Intent Classification  
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Abstract

RFC7575 defines Intent as an abstract high-level policy used to operate the network. Intent management system includes an interface for users to input requests and an engine to translate the intents into the network configuration and manage their life-cycle. Up to now, there is no commonly agreed definition, interface or model of intent.

This document discusses the concept of intent. Specifically, it highlights stakeholder perspectives of intent, methods to classify and encode intent, the associated intent taxonomy, and defines relevant intent terms where necessary. This document provides a foundation for intent related research and facilitate solution development.

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# Introduction

The vision of intent-driven networks has attracted a lot of attention, as it promises to simplify the management of networks by human operators. This is done by simply specifying what should happen on the network, without giving any instructions on how to do it. This vision, and many Standards Development Organization (SDOs) to propose different intent framework.

Several SDOs and open source projects, such as Internet Engineering Task Force (IETF) (by the Autonomic Networking Integrated Model and Approach Working Group [ANIMA]), Open Networking Foundation (ONF) [ONF], Open Network Operating System (ONOS) [ONOS], have proposed intents for defining a set of network operations to execute in a declarative manner.

IETF [ANIMA] defines intent as a declarative policy, but still lacks a more complete definition, a tentative format, and a life-cycle. Within ONOS [ONOS], intent is represented as a list of Command-Line Interface (CLI) commands that allows users to bypass low-level details on the network, such as flows or host addresses. ONF through its Boulder and Aspen projects focuses on NorthBound Interface (NBI) semantics and intent models.

The SDOs usually came up with their own way of specifying an intent, and with their own understanding of what an intent is. Besides that, each SDO defines a set of terms and level of abstraction, its intended users, and the applications and usage scenarios.

However, mostly intent approaches proposed by SDOs share the same following features:

* It must be declarative in nature, meaning that a user specifies the goal on the network without specifying how to achieve that goal.
* It must be vendor agnostic, in the sense that it abstracts the network capabilities, or the network infrastructure from the user, and it can be ported across different platforms.
* It must provide an easy-to-use interface, which simplifies the users’ interaction with the intent system through the usage of familiar terminology or concepts.
* It should be able to detect and resolve intent conflicts, which include, for example, static (compile-time) conflicts and dynamic (run-time ) conflicts.

Currently, work is underway on unifying a common understanding of intent concepts and terminology. Concerning NMRG, [CLEMM] is a document to present a definition for intent as higher-level declarative policy that operates at the level of network and services it provides. In addition, this document captures the differences between intent, policy and service.

However, even with proposed intent concepts and terminology, as well as agreement on common intent characteristics, an intent may still be viewed in different ways by different stakeholders for different use cases and solutions.

The goal of this document is to clarify what an intent represents for different stakeholders through a classification on various dimensions, such as solutions, users, and intent types. This classification can ensure a common understanding across all participants and be used to identify the scope and priorities of individual projects, Proof of Concepts (PoCs), research initiatives, or open-source projects. This goal is achieved by proposing the methodology and initial classification tables. This methodology can be used to update the tables by adding or removing different solutions, users or intent types in order to cater for future scenarios, applications or domains.

The present document, together with [CLEMM], aims to become the foundation for future intent-related topic discussions regarding the NMRG.

# Key Words

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 RFC 2119 [RFC2119].

# Acronyms

AI: Artificial Intelligence

API: Application Programming Interface

CE: Customer Equipment

CFS: Customer Facing Service

CLI: Command Line Interface

DB: Data Base

DC: Data Center

ECA: Event-Condition-Action

GBP: Group-Based Policy

IETF: Internet Engineering Task Force

IP: Internet Protocol

O&M: Operations & Maintenance

ONF: Open Networking Foundation

ONOS: Open Network Operating System

PNF: Physical Network Function

QoS: Quality of Service

RFS: Resource Facing Service

SDO: Standards Development Organization

SD-WAN: Software-Defined Wide-Area Network

SLA: Service-Level Agreement

SUPA: Simplified Use of Policy Abstractions

VLAN: Virtual Local Area Network

VM: Virtual Machine

VPN: Virtual Private Network

# Abstract Intent Requirements

In order to understand the different intent requirements that would drive intent classification, we first need to understand what intent means for different intent users.

## What is Intent?

The term Intent has become very widely used in the industry for different purposes, sometimes it is not even in agreement with SDO shared principles mentioned in the Introduction.

Different stakeholders consider an intent to be an ECA policy, a GBP policy, a business policy, a network service, a customer service, a network configuration, application / application group policy, any operator/administrator task, network troubleshooting / diagnostics / test, a new app, a marketing term for existing management/orchestration capabilities, etc. Their intent is sometimes technical, non-technical, abstract or technology specific. For some stakeholders, intent is a subset of these and for other stakeholders intent is all of these. It has in some cases become a term to replace a very generic ‘service’ or ‘policy’ terminology.

Concerning this, [CLEMM] draft brings clarification with relation to what an intent is and how it differentiates from policies and services.

While it is easier for those familiar with different standards to understand what service, CFS, RFS, resource, policy continuum, ECA policy, declarative policy, abstract policy or intent policy is, it may be more difficult for the wider audience.

An intent is mistaken by many to be just a synonym for policy. While it is easier for those familiar with different standards to understand what service, CFS, RFS, resource, policy continuum, ECA policy, declarative policy, abstract policy or intent policy is, it may be more difficult for the wider audience. Furthermore, those familiar with policies understand the difference between a business, intent, declarative, imperative, and ECA policy.

Therefore, it is important to start a discussion in the industry about what intent is for different solutions and intent users. It is also imperative to try to propose some intent categories / classifications that could be understood by a wider audience. This would help us define intent interfaces, DSLs and models.

## Intent Solutions and Intent Users

Different Solutions and Actors have different requirements, expectations and priorities for intent-driven networking. They require different intent types and have different use cases. Some users are more technical and require intents that expose more technical information. Other users do not understand networks and require intents that shield them from different networking concepts and technologies. The following are the solutions and intent users that intent-driven networking needs to support:

+--------------------+------------------------------------+

| Solutions | Intent Users |

+--------------------+------------------------------------+

| Carrier Networks | Network Operator |

| | Service Designers |

| | Service Operators |

| | Customers/Subscribers |

+--------------------+------------------------------------+

| DC Networks | Cloud Administrator |

| | Underlay Network Administrator |

| | App Developers |

| | End-Users |

+--------------------+------------------------------------+

| Enterprise Networks| Enterprise Administrator |

| | App Developers |

| | End-Users |

+--------------------+------------------------------------+

These intent solutions and intent users represent a starting point for the classification and are expendable through the methodology presented in Section 5.1.

* For carrier networks scenario, for example, if the end-users wants to watch high-definition video, then the intent is to convert the video image to 1080p rate for the users.
* For DC networks scenario, administrators have their own clear network intent such as load balancing. For all traffic flows that need NFV service chaining, restrict the maximum load of any VNF node/container below 50% and the maximum load of any network link below 70%.
* For Enterprise Networks scenario, enterprise administrators express their intent from an external client (application service provider). For example, when hosting a video conference, multiple remote access is required. The intent expressed to the network operator: For any user of this application, the arrival time of hologram objects of all the remote tele-presenters should be synchronised within 50ms to reach the destination viewer for each conversation session.

## Current Problems and Requirements

Network APIs and CLIs are too complex due to the fact that they expose technologies & topologies. App developers and end-users do not want to set IP Addresses, VLANs, subnets, ports, etc. Operators and administrators would also benefit from the simpler interfaces, like:

* Allow Customer Site A to be connected to Internet via Network B
* Allow User A to access all internal resources, except the Server B
* Allow User B to access Internet via Corporate Network A
* Move all Users from Corporate Network A to the Corporate Network B
* Request Gold VPN service between my sites A, B and C
* Provide CE Redundancy for all Customer Sites
* Add Access Rules to my Service

Networks are complex, with many different protocols and encapsulations. Some basic questions are not easy to answer:

* Can User A talk to User B?
* Can Host A talk to Host B?
* Are there any loops in my network?
* Are Network A and Network B connected?
* Can User A listen to communications between Users B and C?

Operators and Administrators manually troubleshoot and fix their networks and services. They instead want:

* a reliable network that is self-configured and self-assured based on the intent
* to be notified about the problem before the user is aware
* automation of network / service recovery based on intent (self-healing, self-optimization)
* to get suggestions about correction / optimization steps based on experience (historical data and behaviour)

Therefore, Operators and Administrators want to:

* simplify and automate network operations
* simplify definitions of network services
* provide simple customer APIs for Value Added Services (operators)
* be informed if the network or service is not behaving as requested
* enable automatic optimization and correction for selected scenarios
* have systems that learn from historic information and behaviour

End-users cannot build their own services and policies without becoming technical experts and they must perform manual maintenance actions. Application developers and end-users/subscribers want to be able to:

* build their own network services with their own policies via simple interfaces, without becoming networking experts
* have their network services up and running based on intent and automation only, without any manual actions or maintenance

## Intent Types that need to be supported

The following intent types need to be supported, in order to address the requirements from different solutions and intent users:

* Customer service intent
  + for customer self-service with SLA or add service
  + for service operator orders
  + Network and Underlay Network service intent
  + for service operator orders
  + for intent driven network configuration, verification, correction and optimization
  + for intent created and provided by the underlay network administrator
  + Network and Underlay Network intent
  + For network configuration
  + For automated lifecycle management of network configurations
  + For network resources (switches, routers, routing, policies, underlay)
* Cloud management intent
  + For DC configuration, VMs, DB Servers, APP Servers
  + For communication between VMs
* Cloud resource management intent
  + For cloud resource life-cycle management (policy driven self-configuration and auto-scaling and recovery/optimization)
* Strategy intent
  + For security, QoS, application policies, traffic steering, etc
  + For configuring and monitoring policies, alarms generation for non-compliance, auto-recovery
  + For design models and policies for network and network service design
  + For design workflows, models and policies for operational task intents
* Operation task intents
  + For network migration
  + For server replacements
  + For device replacements
  + For network software upgrades
  + To automate any tasks that operators/administrator often perform
* Intents that affect other intents
  + It may be task-based intent that modifies many other intents.
  + The task itself is short-lived, but the modification of other intents has an impact on their life-cycle, so those changes must continue to be continuously monitored and self-corrected/self-optimized.

# Functional Characteristics and Behavior

Intent can be used to operate immediately on a target (much like issuing a command), or whenever it is appropriate (e.g., in response to an event). In either case, intent has a number of behaviors that serve to further organize its purpose, as described by the following subsections.

## Abstracting Intent Operation

The modelling of Intents can be abstracted using the following three-tuple:

{Context, Capabilities, Constraints}

* Context grounds the intent, and determines if it is relevant or not for the current situation. Thus, context selects intents based on applicability.
* Capabilities describe the functionality that the intent can perform. Capabilities take different forms, depending on the expressivity of the intent as well as the programming paradigm(s) used.
* Constraints define any restrictions on the capabilities to be used for that particular context.

Metadata can be attached via strategy templates to each of the elements of the three-tuple, and may be used to describe how the intent should be used and how it operates, as well as prescribe any operational dependencies that must be taken into account.

## Intent User Types

Intent user types, or intent actors as they are known in the area of declarative policy, represent the users that define and issue the intent request. Depending on the Intent Solutions, there are specific intent actors. Examples of intent actors are customers, network operators, service operators, enterprise administrators, cloud administrators, and underlay network administrators, or application developers.

* Customers and end-users do not necessarily know the functional and operational details of the network that they are using. Furthermore, they lack skills to understand such details; in fact, such knowledge is typically not relevant to their job. In addition, the network may not expose these details to its users. This class of actor focuses on the applications that they run, and uses services offered by the network. Hence, they want to specify policies that provide consistent behaviour according to their business needs. They do not have to worry about how the intents are deployed onto the underlying network, and especially, whether the intents need to be translated to different forms to enable network elements to understand them.
* Application developers work in a set of abstractions defined by their application and programming environment(s). For example, many application developers think in terms of objects (e.g., a VPN). While this makes sense to the application developer, most network devices do not have a VPN object per se; rather, the VPN is formed through a set of configuration statements for that device in concert with configuration statements for the other devices that together make up the VPN. Hence, the view of application developers matches the services provided by the network, but may not directly correspond to other views of other actors.
* Management personnel, such as network operators, may have the knowledge of the underlying network. However, they may not understand the details of the applications and services of Customers and End-Users.

## Intent Scope

Intent are used to manage the behaviour of the networks they are applied to and all intents are applied within a specific scope, such as:

* Connectivity scope, if the intent creates or modifies a connection.
* Security scope, if the intent specifies the security characteristics of the network or users.
* Application scope, when the intent specifies the applications to be affected by the intent request.
* QoS Scope, when the intent specifies the QoS characteristics of the network.

These intent scopes are expendable through the methodology presented in Section 6.1. .

## Intent Network Scope

Regardless on the intent user type, their intent request is affecting the network, or network components, which are representing the intent targets.

Thus, intent network scope, or policy target as known in the area of declarative policy, can represent VNFs or PNFs, Physical Network Elements, Campus networks, SD-WAN networks, radio access networks, cloud edge, cloud core, branch, etc.

## Intent Abstraction

Intent can be classified by whether it is necessary to feedback technical network information or non-technical information to the intended proponent after the intent is executed. As well, intent abstraction covers the level of technical details in the intent itself.

* For ordinary users, they do not care how the intent is executed, or the details of the network. As a result, they do not need to know the configuration information of the underlying network. They only focus on whether the intent execution result achieves the goal, and the execution effect such as the quality of completion and the length of execution. In this scenario, we refer to an abstraction without technical feedback.
* For administrators, such as network administrators, they perform intents, such as allocating network resources, selecting transmission paths, handling network failures, etc. They require multiple feedback indicators for network resource conditions, congestion conditions, fault conditions, etc. after execution. In this case, we refer to an abstraction with technical feedback.

## Intent Life-cycle

Intents can be classified into transient and persistent intents:

* If intent is transient, it has no life-cycle management. As soon as the specified operation is successfully carried out, the intent is finished, and can no longer affect the target object.
* If the intent is persistent, it has life-cycle management. Once the intent is successfully activated and deployed, the system will keep all relevant intents active until they are deactivated or removed.

## Hierarchy

In different phases of the autonomous driving network [TMF-auto], the intents are different. A typical example of autonomous driving network Level 0 to 5 are listed as below.

* Level 0 - Traditional manual network: O&M personnel manually control the network and obtain network alarms and logs. – **No intent**
* Level 1 - Partially automated network: Automated scripts are used to automate service provisioning, network deployment, and maintenance. Shallow perception of network status and decision making suggestions of machine; - **No intent**
* Level 2 - Automated network: Automation of most service provisioning, network deployment, and maintenance comprehensive perception of network status and local machine decision making; **- simple intent on service provisioning**
* Level 3 - Self-optimization network: Deep awareness of network status and automatic network control, meeting users' network intentions. – **Intent based on network status cognition**
* Level 4 - Partial autonomous network: In a limited environment, people do not need to participate in decision-making and adjust themselves. **– Intent based on limited AI**
* Level 5 - Autonomous network: In different network environments and network conditions, the network can automatically adapt to and adjust to meet people's intentions. **– Intent based on AI**

# Intent Classification

This chapter proposes an intent classification approach that may help to classify mainstream intent related demos / tools.

The three classifications in this draft have been proposed from scratch, following the methodology presented, through three iterations: one for carrier Intent Solution, one for DC Intent Solution, and one for enterprise Intent Solution. For each Intent solution, we identified the specific Intent Users and Intent Types. Then, we further identified the Intent Scope, Network Scope, Abstractions, and Life-cycle requirements.

These classifications and the generated tables can be easily extended. For example, for the DC Intent Solution, a new category is identified, i.e. Resource Scope, and the classification table has been extended accordingly.

In the future, as new scenarios, applications, and domains are emerging, new classifications and taxonomies can be identified, following the proposed methodology.

The output of the intent classification is the intent taxonomy introduced in the next sections.

Thus, this section first introduces the proposed intent classification methodology, followed by consolidated intent taxonomy for three intent solutions, and then by concrete examples of intent classifications for three different intent solutions (e.g. Carrier Network, Data Center, and Enterprise) that were derived using the proposed methodology and then can be filled in for PoCs, demos, research projects or future drafts.

## Intent Classification Methodology

This section describes the methodology used to derive the initial classification proposed in the draft. The proposed methodology can be used to create new intent classifications from scratch, by analysing the solution knowledge. As well, the methodology can be used to update existing classification tables by adding or removing different solutions, users or intent types in order to cater for future scenarios, applications or domains.

We first classify intents into intent types and describe each type based on the solution it belongs to and what intent user it is for. We than present different categories that these intent type can belong to, based on intent scope, network scope, intent abstraction and life-cycle.

+------------------------------------------+

|Solution Knowledge (requirements, |

|use cases, technologies, network, actors, |

|intent requirements) |

+----------------+-------------------------+

|

| Input

v

+--------+--------+

|Identify Intent |

|Solution +------------+

| | |

+---------^-+-----+ |

R1 | | U1 |

| | |

+-------------+ U8 | | R2 +--v----------------+

|Identify New +-----------+ | | +-----------> Identify |

|Categories | R8 | | | | U2 | Intent |

| <---------- | | | | +---------+ User Types |

+--------+----+ | | | | | | +-------------------+

^ | | | | | |

| +-+-v-+-v---+-v+

+--------+----+ U7 | | R3 +-------------------+

|Identify +------->Intent +--------> Identify |

|Life-cycle | R7 |Classification| U3 | Type |

|Requirements <-------+ <--------+ of Intent |

+--------+----+ +-^--^-+--^-+--+ +-------------------+

^ || | | | |

| || | | | |

+--------+----+ || | | | | R4 +-------------------+

|Identify | U6 || | | | +-----------> Identify |

|Abstractions +----------| | | | U4 | Intent |

| <----------+ | | +-------------+ Scope |

+-------+-----+ R6 | | +-------+-----------+

^ | | |

| U5 | |R5 |

| +-------+-v-------+ |

| |Identify Network | |

+----------+Scope <----------------+

+-----------------+

In the above methodology, the arrows mean the following:

* **Input** represents the Solution Knowledge comprising of knowledge about solution requirements, targeted use cases, available technologies and networks, actors, intent requirements.
* R1-U1: Review existing classification and use/add/remove the **intent solution**
* R2-U2: Review existing classification and use/add/remove the **intent user type**
* R3-U3: Review existing classification and use/add/remove the **intent type**s
* R4-U4: Review existing classification and use/add/remove the **intent scope**s
* R5-U5: Review existing classification and use/add/remove the **network scopes**
* R6-U6: Review existing classification and use/add/remove the **abstractions**
* R7-U7: Review existing classification and use/add/remove the **life-cycle requirements**
* R8-U8: Review existing classification and use/add the **newly identified categories.**

## Intent Taxonomy

The following taxonomy describes the various intent solutions, intent user types, intent types, intent scopes, network scopes, abstractions and life-cycle and represents the output of the intent classification tables for each of the solutions addressed (i.e. Carrier Solution, Data Center, and Enterprise).

+--------------------------------+

|Carrier Enterprise |

+-->|Data Center |

| +--------------------------------+

| +--------------------------------+

| |Customer |

+----------+ | |Network or Service Operator |

+>+Solutions +--+ |Application Developer |

| +----------+ +->|Enterprise Administrator |

| | |Cloud Administrator |

| +----------+ | |Underlay Network Administrator |

+>+Intent +---+ +--------------------------------+

| |User | +--------------------------------+

| |Types | |Customer Service Intent |

| +----------+ |Strategy Intent |

| +----------+ |Network Service Intent |

+>+Intent +----->|Underlay Network Service Intent |

+------+ | |Type | |Network Intent |

|Intent+-+ +----------+ |Underlay Network Intent |

+------+ | |Operational Task Intent |

| +----------+ |Cloud Management Intent |

+>+Intent +---+ |Cloud Resource Management Intent|

| |Scope | | +--------------------------------+

| +----------+ | +--------------------------------+

| +->|Connectivity Application |

| +----------+ |Security QoS |

+>+Network +---+ +--------------------------------+

| |Scope | | +--------------------------------+

| +----------+ | |Radio Access Branch |

| +->|Transport Access SD-WAN |

| +----------+ |Transport Aggr. VNF PNF |

+>+Abstrac +----+ |Transport Core Phisical |

| |tion | | |Cloud Edge Logical |

| +----------+ | |Cloud Core Campus |

| +----------+ | +--------------------------------+

+>+Life | | +--------------------------------+

|cycle +--+ +>|Technical Non-Technical |

+----------+ | +--------------------------------+

| +--------------------------------+

+-->|Persistent Transient |

+--------------------------------+

## Intent Classification for Carrier Solution

### Intent Users and Intent Types

The following table describes the Intent Users in Carrier Solutions and Intent Types with their descriptions for different intent users.

+-------------+-------------+---------------------------------------+

| Intent User | Intent Type | Intent Type Description |

+-------------------------------------------------------------------+

| Customer/ |Customer |Customer Self-Service with SLA and |

| Subscriber |Service |Value Added Service |

| |Intent |Example: Always maintain high quality |

| | |of service and high bandwidth for gold |

| | |level users. |

| | |Operational statement: Measure the |

| | |network congestion status, give |

| | |different adaptive parameters to |

| | |stations of different priority, thus in|

| | |heavy load situation, makes the |

| | |bandwidth of the high-priority users |

| | |guaranteed, at the same time ensure the|

| | |overall utilization of system, improve |

| | |the overall throughput of the system .

| +-----------------------------------------------------+

| |Strategy |Customer designs models and policy |

| |Intent |intents to be used by Customer Service |

| | |Intents. |

| | |Example: Request reliable service |

| | |during peak traffic periods for apps |

| | |of type video. |

+-------------------------------------------------------------------+

|Network |Network |Service provided by Network Service |

|Operator |Service |Operator to the Customer |

| |Intent |(e.g. the Service Operator) |

| | |Example: Request network service with |

| | |delay guarantee for access customer A. |

| +-------------+---------------------------------------+

| |Network |Network Operator requests network-wide |

| |Intent |(service underlay or other network-wide|

| | |configuration) or network resource |

| | |configurations (switches, routers, |

| | |routing, policies). Includes |

| | |Connectivity, Routing, QoS, Security, |

| | |Application Policies, Traffic Steering |

| | |Policies, Configuration policies, |

| | |Monitoring policies, alarm generation |

| | |for non-compliance, auto-recovery, etc.|

| | |Example: Request high priority queueing|

| | |for traffic of class A. |

| +-----------------------------------------------------+

| |Operational |Network Operator requests execution of |

| |Task |any automated task other than Network |

| |Intent |Service Intent and Network Intent |

| | |(e.g. Network Migration, Server |

| | |Replacements, Device Replacements, |

| | |Network Software Upgrades. |

| | |Example: Request migration of all |

| | |services in Network N to backup path P.|

| +-----------------------------------------------------+

| |Strategy |Network Operator designs models, policy|

| |Intent |intents and workflows to be used by |

| | |Network Service Intents, Network |

| | |Intents and Operational Task Intents. |

| | |Workflows can automate any tasks that |

| | |Network Operator often performed in |

| | |addition to Network Service Intents and|

| | |Network Intents |

| | |Example: Ensure the load on any link in|

| | |the network is not higher than 50%. |

+-------------+-------------+---------------------------------------+

+-------------+-------------+---------------------------------------+

| Service | Customer | Service Operator's Customer Orders, |

| Operator | Service | Customer Service / SLA |

| | Intent | Example: Provide service S with |

| | | guaranteed bandwidth for customer A. |

| +-----------------------------------------------------+

| | Network | Service Operator's Network Orders / |

| | Service | Network SLA |

| | | Example: Provide network guarantees in|

| | Intent | terms of security, low latency and |

| | | high bandwidth |

| +-----------------------------------------------------+

| | Operational | Service Operator requests execution of|

| | Task | the any automated task other than |

| | Intent | Customer Service Intent and Network |

| | | Service Intent |

| | | Example: Update service operator |

| | | portal platforms and their software |

| | | regularly. Move services from Network |

| | | Operator 1 to Network Operator 2. |

| +-----------------------------------------------------+

| | Strategy | Service Operator designs models, |

| | Intent | policy intents and workflows to be |

| | | used by Customer Service Intents, |

| | | Network Service Intents and |

| | | Operational Task Intents. Workflows |

| | | can automate any tasks that Service |

| | | Operator often performed in addition |

| | | to Network Service Intents and Network|

| | | Intents . |

| | | Example: Request network service |

| | | guarantee to avoid network congestion |

| | | during special periods |

| | | such as Black Friday, and Christmas. |

+-------------+-------------+---------------------------------------+

|Application | Customer | Customer Service Intent API provided |

| Developer | Service | to the Application Developers |

| | Intent | Example: API to request network to |

| | | watch HD video 4K/8K. |

| +-----------------------------------------------------+

| | Network | Network Service Intent API provided to|

| | Service | the Application Developers |

| | Intent | Example: API to request network and |

| | | monitoring an traffic grooming |

| +-----------------------------------------------------+

| | Network | Network Intent API provided to the |

| | Intent | Application Developers |

| | | Example: API to request network |

| | | resources configuration. |

| +-----------------------------------------------------+

| | Operational | Operational Task Intent API provided |

| | Task | to the Application Developers. This is|

| | Intent | for the trusted internal Operator / |

| | | Service Providers / Customer DevOps |

| | | Example: API to request server |

| | | migrations. |

| +-----------------------------------------------------+

| | Strategy | Application Developer designs models, |

| | Intent | policy and workflows to be used by |

| | | Customer Service Intents, Network |

| | | Service Intents and Operational |

| | | Task Intents. This is for the trusted |

| | | internal Operator/Service Provider/ |

| | | Customer DevOps |

| | | Example: API to design network load |

| | | balancing strategies during peak times|

+-------------+-------------+---------------------------------------+

### Intent Categories

The following are the proposed categories:

* Intent Scope: C1=Connectivity, C2=Security, C3=Application, C4=QoS
* Network Function (NF) Scope: C1=VNFs, C2=PNFs
* Network Scope: C1=Radio Access, C2=Transport Access, C3=Transport Aggregation, C4=Transport Core, C5=Cloud Edge, C6=Cloud Core)
* Abstraction(ABS): C1=Technical(with technical feedback), C2=Non-technical (without technical feedback) see Section 5.2. .
* Life-cycle (L-C): C1=Persistent (Full life-cycle), C2=Transient (Short Lived)

The following is the Classification Table Example for Carrier.

+---------+---------+-----------+-----+-----------------+-----+-----+

| Intent | Intent | Intent | NF | Network | ABS |L-C |

| User | Type | Scope |Scope| Scope | | |

| | +-----------+-----+-----------------+-----+-----+

| | |C1|C2|C3|C4|C1|C2|C1|C2|C3|C4|C5|C6|C1|C2|C1|C2|

+---------+---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

|Customer |Customer | | | | | | | | | | | | | | | | |

|/ Sub- |Service | | | | | | | | | | | | | | | | |

| scriber |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Strategy | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

+---------+---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

|Network |Network | | | | | | | | | | | | | | | | |

|Operator |Service | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Network | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Operatio-| | | | | | | | | | | | | | | | |

| | nal Task| | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Strategy | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

+---------+---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

|Service |Customer | | | | | | | | | | | | | | | | |

|Operator |Service | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Network | | | | | | | | | | | | | | | | |

| |Service | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Op Task | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Strategy | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

+---------+---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

|App |Customer | | | | | | | | | | | | | | | | |

|Developer|Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Network | | | | | | | | | | | | | | | | |

| |Service | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Network | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Op Task | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

| +---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| |Strategy | | | | | | | | | | | | | | | | |

| |Intent | | | | | | | | | | | | | | | | |

+---------+---------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

## Intent Classification for Data Center Solutions

### Intent Users and Intent Types

The following table describes the Intent Users in DCN Solutions and Intent Types with their descriptions for different intent users.

+---------------+-------------+-------------------------------------+

| Intent User | Intent Type | Intent Type Description |

+-------------------------------------------------------------------+

| Customer / | Customer | Customer Self-Service via Tenant |

| Tenants | Service | Portal, Customers may have multiple |

| | Intent | type of end-users. |

| | | Example: Request GPU computing and |

| | | storage resources to meet 10k video |

| | | surveillance services. |

| +---------------------------------------------------+

| | Strategy | This includes models and policy |

| | Intent | intents designed by Customers/ |

| | | Tenants to be used by Customer and |

| | | End-User Intents. |

| | | Example: Request dynamic computing |

| | | and storage resources of the service|

| | | in special and daily times. |

| | | |

+-------------------------------------------------------------------+

| | Cloud | Configuration of VMs, DB Servers, |

| Cloud | Management | App Servers, Connectivity, |

| | | Communication between VMs. |

| Administrator | Intent | Example: Request connectivity |

| | | between VMs A,B,and C in Network N1.|

| +---------------------------------------------------+

| | Cloud | Policy-driven self-configuration and|

| | Resource | and recovery / optimization |

| | Management | Example: Request automatic life |

| | Intent |-cycle management of VM cloud |

| | | resources. |

| +---------------------------------------------------+

| | Operational | Cloud Administrator requests |

| | Task Intent | execution of any automated task |

| | | other than Cloud Management |

| | | Intents and Cloud Resource |

| | | Management Intents. |

| | | Example: Request upgrade operating |

| | | system to version X on all VMs |

| | | in Network N1. |

| | |Operational statement: an intent to |

| | |update a system might reconfigure the|

| | |system topology (connect to a service|

| | |and to peers), exchange data (update |

| | |the content), and uphold a certain |

| | |QoE level (allocate sufficient |

| | |network resources). The network,thus,|

| | |carries out the necessary |

| | |configuration to best serve such an |

| | |intent; e.g. setting up direct |

| | |connections between terminals, and |

| | |allocating fair shares of router |

| | |queues considering other network |

| | |services.

| +---------------------------------------------------+

| | Strategy | Cloud Administrator designs models, |

| | Intent | policy intents and workflows to be |

| | | used by other intents. Automate any |

| | | tasks that Administrator often |

| | | performs, in addition to life-cycle |

| | | of Cloud Management Intents and |

| | | Cloud Management Resource Intents. |

| | | Example: In case of emergency, |

| | | automatically migrate all cloud |

| | | resources to DC2. |

+---------------+---------------------------------------------------+

| Underlay | Underlay | Service created and provided by |

| Network | Network | the Underlay Network Administrator |

| Administrator | Service | Example: Request underlay service |

| | Intent | between DC1 and DC2 with |

| | | bandwidth B . |

| +---------------------------------------------------+

| | Underlay | Underlay Network Administrator |

| | Network | requests some DCN-wide underlay |

| | Intent | network configuration or network |

| | | resource configurations. |

| | | Example: Establish and allocate |

| | | DHCP address pool. |

| +---------------------------------------------------+

| | Operational | Underlay Network Administrator |

| | Task Intent | requests execution of the any |

| | | automated task other than Underlay |

| | | Network Service and Resource |

| | | Intent. |

| | | Example: Request automatic rapid |

| | | detection of device failures and |

| | | pre-alarm correlation. |

| +---------------------------------------------------+

| | Strategy | Underlay Network Administrator |

| | Intent | designs models, policy intents & |

| | | workflows to be used by other |

| | | intents. Automate any tasks that |

| | | Administrator often performs |

| | | Example: For all traffic flows |

| | | that need NFV service chaining, |

| | | restrict the maximum load of any |

| | | VNF node/container below 50% and |

| | | the maximum load of any network |

| | | link below 70%. |

+-------------------------------------------------------------------+

| | Cloud | Cloud Management Intent API |

| | Management | provided to the Application |

| | Intent | Developers. |

| | | Example: API to request |

| | | configuration of VMs,or DB Servers |

| Application +---------------------------------------------------+

| Developer | Cloud | Cloud Resource Management Intent |

| | Resource | API provided to the Application |

| | Management | Developers. |

| | Intent | Example: API to request automatic |

| | | life-cycle management of cloud |

| | | resources. |

| +---------------------------------------------------+

| | Underlay | Underlay Network Service API |

| | Network | provided to the Application |

| | Service | Developers. |

| | Intent | Example: API to request real-time |

| | | monitoring of device condition. |

| +---------------------------------------------------+

| | Underlay | Underlay Network Resource API |

| | Network | provided to the Application |

| | Intent | Developers. |

| | | Example: API to request dynamic |

| | | management of IPv4 address pool |

| | | resources. |

| | | |

| +---------------------------------------------------+

| | Operational | Operational Task Intent API |

| | Task Intent | provided to the trusted |

| | | Application Developer (internal |

| | | DevOps). |

| | | Example: API to request automatic |

| | | rapid detection of device failures |

| | | and pre-alarm correlation |

| | | |

| +---------------------------------------------------+

| | Strategy | Application Developer designs |

| | Intent | models, policy intents and |

| | | building blocks to be used by |

| | | other intents. This is for the |

| | | trusted internal DCN DevOps. |

| | | Example: API to request load |

| | | balancing thresholds. |

+---------------+-------------+-------------------------------------+

### Intent Categories

The following are the proposed categories:

* Intent Scope: C1=Connectivity, C2=Security, C3=Application, C4=QoS C5=Storage C6=Compute
* DCN Resource (DCN Res) Scope: C1=Virtual, C2=Physical
* DCN Network (DCN Net) Scope: C1=Logical, C2=Physical
* Abstraction(ABS): C1=Technical(with technical feedback), C2=Non-technical (without technical feedback), see Section 5.2.
* Life-cycle (L-C): C1=Persistent (Full life-cycle), C2=Transient (Short Lived)

The following is the Classification Table Example for DC Solutions.

+---------+-------------+-----------------+-----+-----+-----+-----+

|Intent | Intent | Intent | DCN | DCN | ABS | L-C |

|User | Type | Scope | Res | Net | | |

| | +-----------------+-----+-----+-----+-----+

| | |C1|C2|C3|C4|C5|C6|C1|C2|C1|C2|C1|C2|C1|C2|

+---------+-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

|Customer | Customer | | | | | | | | | | | | | | |

|/Tenants | Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Strategy | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

+---------+-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| Cloud | Cloud | | | | | | | | | | | | | | |

| Admin | Management | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Cloud | | | | | | | | | | | | | | |

| | Resource | | | | | | | | | | | | | | |

| | Management | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Operational | | | | | | | | | | | | | | |

| | Task Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Strategy | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

+---------+-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

|Underlay | Underlay | | | | | | | | | | | | | | |

|Network | Network | | | | | | | | | | | | | | |

|Admin | Service | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Underlay | | | | | | | | | | | | | | |

| | Network | | | | | | | | | | | | | | |

| | Resource | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Operational | | | | | | | | | | | | | | |

| | Task Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Strategy | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

+---------+-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

|App | Cloud | | | | | | | | | | | | | | |

|Developer| Management | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Cloud | | | | | | | | | | | | | | |

| | Resource | | | | | | | | | | | | | | |

| | Management | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Underlay | | | | | | | | | | | | | | |

| | Network | | | | | | | | | | | | | | |

| | Service | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Underlay | | | | | | | | | | | | | | |

| | Network | | | | | | | | | | | | | | |

| | Resource | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Operational | | | | | | | | | | | | | | |

| | Task Intent | | | | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

| | Strategy | | | | | | | | | | | | | | |

| | Intent | | | | | | | | | | | | | | |

+---------+-------------+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

## Intent Classification for Enterprise Solution

### Intent Users and Intent Types

The following table describes the Intent Users in Enterprise Solutions and their Intent Types.

+--------------+-------------+-------------------------------------+

| Intent User | Intent Type | Intent Type Description |

+--------------+---------------------------------------------------+

| End-User | Customer | Enterprise End-User Self-Service or |

| | Service | Applications, Enterprise may have |

| | Intent | multiple types of End-Users. |

| | | Example: Request access to VPN |

| | | service. |

| | | Request video conference between |

| | | user A and B. |

| +---------------------------------------------------+

| | Strategy | This includes models and policy |

| | Intent | intents designed by End-Users to be |

| | | used by End-User Intents and their |

| | | Applications. |

| | | Example: Create a video conference |

| | | type for a weekly meeting. |

+------------------------------------------------------------------+

|Administrator | Network | Service provided by the |

| (internal or | Service | Administrator to the End-Users |

| MSP) | Intent | and their Applications. |

| | | Example: For any user of application|

| | | X, the arrival time of hologram |

| | | objects of all the remote tele- |

| | | presenters should be synchronised |

| | | within 50ms to reach the destination|

| | | viewer for each conversation session|

| | | Create management VPN connectivity |

| | | for type of service A. |

| | | Operational statement: The job of |

| | | the network layer is to ensure that |

| | | the delay is between 50-70ms through|

| | | the routing algorithm. At the same |

| | | time,the node resources need to meet|

| | | the bandwidth requirements of 4K |

| | | video conferences. |

+------------------------------------------------------------------+

| | Network | Administrator requires network wide |

| | Intent | configuration (e.g. underlay, |

| | | campus) or resource configuration |

| | | (switches, routers, policies). |

| | | Example: Configure switches in |

| | | campus network 1 to prioritise |

| | | traffic of type A. |

| | | Configure Youtube as business |

| | | non-relevant. |

| +---------------------------------------------------+

| | Operational | Administrator requests execution of |

| | Task Intent | any automated task other than |

| | | Network Service Intents and Network |

| | | Intents. |

| | | Example: Request network security |

| | | automated tasks such as Web |

| | | filtering and DDOS cloud protection.|

| +---------------------------------------------------+

| | Strategy | Administrator designs models, policy|

| | Intent | intents and workflows to be used by |

| | | other intents. Automate any tasks |

| | | that Administrator often performs. |

| | | Example: In case of emergency, |

| | | automatically shift all traffic of |

| | | type A through network N. |

| | | |

+--------------+-------------+-------------------------------------+

| Application | End-User | End-User Service / Application |

| Developer | Intent | Intent API provided to the |

| | | Application Developers. |

| | | Example: API for request to open a |

| | | VPN service. |

| +---------------------------------------------------+

| | Network | Network Service API Provided to |

| | Service | Application Developers. |

| | Intent | Example: API for request network |

| | | bandwidth and latency for |

| | | hosting video conference. |

| +---------------------------------------------------+

| | Network | Network API Provided to Application |

| | Intent | Developers. |

| | | Example: API for request of network |

| | | devices configuration. |

| +---------------------------------------------------+

| | Operational | Operational Task Intent API provided|

| | Task Intent | to the trusted Application Developer|

| | | (internal DevOps). |

| | | Example: API for requesting |

| | | automatic monitoring and |

| | | interception for network security |

| +---------------------------------------------------+

| | Strategy | Application Developer designs |

| | Intent | models, policy intents and building |

| | | blocks to be used by other intents. |

| | | This is for the trusted internal |

| | | DevOps. |

| | | Example: API for strategy intent in |

| | | case of emergencies. |

| | | |

+--------------+-------------+-------------------------------------+

### Intent Categories

The following are the proposed categories:

* Intent Scope: C1=Connectivity, C2=Security, C3=Application, C4=QoS
* Enterprise Network (Net) Scope: C1=Campus, C2=Branch, C3=SD-WAN
* Abstraction(ABS): C1=Technical(with technical feedback), C2=Non-technical (without technical feedback), see Section 5.2.
* Life-cycle (L-C): C1=Persistent (Full life-cycle), C2=Transient (Short Lived)

The following is the Intent Classification Table Example for Enterprise Solutions.

+---------------+-------------+-----------+--------+-----+-----+

| Intent User | Intent Type | Intent | Net | ABS | L-C |

| | | Scope | | | |

| | +-----------+--------+-----+-----+

| | |C1|C2|C3|C4|C1|C2|C3|C1|C2|C1|C2|

+---------------+-------------+--+--+--+--+--+--+--+--+--+--+--+

| End-User | End-User | | | | | | | | | | | |

| | Intent | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+

| | Strategy | | | | | | | | | | | |

| | Intent | | | | | | | | | | | |

+---------------+-------------+--+--+--+--+--+--+--+--+--+--+--+

| Enterprise | Network | | | | | | | | | | | |

| Administrator | Intent | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+

| | Strategy | | | | | | | | | | | |

| | Intent | | | | | | | | | | | |

+---------------+-------------+--+--+--+--+--+--+--+--+--+--+--+

| Application | End-User | | | | | | | | | | | |

| Developer | Intent | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+

| | Network | | | | | | | | | | | |

| | Service | | | | | | | | | | | |

| | Intent | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+

| | Network | | | | | | | | | | | |

| | Intent | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+

| | Operational | | | | | | | | | | | |

| | Task | | | | | | | | | | | |

| | Intent | | | | | | | | | | | |

| +-------------+--+--+--+--+--+--+--+--+--+--+--+

| | Strategy | | | | | | | | | | | |

| | Intent | | | | | | | | | | | |

+---------------+-------------+--+--+--+--+--+--+--+--+--+--+--+

# Involvement of Intent in the Application of AI to Network Manage ment

In the application of AI to NM, an intent is expected to be, on the one hand, a formal definition of a goal or policy instructed to the decision system and, on the other hand, a formal definition of the specific actions that some network controller must perform. Goal intents and policy intents have different meanings. The former will establish an objective for the automated management system to accomplish, such as "avoiding latency to be higher than 10 ms". Meanwhile, policy intents set the overall regulations and possible actions that the AI system can use to achieve those goals. Both goal and policy intents are expected to be provided by humans, although they must be in some very formal language that can be easily understood by computers. All those relations make the degree of formality an important dimension to classify intents so that users, which here are AI-based agents, can be able to choose the proper solution to consume them.

AI technology has played an important role in the different stages of the intent network implementation.

* Help identify and prevent security threats: Classification algorithms can attempt to identify malware or other undesirable web content or usage;
* Intentional translation: use AI algorithm to assist the translation module, split translation into the requirements contained in the semantics of the intention; automatic delivery and execution strategy; Automate tasks and appropriate network changes based on the existing network infrastructure configuration according to the policy model;
* Adaptive adjustment: perceive the quality of the user experience and perform predictive analysis to proactively optimize performance, such as excessive access time;

To enforce the resulting actions determined by AI-based control modules, action intents will have a format that avoids misconceptions as much as possible. This means that they will be closer to machine language structures than natural (human) language structures. This can sacrificing some degree of human understandability, so it forms another dimension in the classification of intents. This dimension allows automated systems to discern which format of intent to use in relation to the possibility and degree of humans to be involved in their exchanges.

Finally, as intents can use different words and languages to refer to the same concepts, all intents related to AI will be required to follow a specific ontology. This way, input intents will be easily semantically translated to formal structures. Output intents will also be composed by following the ontology, so receivers of those intents will be able to easily understand them.

For instance, in the intent classification, the machine learning algorithm can be utilized to extract the intent feature values and classify the intent according to the intent feature distribution. For example, using artificial intelligence clustering algorithm, a large number of intents proposed by different users are used as training data to extract multiple feature dimensions, such as vocabulary information intended to be used, related feature parameters, context proposed by the intent, and the like. Cluster analysis is performed in the same form as the coordinate system, and multiple categories are classified according to the characteristics of the sample point distribution. For the input intent later, the category of the intent is judged based on the similarity with all categories.

* For specific classification intents, such as safety or fault information, conditions can be preset in advance, and once a common error message occurs, it will automatically alarm.
* For the network resource information, set the corresponding threshold information. When there is a certain number of link users or the network traffic is too large, the adjustment intention is started.
* For users with higher priority, the resources can be configured preferentially.

# Security Considerations

This document does not have any Security Considerations.

# IANA Considerations

This document has no actions for IANA.

# Contributors

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