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Zero-touch network and Service Management (ZSM); Closed-Loop Automation; Part 1: Enablers

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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Zero-touch network and Service Management (ZSM).

The present document is part 1 of a multi-part deliverable covering Closed-Loop Automation (CLA) based on the ZSM architectural framework, as identified below:

Part 1: "Enablers";

Part 2: "Solutions for automation of E2E service and network management use cases";

Part 3: "Advanced topics".

Full details of the entire series can be found in clause 4.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The present document describes enablers for Closed-Loop Automation (CLA) based on the ZSM architectural framework. The present document initially specifies Closed Loop-specific requirements and introduces Closed Loops within the ZSM framework, from both functional and deployment perspectives. The specifications include enablers for Closed Loop Governance (CLG), covering the definitions of Closed Loop lifecycle management as well as Closed Loop models. Such enablers allow automatic deployment and configuration of Closed Loops involving both the end-to-end service management domain and the individual management domains. Then, the present document specifies enablers for Closed Loops coordination within the ZSM framework, including means for delegation and escalation between Closed Loops as well as other coordination means. Finally, the deliverable specifies stage-2 generic enablers for Closed-Loop Automation (CLA) and includes new management services in addition to those identified in ETSI GS ZSM 002 [2]. Closed loops running entirely within the managed entities are out-of-scope.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI GS ZSM 001: "Zero-touch network and Service Management (ZSM); Requirements based on documented scenarios".

[2] ETSI GS ZSM 002: "Zero-touch network and Service Management (ZSM); Reference Architecture".

[3] ETSI GS ZSM 007: "Zero-touch network and Service Management (ZSM); Terminology for concepts in ZSM".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI GS ZSM 009-2: "Zero-touch network and Service Management (ZSM); Closed-loop automation; Part 2: Solutions for automation of E2E service and network management use cases".

[i.2] ETSI GR ZSM 009-3: "Zero-touch network and Service Management (ZSM); Closed-loop automation; Part 3: Advanced topics".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI GS ZSM 007 [3] and the following apply:

delegation: action taken by a ZSM entity to assign responsibility for one or more goals to one or more other ZSM entities within stated limits

NOTE 1: Delegation defines the operation autonomy the receiving ZSM entity may use to achieve the assigned goal(s) and defines conditions for escalation (i.e. to address situations leading to breach in operation autonomy).

NOTE 2: Delegation is often combined with the concept of escalation in the context of operation autonomy. Operation autonomy is a central concept in Closed-Loop Automation (see clause 7 of ETSI GS ZSM 002 [2]).

NOTE 3: Delegation can define the escalation entity or entities.

NOTE 4: Delegation relies on acknowledgment by the receiving entity, and may contain a phase of negotiation between the entity that originates the delegation and the entity/entities that receive the delegation (e.g. if the receiving entity can achieve, entirely, partly, or not the delegated goal).

escalation: action taken by a ZSM entity to inform one or more ZSM entities about a breach in its operation autonomy

NOTE 1: A ZSM entity escalates an issue that prevents it from achieving its goal properly, and that is not solvable with means under its control. An escalation differs from other types of issue or problem reporting in the sense that an escalation signals a breach in operation autonomy.

NOTE 2: Escalation is often combined with the concept of delegation in the context of operation autonomy. Operation autonomy is a central concept in Closed-Loop Automation (see clause 7 of ETSI GS ZSM 002 [2]).

NOTE 3: Escalation can target explicitly an entity or list of entities. Escalation can be with or without acknowledgment by the receiving entity or entities.

NOTE 4: Escalation can contain contextual information about the problematic situation faced, attempt(s) to solve it, and other contextual information that could be useful to the recipient of the escalation, or any other information defined by the corresponding policies.

managed entity: managed resource, a managed service or a managed Closed Loop

NOTE: This term differs from the definition in ETSI GS ZSM 007 [3] because a Closed Loop may also be managed, similarly to managed resources (e.g. VNFs, PNFs) and managed services (e.g. cloud services, RFSs, CFSs).

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI GS ZSM 007 [3] apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GS ZSM 007 [3] and the following apply:

AI	Artificial Intelligence
CL	Closed Loop
CLA	Closed-Loop Automation
CLC	Closed Loop Coordination
CLG	Closed Loop Governance
E2E	End-to-End

E2ES	End-to-End Service
KPI	Key Performance Indicator
LCM	Lifecycle Management
M2O-CL	Made-to-Order Closed Loop
MD	Management Domain
ML	Machine Learning
MnF	Management Function
MnS	Management Service
RDBMS	Relational DataBase Management System
RM-CL	Ready-Made Closed Loop
ZSM	Zero-touch network and Service Management

4 Description of ZSM 009 multi-part deliverable

The present document specifies part 1 of a multi-part deliverable that focuses on Closed-Loop Automation (CLA) based on the ZSM framework architecture.

The present document specifies the enablers for Closed-Loop Automation (CLA) that can be used in different use cases. It includes aspects of Closed Loop Governance (CLG) in clause 8.1 and Closed Loop Coordination (CLC) in clause 8.2. The present document also extends the ZSM framework architecture specified in ETSI GS ZSM 002 [2] with new management services and capabilities needed for the specified Closed Loop enablers (clause 9).

ETSI GS ZSM 009-2 [i.1] specifies solutions for end-to-end service and network automation use cases, based primarily on the enablers and architectural elements specified in ETSI GS ZSM 009-1 (the present document).

ETSI GR ZSM 009-3 [i.2] investigates advanced topics related to Closed-Loop Automation (CLA) such as learning and cognitive capabilities. It documents problem statements and technical challenges, derives potential requirements and provides recommendations for the evolution of Closed-Loop Automation (CLA) standardization activities.

5 Requirements for Closed-Loop Automation

5.1 Introduction

This clause defines the requirements relevant to Closed-Loop Automation (CLA) within the ZSM framework architecture. The requirements are derived from ETSI GS ZSM 001 [1] and ETSI GS ZSM 002 [2], as well as new requirements introduced specifically for Closed-Loop Automation (CLA).

The requirements are considered for the specification of the Closed-Loop Automation (CLA) enablers in clause 8.

5.2 General requirements

[CL-general-1] Closed loops within the ZSM framework shall have access to the data necessary to allow its proper operation.

NOTE 1: Examples of data include system log data, historical data, policy data, other external data input, etc.

[CL-general-2] The ZSM framework shall allow establishing different types of relationships between Closed Loops.

NOTE 2: Examples of relationships are peer Closed Loops, hierarchical or nested Closed Loops.

[CL-general-3] Closed loops stages should be able to expose their outcomes to the authorized entities.

NOTE 3: Examples of authorized entities are other Closed Loops and ZSM framework consumers.

[CL-general-4] Authorized Closed Loops within the ZSM framework shall be able to interact with other Closed Loops within the ZSM framework in different management domains.

[CL-general-5] Closed loops within the ZSM framework shall be able to be defined across multiple management domains.

NOTE 4: The management services for different Closed Loop stages may be provided by different management domains, e.g. data can be collected from one management domain and execution of actions may be performed in another management domain, etc.

[CL-general-6] Closed loops within the ZSM framework working in a management domain shall be able to request other Closed Loops in the E2E service management domain to take necessary action(s) in different management domains.

[CL-general-7] Closed loops stages should support influences from authorized entities outside the Closed Loop, but within the ZSM framework.

[CL-general-8] The actions taken by Closed Loops shall be logged.

[CL-general-9] The period for which Closed Loops logs are retained should be configurable.

[CL-general-10] The ZSM framework should support capabilities to present external instructions to the Closed Loops in a declarative form.

[CL-general-11] Closed loops within the ZSM framework should understand external instructions received in a declarative form.

[CL-general-12] Closed loops within the ZSM framework should support the capability to provide the state of each stage for its proper operation.

[CL-general-13] Closed loops within the ZSM framework should support the capability to detect abnormal states of any stage and notify the authorized entities.

[CL-general-14] Decisions based on AI/ML made by a Closed Loop within the ZSM framework should be monitored to support administrative audit trails.

[CL-general-15] Closed loops within the ZSM framework should support data collection from multiple available and applicable data sources, including their several data schemas.

[CL-general-16] The ZSM framework should support capabilities to avoid conflicts between Closed Loops.

[CL-general-17] The ZSM framework should support capabilities to minimize the negative effects of conflicts between Closed Loops.

[CL-general-18] Closed loops within the ZSM framework should support capabilities to enable continuous data integration from several available and applicable data sources.

[CL-general-19] The ZSM framework should support capabilities to enable continuous data integration from management data sources in a Closed Loop within the ZSM framework.

[CL-general-20] The ZSM framework should support capabilities to enable real-time data integration from management data sources in a Closed Loop within the ZSM framework.

[CL-general-21] The ZSM framework shall support a capability to uniquely identify a Closed Loop instance.

[CL-general-22] The ZSM framework should support capabilities to control the execution of a Closed Loop during its run time.

NOTE 5: An example of control capabilities could be the use of pause points.

[CL-general-23] Closed loops within the ZSM framework should support capabilities to handle control requests from authorized external entities.

[CL-general-24] Closed loops within the ZSM framework should support capabilities to dynamically adapt the exposure of control capabilities to external entities.

NOTE 6: Closed loop control capabilities could be defined by the Closed Loop model and may vary depending on the phases of the defined Closed Loop life cycle.

6 Introduction to Closed-Loop Automation

A Closed Loop (CL) is a type of control mechanism that monitors and regulates a set of managed entities with the objective of achieving a specific goal. CLs can be logically decomposed into a variable number of stages, each of them responsible for performing part(s) of the functionality of the Closed Loop. Well-known Closed Loop types are OODA loop, composed of 4 stages (Observe, Orient, Decide, Act) and MAPE-K, also composed of 4 stages (Monitor, Analyse, Plan, Execute) plus Knowledge.

Closed-Loop Automation (CLA) is the combination of CL stages that create automated processes that based on feedback from monitoring data can manage the network reducing or removing human involvement from the operation of a system. CLA in management systems can be realized with the combination and chaining of management services (data, analytics, policy, orchestration, etc.), and it creates autonomous systems that are able to constantly monitor and assess the network and take corrective actions when the goals (e.g. business intents, SLSs, etc.) are not fulfilled.

Although the purpose of CLA is to reduce the direct human intervention, it is important that any autonomous system still allows interactions with human operators. Such interactions can be used for the specification and modification of the goals of the CL, as well as for monitoring the performance of the autonomous system and eventual approval/rejection of actions taken by it.

The focus of the present document is to enable the creation and execution of CLs as well as on the integration and interoperability between CLs within the scope of ZSM framework, including CLs running at different domains. The interactions between CLs and external entities such as human operators are also considered, as this is important for the gradual increase of autonomy of Closed Loops.

NOTE: There are other CLs running outside of the scope of the ZSM framework (e.g. at the network resources) that can influence the CLA within the ZSM framework.

7 Closed loops within the ZSM framework

7.1 Introduction

ETSI GS ZSM 002 [2] specifies the overall architecture of the ZSM framework. CLs may exist in any of the management domains of the ZSM architecture as shown in Figure 7.1-1.

The present document specifies the management services relating to how CLs in the (E2E) MDs can be integrated into the ZSM framework. Two main groups of management capabilities are identified: capabilities relating to:

i) Closed Loop Governance (CLG); and

ii) Closed Loop Coordination (CLC).

Management capabilities belonging to these groups are specified in clause 9. Furthermore, the information models relating to a CL are presented in clause 8.1.4.

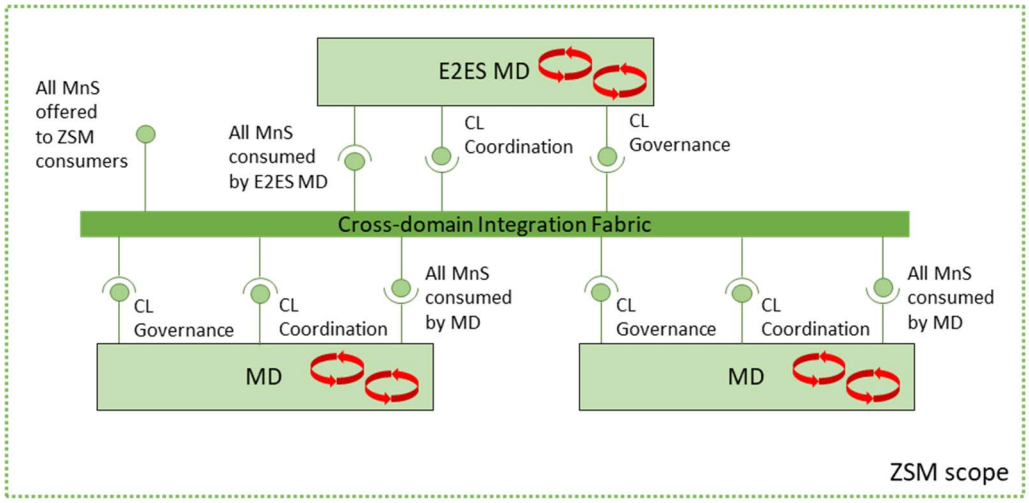

Figure 7.1-1: CL related management capabilities introduced in the present document

In the ZSM framework, CLs are realized by the interworking of management services defined in ETSI GS ZSM 002 [2] (and other future specifications in ISG ZSM) that are relevant to achieving the functionalities of the different stages of the CL. The stages when connected in a CL can be used to autonomously collect data, make decisions and execute actions upon one or more managed entities.

The set of stages that compose a CL includes at least one stage, called "Monitoring", responsible for collection of data from one or several sources (e.g. one or more managed entities, or external data sources) and one stage, called "Execution", responsible for executing actions upon one or more managed entities. The managed entities over which the execution is made are not necessarily the same as those where the data came from. Besides the two elementary stages, i.e. monitoring and execution, there may be other stages responsible for the analysis of operational and historical data and decisions based on the outcomes of the analysis. The number and functionality of intermediate stages between the "monitoring" of data and the "execution" can vary depending on the implementation and the deployment choices. This specification does not mandate a fixed number of stages that compose a CL within the ZSM framework, but it recommends at least three: one for monitoring, one for execution and one for analysis and decision making. Analysis and decision making can further be composed of several stages.

The CLs running within the ZSM framework can be represented by a functional view (clause 7.2) or by a deployment view (clause 7.3). The functional view expresses the functions that are conveyed in each stage and the flow of data and control between different stages of the Closed Loop and between the Closed Loop and external entities (clause 7.2.2). The deployment view expresses the connections between ZSM architectural components that are necessary for the realization of Closed Loops within the ZSM framework.

7.2 Functional view

7.2.1 Introduction

This specification takes as a baseline for the functional view the CL from Annex C of ETSI GS ZSM 002 [2] that is composed by 4 stages plus knowledge as its components, as shown in Figure 7.2.1-1. This collection and ordering of the components within a CL is referred to as the chain that forms the Closed Loop.

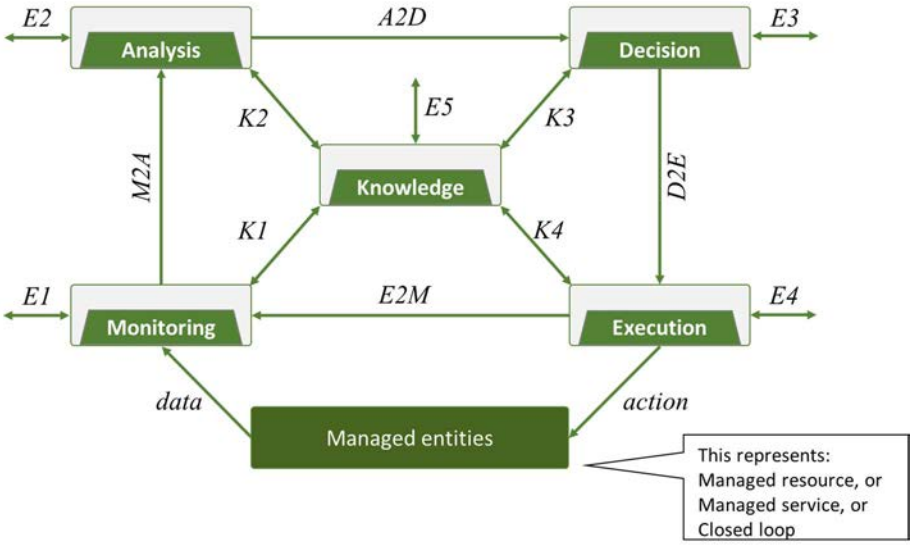

Figure 7.2.1-1: Functional view of a Closed Loop and its stages within the ZSM framework

In Figure 7.2.1-1, the "Managed entities" is not a stage in the CL, but rather the target of automation. A managed entity can be a managed service, a managed resource or another Closed Loop.

The "Monitoring" stage is responsible for collecting and pre-processing data from managed entities or from external sources.

NOTE 1: Data ingestion is a part of this stage. It is a process where data is transferred from one or more sources to a destination where it can be stored and further analysed. The data might be in different formats and come from various sources, including RDBMS, other types of databases, or from data streams. Since there is data of different origin, there is need for each source to be transformed in a way that allows it to be analysed in conjunction with data from other sources.

The "Analysis" stage is responsible for deriving insights from available data from the monitoring stage as well as historical data.

NOTE 2: An insight is produced based on data and the context of the finding. An example of insight may be the conclusion that congestion has taken place in a set of resources, and the context could be the time and date, the service affected, users involved and set of resources that make up the service. Insights can answer questions such as "What happened?" as well as "Why did it happen?". The insight derivation is a continuous process that can be enhanced by new data. Analysis should be able to continuously improve its results and, consequently, provide better decision options to the decision stage.

The "Decision" stage is responsible for deriving workflows from insights provided by the analysis stage.

NOTE 3: The decision stage governs the behaviour of the system as it decides which actions should be taken in face of issues detected in the analysis stage. The actions can be either reactive, proactive or predictive. The decision stage should decide which actions are required, but not necessarily how they should be taken in the managed entities. The translation from actions to commands is a responsibility of the execution stage.

In a CL the analysis and decision stages can optionally be combined into one single stage, kept separate as two stages, or even further split into multiple stages. The general objective of the stages that sit in between the monitoring and execution stages is to translate data into knowledge and by means of any type of intelligence mechanism (e.g. ML/AI, rules, policies) derive decisions that move the management target towards the desired state.

The "Execution" stage is responsible for executing workflows towards managed entities within the ZSM framework. Execution occurs when the decision stage determines that an action is required. Workflows may be composed of one or more operations that need to be properly orchestrated.

NOTE 4: Execution towards managed services or managed resources occurs when the CL involves one or more management domains and have direct access to steer the state of the managed services or managed resources by means of ZSM domain control services. Execution towards other CLs occurs when the goal of the CL that originates the execution is to steer the state of another CL. The latter case allows interactions between different CLs and enables the interworking of multiple distributed CLs that are required for the automation of the E2E services management.

The "Knowledge" is technically not a stage in the CL, but rather a means for storing and retrieving data that is shared between the stages within a Closed Loop, as well as between different Closed Loops. Examples of data are configuration data, operational and historical data. Knowledge can be used as a means for feedback signalling between the other stages.

Data and control flow are represented by the arrows between the stages of the Closed Loop (i.e. M2A, A2D, D2E, E2M). The types of data are information (M2A), insights (A2D), decisions (D2E) and feedback (E2M).

NOTE 5: The feedback in E2M may be used to improve responsiveness of the CL and when the CL does not use persistent data services. However, feedback is also possible to be conveyed by means of the knowledge, not only between execution and monitoring stages, but also between any stages of the CL.

The double-headed arrows between each stage and the knowledge (i.e. K1, K2, K3 and K4) are used for data-related inputs and outputs from CL stages.

The double-headed arrows pointing into each stage and the knowledge (i.e. E1, E2, E3, E4, E5) are used for data and control flows (e.g. policy/intent specification, parameter tuning, etc.) between different CLs within the ZSM framework, or between CLs and external entities. Interactions specified in clause 8.2 are conveyed through E1, E2, E3, E4 or E5.

All arrows in Figure 7.2.1-1 are realized by the endpoints exposed by the ZSM management functions that are part of the CL, as described in clause 7.3.

Clause 7.2.2 specifies examples of data and control flows that can exist between the CL stages.

7.2.2 Closed loops data and control flow

7.2.2.1 Introduction

The arrows in Figure 7.2.1-1 represent flow of data and control messages between the various components of the CL chain. There can be multiple flows running concurrently in a CL chain.

Which flows exist in a CL chain depends on the scenario and implementation choice. The typical, non-exhaustive, list of flows is detailed below.

7.2.2.2 Primary flow

Upon receiving data from the underlying managed entities and/or context sources, the primary flow can be executed. It involves all 4 Closed Loop stages and generates actions towards the managed entities. The transitions between stages in the primary flow are expressed by arrows M2A, A2D, D2E and E2M, as explained below.

M2A

- Monitoring stage provides information based on historical and/or streaming real-time data coming from various data sources. Information is a set of data processed in a meaningful way following the goals assigned to the Closed Loop. The information derived from raw data is highly depend on the context. Monitoring stage also provides capabilities for tuning the data sources and data ingestion.
    - Provide historical information
    - Provide real-time information
    - Tune data sources
    - Tune data ingestion