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Intent-Driven Network & Service Management

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Agenda

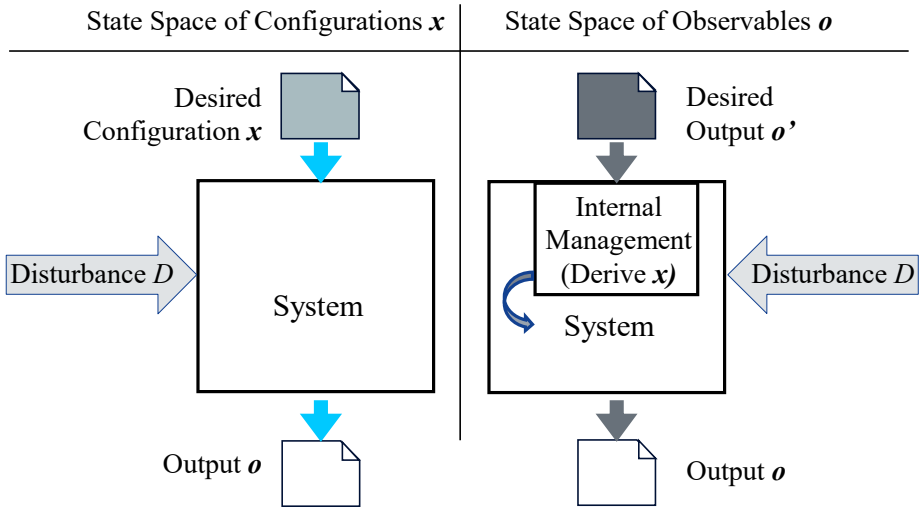
- Intent Definitions
  - Background: Controlling input
  - Intent as controlling input
  - Definition of intent
- Intent Modelling
  - Ad hoc: 3GPP NetworkSlice / GSMA NEST
  - Context to define scope & bordering conditions
  - Intent as set of components
  - Generic model of intents
- System Architecture

Theoretical background

Controlling input to a system

Systems can be controlled by different strategies:

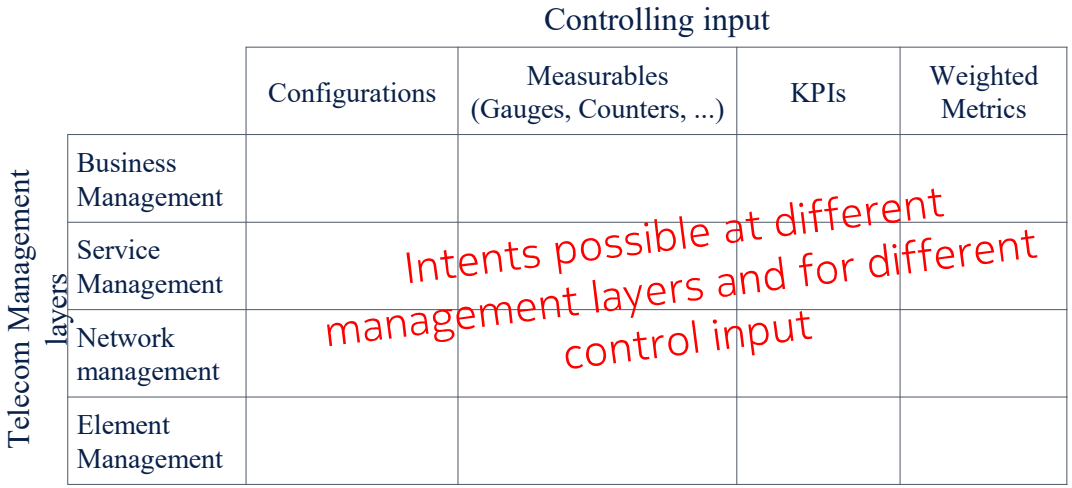
- **Configurations state space:**
  - Defines the “setup of the system”: *x*.
  - Number & location of network elements, configuration parameters & context like mountains, buildings, ongoing traffic …
- **Observations state space:**
  - Defined by measurable observations: *o*.
  - Signal strength, throughput, latency, all Performance Management (PM) data like counters and all traces of the signaling interfaces
- **Concrete parameters at very lowest layer**



Theoretical background

Controlling input to a system

- Both strategies can be applied at any level of abstraction
  - At any layer of telecom management.
  - CEO: “Build a network!” vs. “Ensure coverage!”
  - Network element: “x=5” vs. “HO failure rate < 2%”
- Observations can be aggregated in each layer.
  - 2-dimensional continuum of control.
  - Generalization of “policy continuum”)*
- Combinations are possible.
  - Any layer, any level of aggregation.
  - Note: Might result in conflicts !

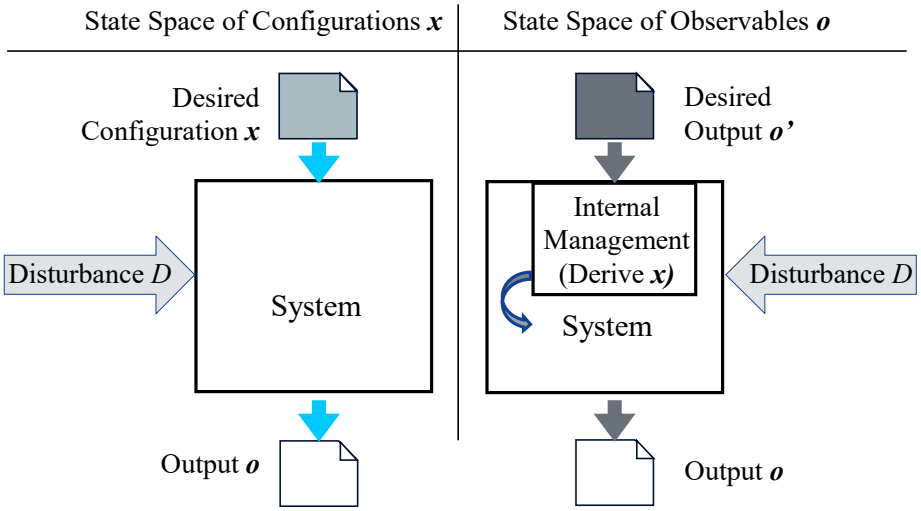


Theoretical background

Controlling input to a system

Both strategies have drawbacks:

- Especially for Radio Access Networks the system function is partially unknown:
  - IP: Configuration is known <=> outcome is known.
  - RAN: The very same cell configuration will lead to completely different results depending on the site.
    - Configuration is known, but not the outcome
    - Desired outcome is known, but not the configuration
    - Desired outcome might be infeasible, even in theory.



Intent definitions

Intent as controlling input

- Definition:

  intent = desired state of the system

  - state described by a combination of components from configurations and observations state spaces.

- State includes achievable outcomes and context from configuration or observations state spaces
  - to restrict the intent to specific network elements, areas, or time frames the intent might be augmented by additional components from the to define the context of the intent.
  - To define bordering conditions / constraints - observables are not independent can degrade one another.

Implications

- the definition ”the desired state of the system” *does not*
  - prescribe a level of abstraction and so is flexible
  - prescribe a way of achieving the outcomes but does not guarantee them either
  - guarantee interpretability or implementability
  - exclude concrete parameter values

- Why then not simply use intents on outcomes (i.e. as ”goals”) → delegate all to the system?
  - the system still needs to translate between the desired goal and a very concrete setup that can fulfil the goal, a translation that might be impossible
  - Certain parameters *must* be set explicitly

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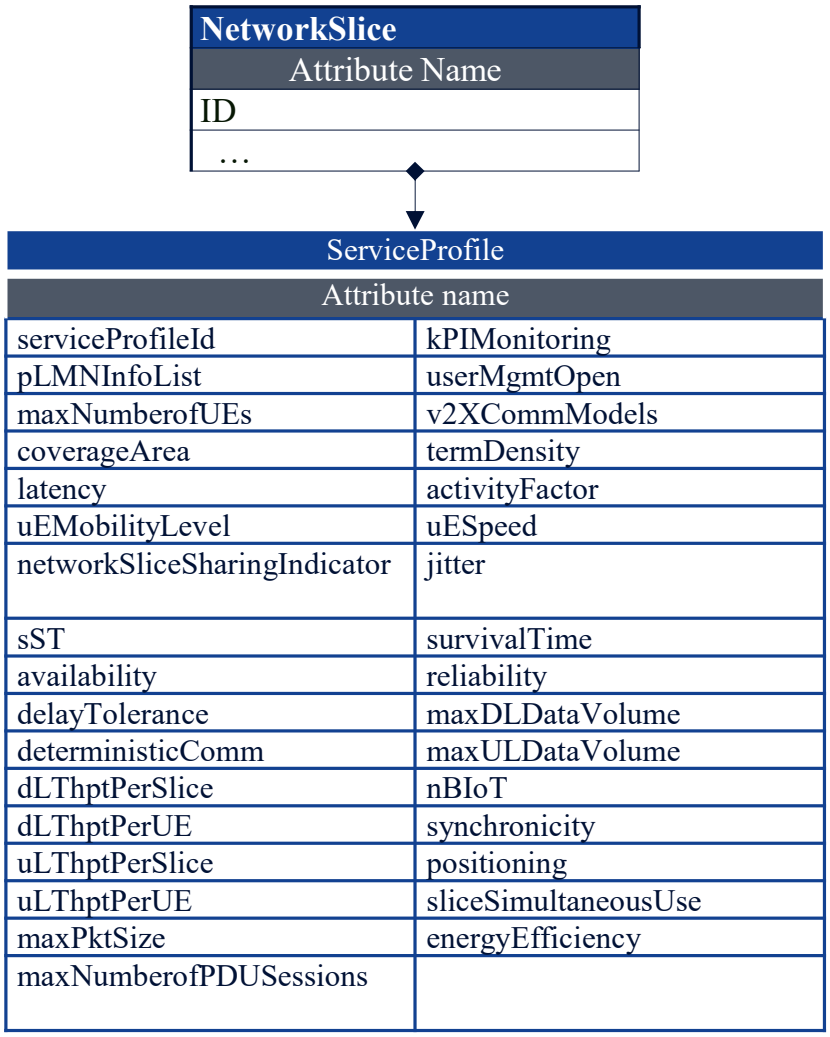
Intent modelling

Intent “by accident”: `ServiceProfile` by 3GPP SA5

- Network management by 3GPP-defined interfaces
  - Model of “Slices”: TS 28.541
- `ServiceProfile`
  - Inherited from GSMA NG.116 - Generic Network Slice Template.
  - Tenant defines requirements in terms of “desired outcomes”.
  - It’s left to the system to fulfil these requirements
  - => clear case of intent.
- Automatic translation mostly impossible so far.
  - Used, but *very* limited.
- Ad hoc, scope is specific to `NetworkSlice`
  - for NetworkSliceSubnet in a similar way (“SliceProfile”).



NetworkSlice
Attribute Name
ID
…

ServiceProfile	
Attribute name	
serviceProfileId	kPIMonitoring
pLMNInfoList	userMgmtOpen
maxNumberofUEs	v2XCommModels
coverageArea	termDensity
latency	activityFactor
uEMobilityLevel	uESpeed
networkSliceSharingIndicator	jitter
sST	survivalTime
availability	reliability
delayTolerance	maxDLDataVolume
deterministicComm	maxULDataVolume
dLThptPerSlice	nBIoT
dLThptPerUE	synchronicity
uLThptPerSlice	positioning
uLThptPerUE	sliceSimultaneousUse
maxPktSize	energyEfficiency
maxNumberofPDUSessions	

Intent modelling

Intent as list of components

- It is preferred that Intents are declarative
- Desired outcome = list of measurable state values

$$\mathbf{s}[t] = (s_1[t], s_2[t], \ldots, s_N[t])^T \quad \text{for } t = 0, 1, \ldots,$$

- But: How to distinguish “what must be achieved” from “context to be considered “?

Ensure [CBD cells; RLF < 2%; Load < 80%]

?

Ensure RLF<2% **if** Load < 80 in CBD cells

→“**if**" expresses context

Ensure RLF<2%; **&** Load < 80 in CBD cells

→“**&**" expresses another target

- → intent is a set of components

$$intent := [scope(s), target1, target2, ...constraint1, ...].$$

- Intents need a formal information model

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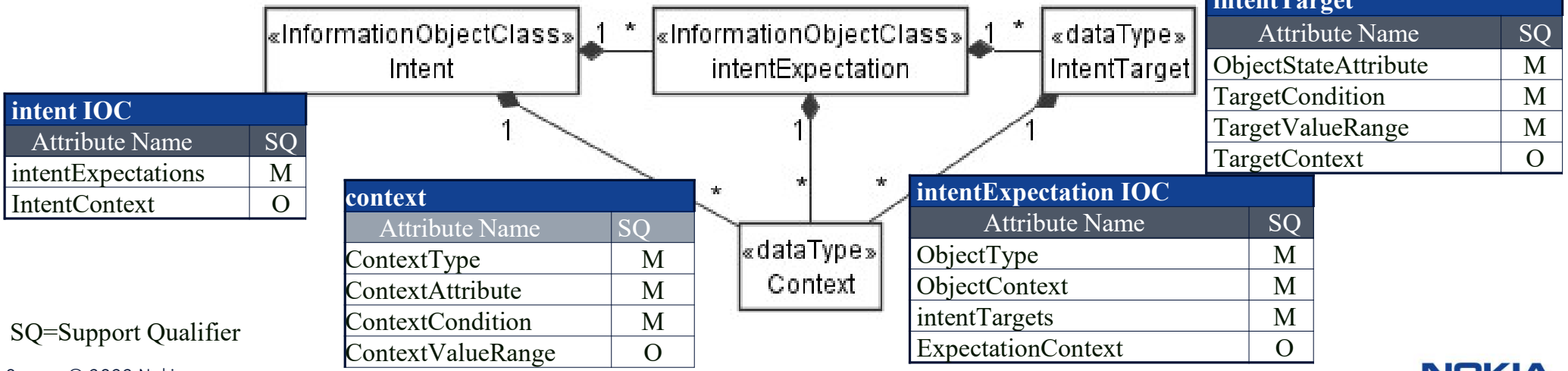
Intent modelling

General, declarative intent model

- Model specifies information in intent statements
  - An intent may include multiple expectations
  - An Expectation is specific to an object or type of object e.g., a cell/cells, a slice/slices, ..
  - An intent may have multiple targets on an object
  - Intents, Expectations and Targets may be desired under one or more specific contexts
- Critical to distinguish targets and contexts
  - IntentTarget is a triple [attribute, condition, valueRange]
  - Context is a triple [attribute, condition, valueRange]
  - But context is explicitly stated – an attribute could be either a target or a context



intent IOC

Attribute Name	SQ
intentExpectations	M
IntentContext	O

context

Attribute Name	SQ
ContextType	M
ContextAttribute	M
ContextCondition	M
ContextValueRange	O

intentTarget

Attribute Name	SQ
ObjectStateAttribute	M
TargetCondition	M
TargetValueRange	M
TargetContext	O

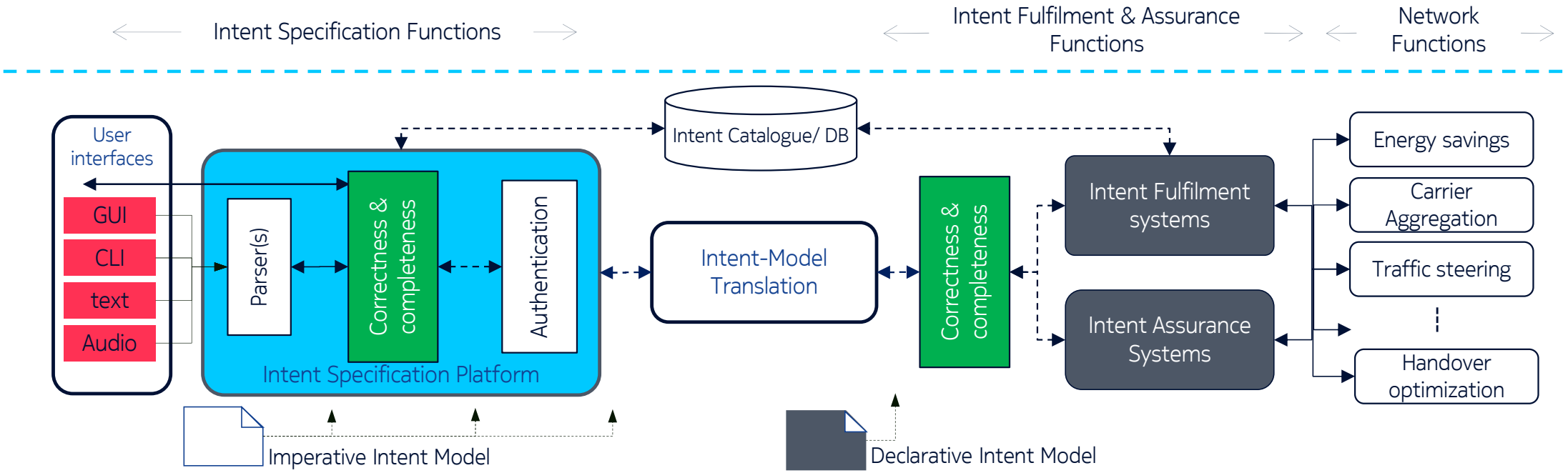
intentExpectation IOC

Attribute Name	SQ
ObjectType	M
ObjectContext	M
intentTargets	M
ExpectationContext	O

SQ=Support Qualifier

System architecture

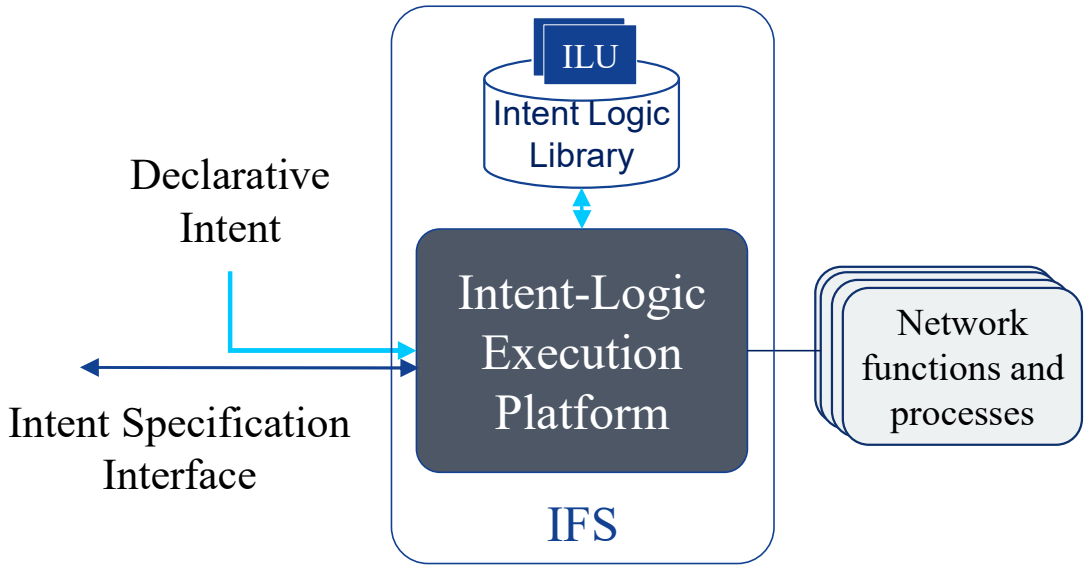
What is required to support Intent Driven management?



Intent fulfilment

Intent Logic Units (ILU) in an Intent Logic Library (ILL)

- Each ILU is a wrapper around a piece of logic for a specific task
  - Can be mapped to network functions and processes, e.g. to SON or AI/ML functions
  - as small as adjusting a cell's transmit power
  - can be combined to accomplish a larger task
- ILUs are stored in a library with descriptive meta data on what they accomplish
- For a given Intent, an Intent Logic Execution Platform (ILEP) searches the library for ILUs
  - To be independently executed or combined to achieve the outcomes of a stated intent.



Conclusion

Intent of intent-based network management still is an intent, mostly

- The concept of intent as *desired state of the system* in state space seems to be reasonable:
  - Avoids the heavily overloaded and fuzzy terms like “declarative”, “goal”, “non explicit”, etc.
  - Allows to model intents as expectation / targets that are conditioned on a specific context (scope and other conditions).
  - Implies that the management system must get the managed system into the desired state and has to keep it there.
  - This might be accomplished by a modular management system based on “Intent Logic Units”.

References and related work

References and related work

Surveys, open-source projects and standards development work

Referenced papers, books

- *Towards Cognitive Autonomous Networks: Network Management Automation for 5G and Beyond*, S. S. Mwanje, C. Mannweiler (Wiley, 2020)
- *Intent-Driven Network and Service Management: Definitions, Modeling and Implementation*, S. S. Mwanje et al.
- *Experiential Networked Intelligence (ENI); Context-Aware Policy Management Gap Analysis*, ETSI GR ENI, (ETSI , 2018)

Open-source and Standards Development

- Widely under discussion, no concrete outcomes
  - ONF
  - IRTF network management research group (NMRG)
  - ETSI Experiential Networked Intelligence (ENI) 008
  - 3GPP Technical Report 28.812 & Technical Specification 28.312
  - TM Forum's Autonomous network project for intent-based operation - IG1253 [19]
  - ETSI ZSM011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