 6 – Examples of Evaluating Access.....	28
Table 7 – Base NodeClass.....	35
Table 8 – RolePermissionType	37
Table 9 – ReferenceType NodeClass	39
Table 10 – View NodeClass	42
Table 11 – Object NodeClass	43
Table 12 – ObjectType NodeClass	45
Table 13 – Variable NodeClass.....	47
Table 14 – VariableType NodeClass	53
Table 15 – Method NodeClass	56
Table 16 – DataType NodeClass.....	62
Table 17 – Overview of Attributes	65
Table 18 – The InstanceDeclarationHierarchy for BetaType.....	69
Table 19 – The Fully-Inherited InstanceDeclarationHierarchy for BetaType.....	70
Table 20 – Rule for ModellingRules Properties when Subtyping.....	75
Table 21 – NodeId Definition.....	92
Table 22 – IdType Values	93
Table 23 – NodeId Alternative Null Values	94
Table 24 – QualifiedName Definition.....	94
Table 25 – LocaleId Examples	95
Table 26 – LocalizedText Definition	95
Table 27 – Argument Definition.....	96
Table 28 – TimeZoneDataType Definition	98
Table 29 – NodeClass Values.....	99
Table 30 – EnumValueType Definition	100
Table 31 – OptionSet Definition	101
Table 32 – StructureDefinition Structure	103
Table 33 – StructureType Values	104
Table 34 – EnumDefinition Structure.....	104
Table 35 – StructureField Structure	104
Table 36 – EnumField Structure.....	105
Table 37 – PermissionType Definition.....	106
Table 38 – AccessRestrictionType Definition	108
Table 39 – AccessLevelType Definition.....	108
Table 40 – Use Cases of Constant and NonVolatile Fields.....	109
Table 41 – AccessLevelExType Definition.....	109

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

Table 43 – Bit mask for WriteMask and UserWriteMask	110
Table 44 – CurrencyUnitType Definition	111
Table C.1 – Notation of Nodes depending on the NodeClass	133
Table C.2 – Simple Notation of Nodes depending on the NodeClass.....	135
Table C.3 – Extended Notation of Reference Cardinality.....	137

OPC unified architecture - Part 3: Address Space Model

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62541-3 has been prepared by subcommittee 65E: Devices and integration in enterprise systems, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2020. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) addition of the concept and modelling elements for Interfaces and AddIns;
- b) addition of Currency;
- c) addition of Method Meta Data to define additional attributes for Method Arguments;
- d) addition of ApplyRestrictionToBrowse bit to AccessRestrictionType;
- e) addition of a Non-Volatile Storage bit to AccessLevelExType;

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

- g) the View NodeClass has been changed to define the EventNotifier as an EventNotifierType in the same way the Object NodeClass defines it;
- h) correction of HasNotifier, HasEventSource, and Organizes, to include ObjectType as valid source node;
- i) NamingRules have become deprecated;
- j) addition of AssociatedWith ReferenceType.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65E/1061/CDV	65E/1128/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

Throughout this document and the other parts of the IEC 62541 series, certain document conventions are used:

Italics are used to denote a defined term or definition that appears in the "Terms and definitions" clause in one of the parts of the IEC 62541 series.

Italics are also used to denote the name of a service input or output parameter or the name of a structure or element of a structure that are usually defined in tables.

The *italicized terms and names* are, with a few exceptions, written in camel-case (the practice of writing compound words or phrases in which the elements are joined without spaces, with each element's initial letter capitalized within the compound). For example, the defined term is *AddressSpace* instead of Address Space. This makes it easier to understand that there is a single definition for *AddressSpace*, not separate definitions for Address and Space.

A list of all parts in the IEC 62541 series, published under the general title *OPC Unified Architecture*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. [Click here to purchase the full version from the ANSI store.](#)

This part of IEC 62541 describes the OPC Unified Architecture (OPC UA) *AddressSpace* and its *Objects*. This specification is the OPC UA meta model on which OPC UA information models are based.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62541-1, *OPC Unified Architecture – Part 1: Overview and Concepts*

IEC 62541-4, *OPC Unified Architecture – Part 4: Services*

IEC 62541-5, *OPC Unified Architecture – Part 5: Information Model*

IEC 62541-6, *OPC Unified Architecture – Part 6: Mappings*

IEC 62541-8, *OPC Unified Architecture – Part 8: Data Access*

IEC 62541-11, *OPC Unified Architecture – Part 11: Historical Access*

IEC 62541-18, *OPC Unified Architecture – Part 18: Role-Based Security*

IEC 62541-21, *OPC Unified Architecture – Part 21: Device Onboarding*

ISO 639 (all parts), *Codes for the representation of names of languages*

ISO 3166 (all parts), *Codes for the representation of names of countries and their subdivisions*

ISO 4217, *Codes for the representation of currencies*

ISO 8601-1:2019, *Date and time – Representations for information interchange – Part 1: Basic rules*

ISO/IEC/IEEE 60559:2020, *Information technology – Microprocessor Systems – Floating-Point arithmetic*

IETF RFC 3986, Berners-Lee T., Fielding R. and Masinter L., “Uniform Resource Identifier (URI): Generic Syntax”, January 2005, available at <https://www.ietf.org/rfc/rfc3986.txt>

IETF RFC 4151, Kindberg T. and Hawke S., “The 'tag' URI Scheme”, October 2005, available at <https://datatracker.ietf.org/doc/html/rfc4151>

IETF RFC 5646, Davis M. and Phillips A., “Tags for Identifying Languages”, September 2009, available at <http://tools.ietf.org/html/rfc5646>

Unicode Annex 15, *Unicode Standard Annex #15: Unicode Normalization Forms*
<http://www.unicode.org/reports/tr15/>

W3C XML Schema Definition Language (XSD) Part 2, DataTypes
<http://www.w3.org/TR/xmlschema-2>

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. Click here to purchase the full version from the ANSI store.

<https://www.unicode.org/charts/PDF/U0000.pdf>

Unicode C1 Controls and Latin-1 Supplement:

<https://www.unicode.org/charts/PDF/U0080.pdf><https://www.unicode.org/Public/UCD/latest/ucd/PropList.txt>

This is a preview of IEC 62541-3 Ed. 4.0 en:2025. Click [here](#) to purchase the full version from the ANSI store.

[GH95] Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides, *Design Patterns – Elements of Reusable Object-Oriented Software*, Addison-Wesley 1995
<https://www.oreilly.com/library/view/design-patterns-elements/0201633612/>

[FF04] Eric Freeman, Elisabeth Freeman, Kathy Sierra, Bert Bates, *Head First Design Patterns*, O'Reilly, 2004
<https://www.oreilly.com/library/view/head-first-design/0596007124/>
