

# TECHNICAL REPORT



---

## OPC unified architecture – Part 2: Security Model

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 25.040.40; 35.100.01

ISBN 978-2-8322-9077-4

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD .....	5
1 Scope .....	7
2 Normative references .....	7
3 Terms, definitions, and abbreviated terms .....	8
3.1 Terms and definitions .....	8
3.2 Abbreviated terms .....	13
4 OPC UA security architecture .....	13
4.1 OPC UA security environment .....	13
4.2 Security objectives .....	14
4.2.1 Overview .....	14
4.2.2 Authentication .....	15
4.2.3 Authorization .....	15
4.2.4 Confidentiality .....	15
4.2.5 Integrity .....	15
4.2.6 Non-Repudiation .....	15
4.2.7 Auditability .....	15
4.2.8 Availability .....	15
4.3 Security threats to OPC UA systems .....	15
4.3.1 Overview .....	15
4.3.2 Denial of Service .....	16
4.3.3 Eavesdropping .....	17
4.3.4 Message spoofing .....	17
4.3.5 Message alteration .....	17
4.3.6 Message replay .....	17
4.3.7 Malformed Messages .....	18
4.3.8 Server profiling .....	18
4.3.9 Session hijacking .....	18
4.3.10 Rogue Server .....	18
4.3.11 Rogue Publisher .....	18
4.3.12 Compromising user credentials .....	19
4.3.13 Repudiation .....	19
4.4 OPC UA relationship to site security .....	19
4.5 OPC UA security architecture .....	20
4.5.1 Overview .....	20
4.5.2 Client / Server .....	21
4.5.3 Publish-Subscribe .....	22
4.6 SecurityPolicies .....	23
4.7 Security Profiles .....	24
4.8 Security Mode Settings .....	24
4.9 User Authentication .....	24
4.10 Application Authentication .....	24
4.11 User Authorization .....	25
4.12 Roles .....	25
4.13 OPC UA security related Services .....	25
4.14 Auditing .....	26
4.14.1 General .....	26

- 4.14.2 Single Client and Server ..... 27
- 4.14.3 Aggregating Server ..... 28
- 4.14.4 Aggregation through a non-auditing Server ..... 28
- 4.14.5 Aggregating Server with service distribution ..... 29
- 5 Security reconciliation ..... 30
  - 5.1 Reconciliation of threats with OPC UA security mechanisms ..... 30
    - 5.1.1 Overview ..... 30
    - 5.1.2 Denial of Service ..... 31
    - 5.1.3 Eavesdropping ..... 32
    - 5.1.4 Message spoofing ..... 32
    - 5.1.5 Message alteration ..... 33
    - 5.1.6 Message replay ..... 33
    - 5.1.7 Malformed Messages ..... 33
    - 5.1.8 Server profiling ..... 33
    - 5.1.9 Session hijacking ..... 33
    - 5.1.10 Rogue Server or Publisher ..... 34
    - 5.1.11 Compromising user credentials ..... 34
    - 5.1.12 Repudiation ..... 34
  - 5.2 Reconciliation of objectives with OPC UA security mechanisms ..... 34
    - 5.2.1 Overview ..... 34
    - 5.2.2 Application Authentication ..... 34
    - 5.2.3 User Authentication ..... 35
    - 5.2.4 Authorization ..... 35
    - 5.2.5 Confidentiality ..... 35
    - 5.2.6 Integrity ..... 35
    - 5.2.7 Auditability ..... 35
    - 5.2.8 Availability ..... 36
- 6 Implementation and deployment considerations ..... 36
  - 6.1 Overview ..... 36
  - 6.2 Appropriate timeouts ..... 36
  - 6.3 Strict Message processing ..... 36
  - 6.4 Random number generation ..... 37
  - 6.5 Special and reserved packets ..... 37
  - 6.6 Rate limiting and flow control ..... 37
  - 6.7 Administrative access ..... 37
  - 6.8 Cryptographic Keys ..... 38
  - 6.9 Alarm related guidance ..... 38
  - 6.10 Program access ..... 38
  - 6.11 Audit event management ..... 39
  - 6.12 OAuth2, JWT and User roles ..... 39
  - 6.13 HTTPs, SSL/TLS & Websockets ..... 39
  - 6.14 Reverse Connect ..... 39
- 7 Unsecured Services ..... 40
  - 7.1 Overview ..... 40
  - 7.2 Multicast Discovery ..... 40
  - 7.3 Global Discovery Server Security ..... 40
    - 7.3.1 Overview ..... 40
    - 7.3.2 Rogue GDS ..... 40
    - 7.3.3 Threats against a GDS ..... 41

7.3.4	Certificate management threats .....	41
8	Certificate management.....	42
8.1.1	Overview .....	42
8.1.2	Self-signed certificate management .....	42
8.1.3	CA Signed Certificate management .....	43
8.1.4	GDS Certificate Management .....	44
	Bibliography.....	47
	Figure 1 – OPC UA network example .....	14
	Figure 2 – OPC UA security architecture – Client / Server .....	20
	Figure 3 – OPC UA security architecture – Publisher-Subscriber .....	21
	Figure 4 – Role overview .....	25
	Figure 5 – Simple Servers.....	27
	Figure 6 – Aggregating Servers .....	28
	Figure 7 – Aggregation with a non-auditing Server .....	29
	Figure 8 – Aggregate Server with service distribution.....	30
	Figure 9 – Manual Certificate handling .....	42
	Figure 10 – CA Certificate handling .....	43
	Figure 11 – Certificate handling .....	45
	Table 1 – Security Reconciliation Threats Summary .....	31

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**OPC UNIFIED ARCHITECTURE –****Part 2: Security 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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 62541-2, which is a technical report, has been prepared by subcommittee 65E: Devices and integration in enterprise systems, of IEC technical committee 65: Industrial-process measurement, control and automation.

This third edition cancels and replaces the second edition of IEC TR 62541-2, published in 2016. This edition constitutes a technical revision.

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

- a) protection-targets definition change;
- b) threat type clarifications;
- c) expanded best practices;

- d) added Websockets;
- e) added Pub/Sub.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
65E/679/DTR	65E/703/RVDR

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

Throughout this document and the referenced other Parts of the series, certain document conventions are used:

Italics are used to denote a defined term or definition that appears in the “Terms and definition” clause in one of the parts of the 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 also often 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 of 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 publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

# OPC UNIFIED ARCHITECTURE –

## Part 2: Security Model

### 1 Scope

This part of IEC 62541 describes the OPC Unified Architecture (OPC UA) security model. It describes the security threats of the physical, hardware, and software environments in which OPC UA is expected to run. It describes how OPC UA relies upon other standards for security. It provides definition of common security terms that are used in this and other parts of the OPC UA specification. It gives an overview of the security features that are specified in other parts of the OPC UA specification. It references services, mappings, and *Profiles* that are specified normatively in other parts of the OPC UA Specification. It provides suggestions or best practice guidelines on implementing security. Any seeming ambiguity between this part and one of the other normative parts does not remove or reduce the requirement specified in the other normative part.

It is important to understand that there are many different aspects of security that have to be addressed when developing applications. However, since OPC UA specifies a communication protocol, the focus is on securing the data exchanged between applications. This does not mean that an application developer can ignore the other aspects of security like protecting persistent data against tampering. It is important that the developers look into all aspects of security and decide how they can be addressed in the application.

This part is directed to readers who will develop OPC UA *Client* or *Server* applications or implement the OPC UA services layer. It is also for end Users that wish to understand the various security features and functionality provided by OPC UA. It also offers some suggestions that can be applied when deploying systems. These suggestions are generic in nature since the details would depend on the actual implementation of the *OPC UA Applications* and the choices made for the site security.

### 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 TR 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 62541-7, *OPC Unified Architecture – Part 7: Profiles*

IEC 62541-12, *OPC Unified Architecture – Part 12: Discovery and Global Services*

IEC 62541-14, *OPC Unified Architecture – Part 14: PubSub*

IEC 62351 (all parts), *Power systems management and associated information exchange*