

DIN SPEC 92222:2021-12 (E)

Reference architecture for Industrial Cloud Federation; Text in English

| Contents | | Page |
|--|--|-------------|
| Foreword | | 5 |
| Introduction..... | | 7 |
| 1 Scope..... | | 8 |
| 2 Normative references | | 8 |
| 3 Terms and definitions..... | | 9 |
| 4 Abbreviated terms | | 11 |
| 5 Conceptual structure of the document..... | | 11 |
| 5.1 General..... | | 11 |
| 5.2 Elements and relations..... | | 12 |
| 5.2.1 Conceptual model for Industrial Cloud Federation..... | | 12 |
| 5.2.2 Reference Architecture Model for Industrial Cloud Federation | | 12 |
| 5.2.3 Reference Architecture for Industrial Cloud Federation | | 12 |
| 6 Conceptual Model for Industrial Cloud Federation..... | | 13 |
| 6.1 General..... | | 13 |
| 6.2 Elements and relations..... | | 13 |
| 6.2.1 General..... | | 13 |
| 6.3 Requirements | | 14 |
| 6.3.1 General..... | | 14 |
| 6.3.2 Interoperability | | 14 |
| 6.3.3 Scalability and flexibility | | 14 |
| 6.3.4 Shareability | | 14 |
| 6.3.5 Connectivity | | 14 |
| 6.3.6 Resilience..... | | 14 |
| 6.3.7 Configurability | | 14 |
| 6.3.8 Security and integrity..... | | 15 |
| 7 Reference Architecture Model for Industrial Cloud Federation | | 15 |
| 7.1 General..... | | 15 |
| 7.2 RAMI 4.0 derivation | | 15 |
| 7.3 Hierarchy Level perspective | | 16 |
| 7.4 Life cycle and value stream perspective | | 17 |
| 7.5 Layer perspective..... | | 17 |
| 7.6 Usage perspective | | 17 |
| 8 Reference Architecture for Industrial Cloud Federation | | 19 |
| 8.1 General..... | | 19 |
| 8.2 Architectural requirements..... | | 19 |
| 8.2.1 Interoperability related requirements | | 19 |
| 8.2.2 Connectivity related requirements | | 20 |
| 8.2.3 Configuration related requirements..... | | 20 |
| 8.2.4 Security and integrity..... | | 21 |
| 8.3 Communication patterns | | 21 |
| 8.3.1 General..... | | 21 |
| 8.3.2 Communication patterns | | 22 |
| 8.3.3 Application of communication patterns in ICF | | 23 |
| 8.4 Architectural patterns of ICF | | 24 |

| | | |
|---------------------------------------|--|----|
| 8.4.1 | General | 24 |
| 8.4.2 | Edge-to-one-to-many clouds communication | 24 |
| 8.4.3 | Edge-to-many_clouds communication brokering..... | 25 |
| 8.4.4 | Combining architectural patterns | 26 |
| 9 | Outlook..... | 29 |
| Annex A (informative) Icon set..... | | 31 |
| Annex B (informative) Use cases | | 33 |
| B.1 | Data as a service — order data access [Expleo]..... | 33 |
| B.1.1 | Activity “Order data access at machine-building company” | 33 |
| B.2 | Reconfiguration of production processes in a micro-flow cell [Fraunhofer IPA]..... | 35 |
| B.2.1 | Activity “operating the cell to plan and execute production orders” | 35 |
| B.3 | Monitoring of humidity in a production hall (Fraunhofer IPA) | 36 |
| B.3.1 | Activity “setup and operate monitoring” | 36 |
| B.4 | Robot systems in a pay per use / predictive maintenance scenario [Fujitsu] | 38 |
| B.4.1 | Activity „installation and setup of robots“ | 38 |
| B.5 | Seamless approach for condition monitoring systems [SCHAEFFLER]..... | 39 |
| B.5.1 | Activity „installation and setup of condition monitoring system“ | 39 |
| B.6 | Robotic edge/cloud-2-cloud [SCHAEFFLER] | 41 |
| B.6.1 | Activity “installation and setup of AGV” | 41 |
| B.7 | Verification as a service [TÜV SÜD]..... | 42 |
| B.7.1 | Activity „verify safety certificates“ | 42 |
| B.8 | Condition monitoring for smart products [Wittenstein]..... | 44 |
| B.8.1 | Threshold monitoring and alerting..... | 44 |
| B.8.2 | Update condition monitoring threshold values | 45 |
| B.9 | Monitoring of component quality (Fraunhofer IGCV) | 47 |
| B.9.1 | Activity „monitoring during production“ | 47 |
| Bibliography | | 49 |

Figures

| | | |
|-----------|--|----|
| Figure 1 | — Overview of stakeholders and major building blocks of this document | 8 |
| Figure 2 | — Overall conceptual structure for Industrial Cloud Federation | 12 |
| Figure 3 | — Elements of Conceptual Model for Industrial Cloud Federation | 13 |
| Figure 4 | — Derivation of RAM4ICF from RAMI 4.0 | 16 |
| Figure 5 | — RAMI 4.0 life cycle & value stream axis | 17 |
| Figure 6 | — System under consideration “Industrial Cloud Federation” and its stakeholders..... | 18 |
| Figure 7 | — Industrial Cloud Federation implementation with multicast communication pattern..... | 23 |
| Figure 8 | — Industrial Cloud Federation implementation with unicast and request response communication pattern..... | 24 |
| Figure 9 | — Edge-to-one-to-many_clouds communication..... | 25 |
| Figure 10 | — Edge-to-many clouds exemplified by two edge computing entities and two supplier’s service platforms..... | 26 |
| Figure 11 | — Example for a combination of the edge-to-one-to-many clouds und edge-to-one cloud | 27 |

| | |
|--|-----------|
| Figure 12 — Transparent communication through ICF | 28 |
| Figure 13 — Standardization of end-to-end communication in ICF | 29 |
| Figure B.1 — Usage viewpoint of the use case “data as a service” | 34 |
| Figure B.2 — Usage Viewpoint of the use case “reconfiguration of production processes in a micro-flow cell” | 36 |
| Figure B.3 — Usage Viewpoint of the use case “Monitoring of humidity in a production hall” | 38 |
| Figure B.4 — Usage Viewpoint of the use case “seamless approach for condition monitoring systems” | 40 |
| Figure B.5 — Usage Viewpoint of the use case “robotic edge/cloud-2-cloud” | 42 |
| Figure B.6 — Usage Viewpoint of the use case “verification as a service” (direct connection variant) | 43 |
| Figure B.7 — Usage Viewpoint of the use case “condition monitoring for smart products — threshold monitoring and alerting” | 45 |
| Figure B.8 — Usage Viewpoint of the use case “condition monitoring for smart products — update condition monitoring threshold values” | 46 |
| Figure B.9 — Usage Viewpoint of the use case “monitoring of component quality” | 48 |

Tables

| | |
|--|-----------|
| Table 1 — Main roles involved in using an ICF in production state | 19 |
| Table 2 — Overview of basic communication patterns in ICF | 22 |
| Table A.1 — Overview and description of the used icon set | 31 |