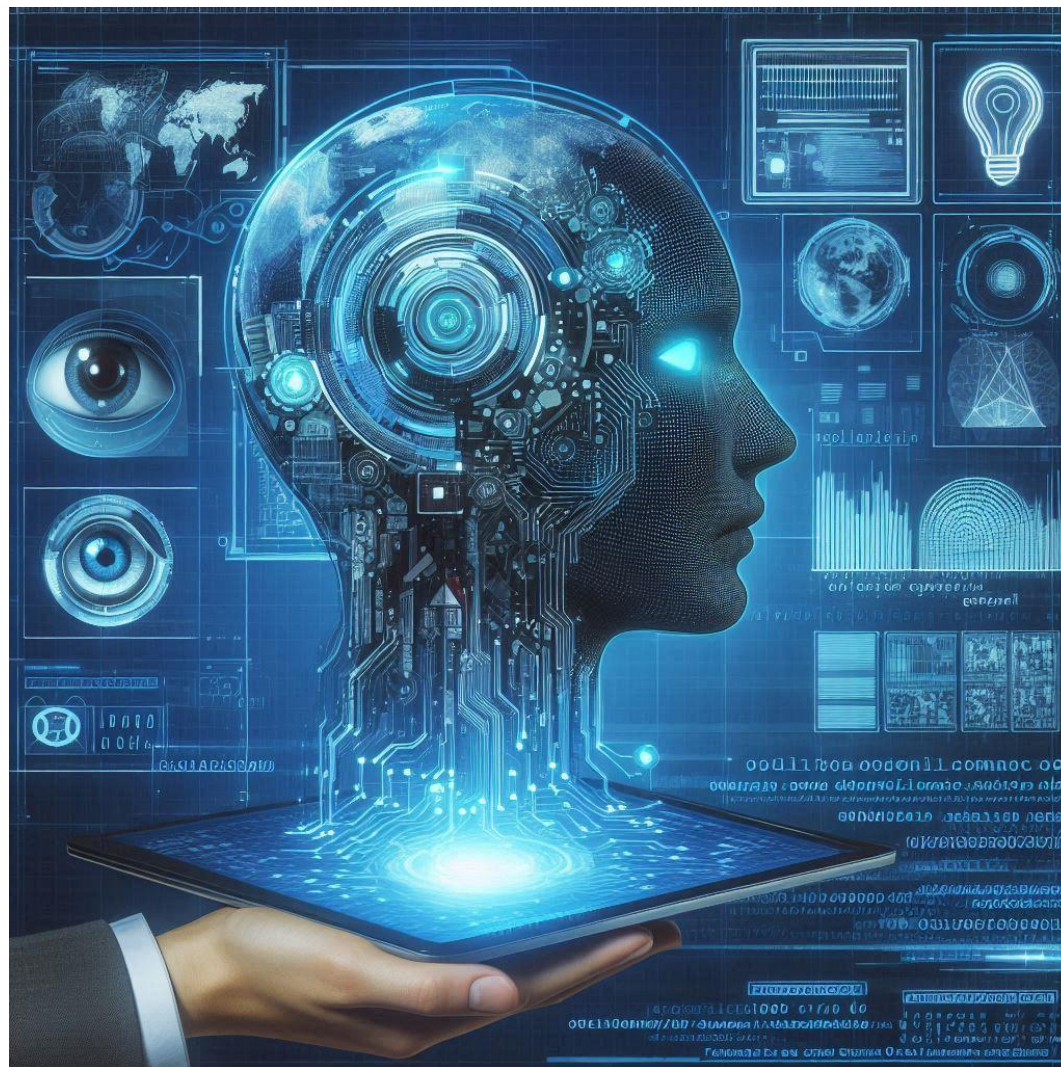


Chunks and Rules for Cognitive Control






Cognitive Approach to Low-Code Control

- *Low-code* is an approach to application development that simplifies the process of automating workflows and building applications
- Some low-code platforms use visual drag-and-drop elements and prebuilt components along with scripting
- Empowering professional developers and business users to create applications more efficiently
- Cognitive approach mimics how humans execute tasks, drawing upon decades of work in the cognitive sciences
- Behaviour is described using facts + rules
- Enabling application developers to use a low-code cognitive approach to specifying real-time behaviour
 - Enabling resilience and adaptability
- Event-driven concurrent threads of behaviour using APIs exposed by resources as described in taxonomies
- Easy to learn, convenient syntax for chunks* and condition-action rules
 - W3C Cognitive AI CG's [Chunks & Rules](#) specification
- Mature JavaScript library
- Extension to distributed agents, e.g. swarms using asynchronous message exchange

* Chunks are sets of name/value pairs



Formal Specification from Cognitive AI CG



W3C Community Group
Draft Report

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Chunks and Rules

Draft Community Group Report 02 April 2024

Latest published version:
<https://www.w3.org/chunks/>

Latest editor's draft:
<https://w3c.github.io/cogai/>

Editors:
François Daoust ([W3C](#))
Dave Raggett ([W3C](#))

Feedback:
[GitHub w3c/cogai](#) ([pull requests](#), [new issue](#), [open issues](#))

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Abstract

This specification defines a cognitive graph database model featuring chunks as collections of properties, and rules that operate on them in conjunction with highly scalable graph algorithms, and a simple notation for serializing graphs. The model is designed with the aim of facilitating machine learning for vocabularies and rules, and inspired by advances in the cognitive sciences on the organisation of the mammalian brain.

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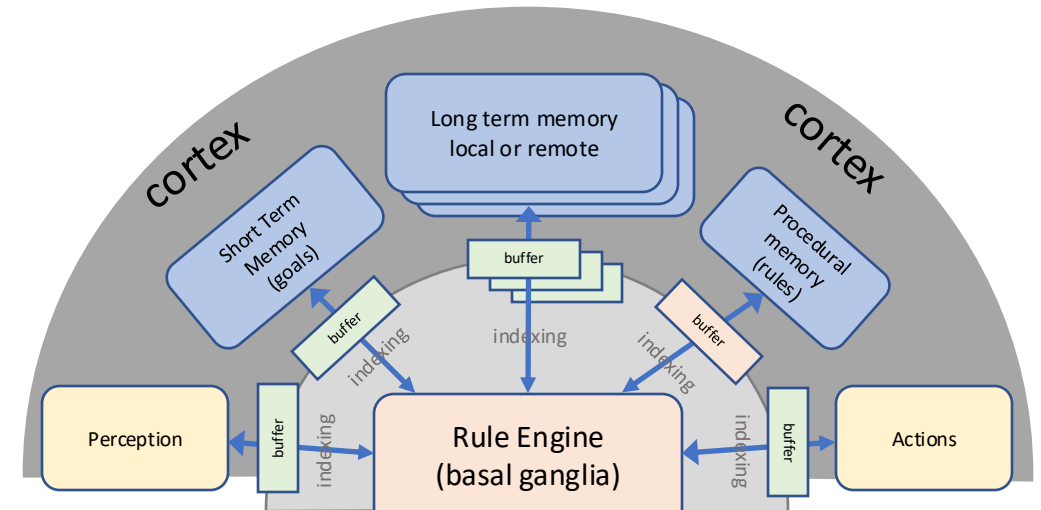
This specification was published by the [Cognitive AI Community Group](#). It is not a W3C Standard nor is it on the W3C Standards Track. Please note that under the [W3C Community Contributor License Agreement \(CLA\)](#) there is a limited opt-out and other conditions apply. Learn more about [W3C Community and Business Groups](#).



Cognitive Architecture

- Inspired by John Anderson's [ACT-R](#)
- Mimics characteristics of human cognition and memory, including spreading activation and the forgetting curve
- Asynchronous operations that enable distributed cognition
- Perception builds live models of the environment including events that trigger corresponding behaviours
- Actions expressed as intents to be realised as appropriate
 - *intent*: an aim, purpose, goal or objective
- Reasoning is decoupled from real-time control over external actions, e.g. a robot arm

Cognition – Sequential Rule Engine



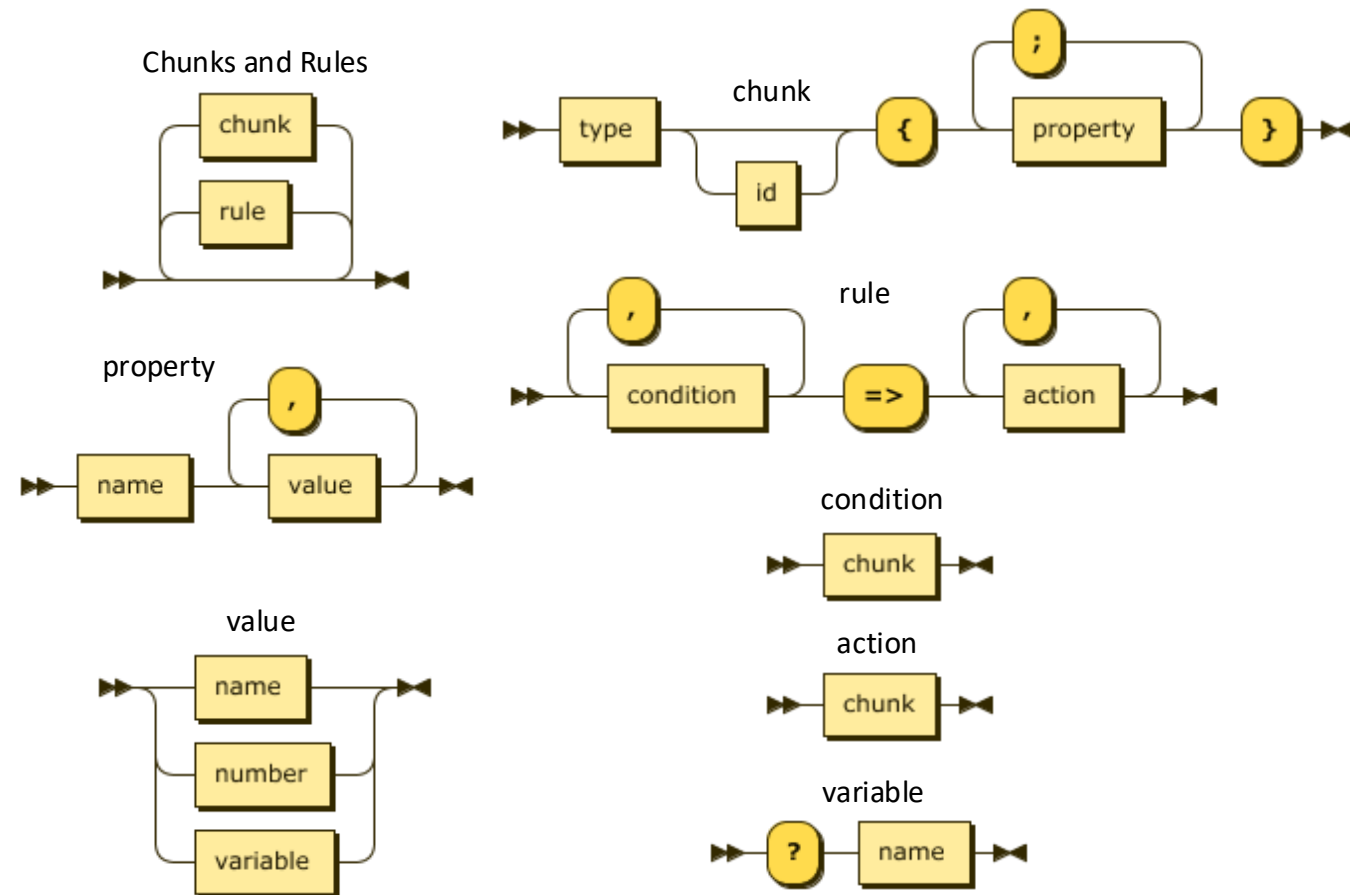
- The cortex holds a set of cognitive modules, each of which is associated with a module buffer that holds a single chunk
- Predefined asynchronous operations on buffers in analogy with REST



Chunks and Rules

web-based demos for smart homes and factories

- Chunks are sets of properties
 - Name/value pairs that correspond to a set of RDF triples with same subject
- Rule conditions and actions that specify which cognitive module buffer they apply to
- Variables are scoped to the rule they appear in
- Actions either directly update the buffer or invoke operations on the buffer's module, which asynchronously updates the buffer
- Extensible suite of cortical operations inspired by REST



names beginning with "@" are reserved, e.g. @do for actions

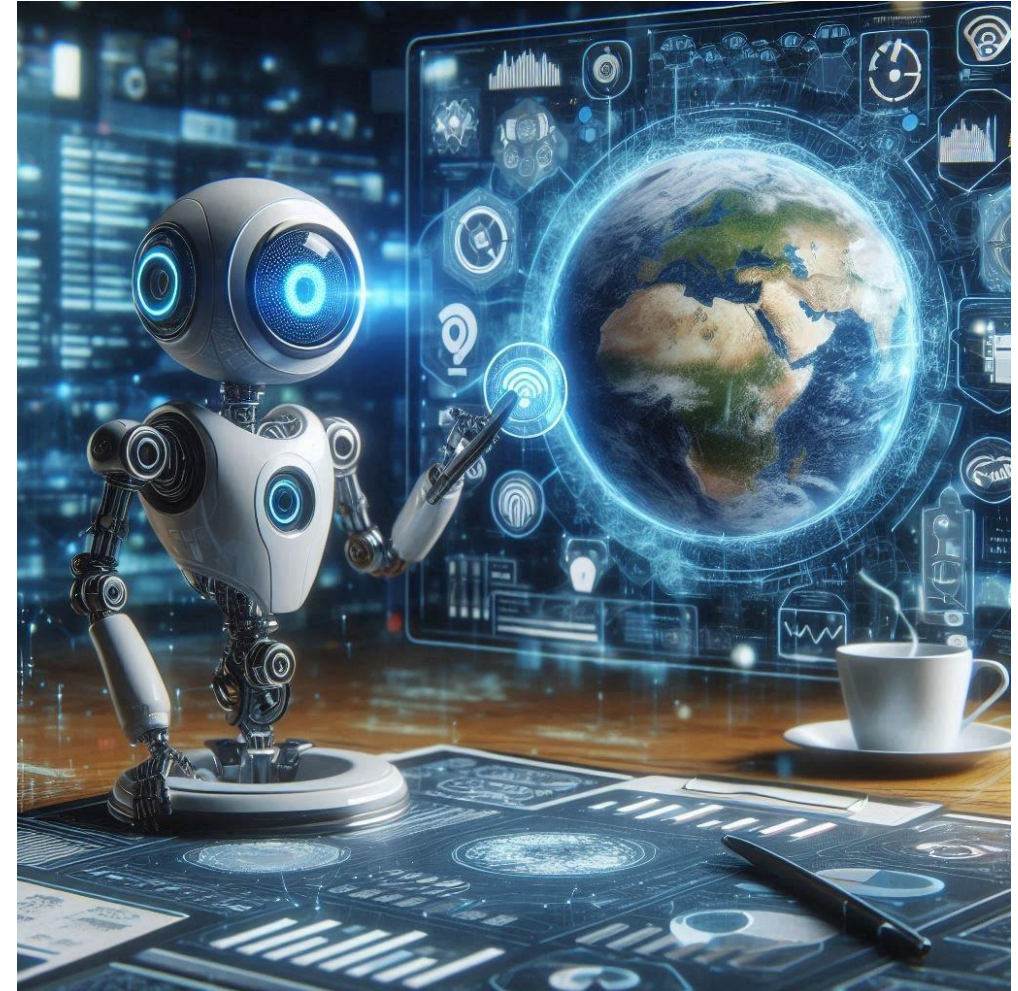
See [W3C Cognitive AI Community Group](https://www.w3.org/2017/05/cognitive/)



Chunk Rules for Digital Twins

- Nephele's Virtual Objects are related to digital twins for devices, processes and even people*
- Digital Twin affordances (properties, actions, events) and semantics are described using W3C Thing Descriptions, and searchable in Thing Description Directories
- Chunk rule actions can be used to invoke the affordances exposed by digital twins
- Some glue code is needed to handle the data formats and protocols
- Complex results involve using the predefined suite of operations over chunk graphs given that module buffers are limited to single chunks

* Digital twins for use in healthcare applications, and for virtual devices as abstractions over multiple physical devices (i.e. composite virtual objects)

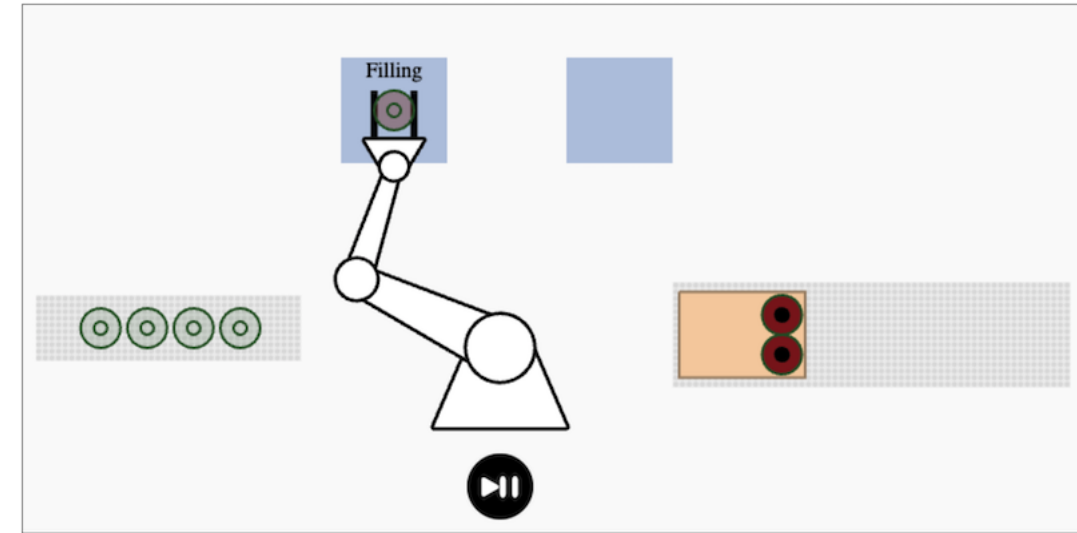




Chunks and Rules

- Mature [JavaScript library](#) for use in webpages or with NodeJS
- Application script declares additional operations, e.g. for robot control, layered above ROS operations
- These are implemented in JavaScript and can use real-time clock as well as networking for external messaging
- ERCIM can help with this
- Contact Dave Raggett <dsr@w3.org>

Note: rules can use variables for dynamic parameters where an object location is determined at run-time.



[Factory demo](#): filling, capping and packing bottles of wine with real-time control over conveyor belts, filling and capping machines, and a robot arm

```
# move robot arm into position to grasp empty bottle
after {step 1} =>
  robot {@do move; x -170; y -75; angle -180; gap 30; step 2}

# grasp bottle and move it to the filling station
after {step 2} =>
  goal {@do clear},
  robot {@do grasp},
  robot {@do move; x -80; y -240; angle -90; gap 30; step 3}
```

See also [smart homes demo](#)



Robot Operating System (ROS)



[ROS diffbot](#)

- [ROS](#) is an open source software framework for robots
 - Linux, Windows, MacOS
- Strong developer community
- Message based with hardware abstraction
 - Topic based streams
 - Services with request/response
 - Nodes for message exchange
 - Shared database for parameters
- **Chunks & Rules** are a good fit for controlling ROS robots
- Using ROS topic streams to update chunk models of robots and their environment
- Using Chunk Rules to involve ROS services
 - Delegation for planning and execution
- Existing [JavaScript libraries](#) for integration with ROS



Swarm Intelligence

- A single cognitive agent may be used to control multiple devices
 - [Factory demo](#): a single chunks & rules agent controls two conveyor belts, one robot arm, a filling station and a capping station
- Cognitive agents can fuse information from local and remote sources for situational awareness
 - Not limited to on-device sensors
- Cognitive agents can share information that other agents may find useful*
 - e.g. unexpected obstacles
- You can think of the swarm as a hive mind composed from multiple communicating cognitive agents
 - Asynchronous chunk messages
- Increased resilience and flexibility

Agents can leave information in the physical or virtual environment as a form of *stigmergy*. This is a mechanism of indirect coordination through the environment, between agents or actions. The principle is that the trace left in the environment by an individual action stimulates the performance of a succeeding action by the same or different agent. Agents can also communicate directly, e.g. when they are in close proximity, or via their names or roles.



Iterative Refinement

- Cognitive rules can respond in milliseconds*, and can be complemented by faster reactions using simple reflex responses implemented at a lower level
- Application development is a collaboration between people maintaining the low-code description of high level behaviour and system programmers responsible for the glue code for the digital twins, i.e. Nephele (composite) VOs
- Development starts using a simple approach and iteratively refines it as new requirements come to light, e.g. when something unexpected occurs at run-time and needs to be handled
- That may further necessitate changes to the digital twins, e.g. to sense error conditions
- In robot use case: errors such as a bottle falling over, being only partially filled, or badly capped

* Rule execution is fast as time consuming operations are handled asynchronously



Questions?

