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Agility of networks: changing & using resources dynamically

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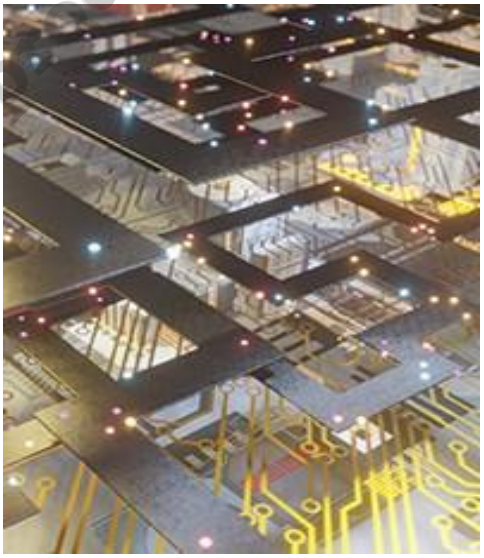


Cognition is the process of acquiring and understanding data and information and producing new data, information, and knowledge. This means that the knowledge of a Cognitive Network increases and becomes more accurate with experience. It can understand the significance of changing telemetry, reason about what caused those changes, and reconfigure resources dynamically at runtime to protect existing services and/or offer new services. A Cognitive Network thus bases its decisions on changing user needs, business goals, and network conditions, and learns experientially from its own decisions as well as those of the operator. Given a set of goals, a Cognitive Network can dynamically optimize network resources to provide a set of services that both meets user needs and the business goals of the Operator.

As technology becomes increasingly complex, managing telecommunications infrastructure grows accordingly in complexity. Operators need data-driven, context-aware tools to help them make the right decisions at the right time. This enables actionable decisions to facilitate prompt adaptation to various business and operational needs.

The main objectives of the ETSI agile cognitive work are listed as:

- To develop standards for a Cognitive Network Management system, incorporating a set of closed control loops. The closed control loops are based on extensions to the “observe-orient-decide-act” model (e.g., the incorporation of situation awareness, learning, and reasoning capabilities).
- To adapt the usage of available network resources and services of the managed system using Cognitive Management. This enables the real-time evolution of user needs, environmental conditions, and business goals to determine which services should be offered during a given context.
- To define how cognitive management can use different types of policies (e.g., imperative, declarative, and intent) to specify adaptive behavioral changes.
- To develop standards that define a model-driven architecture using cognitive management to provide the required Operator Experience.

The agile cognitive system is an experiential architecture—it learns through experience. This self-learning principle improves operator experience and enables the system to adjust the offering of services in response to contextual changes.

Agile Cognitive Principles

The agile Cognitive Management Functions are based on an innovative cognition model. A cognition model defines how cognitive processes, such as comprehension, action, and prediction, are performed and influence decisions. The agile cognition model draws heavily on how human cognition is performed. The perception portion provides the notion of classifying data into pre-defined representations that are understood and relevant to the current situation; memory is used to increase comprehension of the situation; and actions are judged by how effectively they perform to support the situation.

Agile Cognitive Management learns from experience to improve its performance. Agile Cognition Management is based on human cognition. Cognitive psychology defines three interacting layers, called reactive (or subconscious), deliberative, and reflective. Reactive processes will take immediate responses based upon the reception of an appropriate external stimulus. In humans, these processes correspond to instinctual and learned behaviors.Knowledge Management, Context-Aware Management, Cognition Management, and Situational Awareness Functions perform all or part of these tasks. The purpose of this part of the control loop is to ensure that input data and information is adapted to the current context and situation. Inferencing discovers more about the nature and meaning of the data. Situational processing analyzes the information to determine if anything has just occurred that threatens its system goals. If problems are identified, then situational processing decides what is likely to happen, and how that affects the goals that the system is trying to achieve. This produces a set of possible alternative actions.

The Cognition Management

Cognition Management uses existing knowledge to validate and generate new knowledge. This means that new knowledge may be added, and in some cases, existing knowledge may be changed. A cognition framework uses multiple diverse processes and technologies, including linguistics, computer science, AI, formal logic, neuroscience, psychology, and philosophy, along with others, to analyze existing knowledge and synthesize new knowledge.

The Agile Cognition Process

An agile cognitive system is based on how humans think. A cognitive system is a system that can reason about what actions to take, even if a situation that it encounters has not been anticipated or seen before. A cognitive system can learn from its experience to improve its performance. It can also examine its own capabilities and prioritize the use of its services and resources. In addition, it is able to explain what actions it took and accept external commands to perform necessary actions.

Situational Awareness

Situational Awareness enables the agile cognitive system to be aware of events and behavior that are relevant to a set of entities in the system being assisted and/or governed), and how those events and behavior affect the achievement of the current set of goals that are being worked on by the agile cognitive system. This includes the ability to understand how recommendations and commands given by the agile cognitive system impact the current set of goals, both immediately and in the near future. Situation awareness is especially important in environments where the information flow is

high, and poor decisions have the possibility to lead to serious consequences (e.g., violation of Service Level Agreements).

A cognitive system is a system capable of independently developing strategies for and solving human tasks. A cognitive system is both context- and situation-aware. It may draw on multiple sources of information, including both structured and unstructured digital information, as well as sensory inputs (visual, gestural, auditory, or sensor-provided). A cognitive system should be able to adapt its governance in accordance with changing information and context. A cognitive system should also be able to adapt its functionality as its goals and requirements evolve. Cognitive systems may use deterministic mechanisms to make decisions; however, cognitive systems should mainly use probabilistic processes for decision-making.

The individual functions of a cognitive system, as well as multiple cognitive systems, shall be able to collaborate on a set of tasks. The specific set of functions is assigned to the collective and is driven by its suitability to accomplish the tasks of the current set of goals.

Architectural Implications

Cognitive systems should generate hypotheses, reasoned arguments, and recommendations. They should be able to generate explanations of their reasoning processes. A cognitive system shall be able to reason about what actions to take, even if a situation that it encounters has not been anticipated. It shall learn from its experience to improve its performance. It should be able to examine its own capabilities and prioritize the use of its services and resources, and if necessary, explain what it did and accept external commands to perform necessary actions.

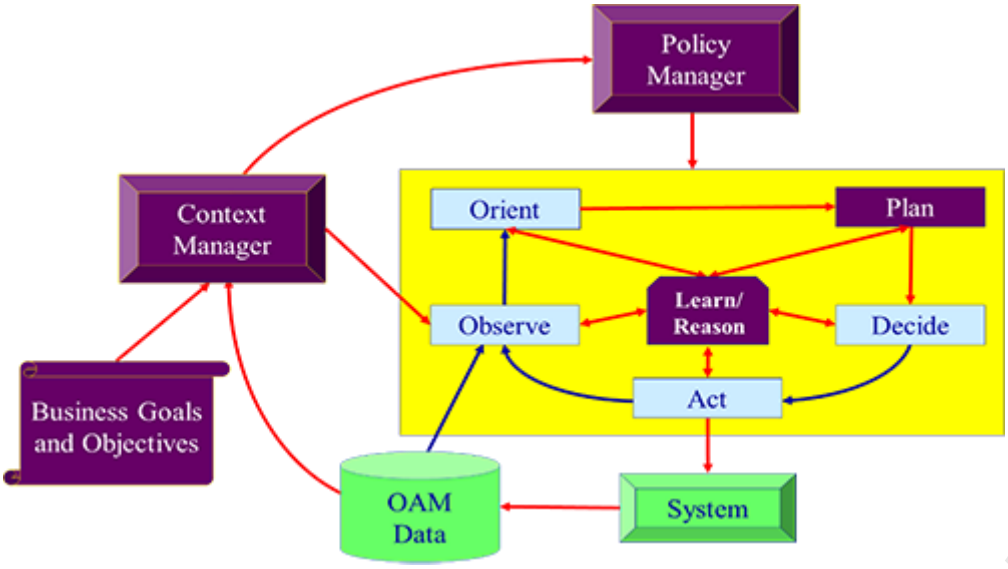
Cognitive systems should be used to augment human decision-making and action processes. Cognitive systems are not meant to replace humans, but rather, enhance them. Autonomic Systems are indeed more intelligent, but that is not their primary benefit. For example, consider smart phones. People do not buy them because they are “more intelligent,” but rather, because they have features that are important to users. Similarly, autonomic systems use their intelligence to transform a system into an Intelligent Provider of Services. The “intelligence” is the ability to adapt to change using cognition.

Autonomics is not just about self-configuration, self-healing, self-optimization, and self-protection; these are all benefits of a cognitive system. These capabilities collectively enable the cognitive system to recognize change in itself and the environment, analyze its performance with respect to its current goals, and comprehend the effects of issuing a command in that situation.

Enhancing the Operator Experience using Agile Cognitive Management

Operators must manage services provided by the network (e.g., streaming multimedia or call quality) in increasingly complex networking environments. This is exacerbated by new technologies deployed in new applications, including the Internet of Things, 5G, telehealth, Smart Cities, and communications over multiple media. Networks are now a software-driven fusion of virtual and physical networks that may have different Key Performance and Quality Indicators, and even different Service Level Agreements, under different conditions.

The Agile System can function as either an advisor or (when sufficient trust is established) a manager. It has the ability to use policies authored in natural language, and provides trends and predictions that notify the operator of problems that will occur before they impact a service. Intelligent telemetry and dynamic knowledge bases are used to provide evidence that supports recommendations and commands.



Conclusions and Future Work on Agile Cognitive Management

Future work will include specification of APIs and protocols, including policies. ETSI specifies a novel information model that enables different types of policies to be represented. Currently imperative (e.g., when an event occurs, if conditions are satisfied, then actions may be executed), declarative (e.g., logic-based policies), and intent (e.g., restricted natural language) policies are defined.

In conclusion, ETSI is studying Agile Cognition as a set process that consists of three parts: acquiring data (perception), understanding information (comprehension), and producing new data, information, and knowledge that support taking actions. These human-like tasks will increase the agility and re-use of resources in the network that are expressed as policies that may be described in a reduced-intent language and grammar.

The concept of Agile Cognition systems with control loops, is shown in graphic above.