The Web as a Basis for a Global Cognitive Organization

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1 From Society of Mind to Web-based Cognitive Organizations

Marvin Minsky's "Society of Mind" theory argues that intelligent systems can be realized as societies of simpler components called "agents" [Minsky(1986)]. In this view, while each agent is only capable to perform a (relatively) simple task, the society created by these agents is capable of performing sophisticated tasks that result in intelligent behavior.

While (individual) agents are not considered to be intelligent or autonomous in Minsky's model, we may also consider *societies* of autonomous and intelligent agents, as done in the field of Multi-Agent Systems. The field of cognitive architectures seeks to identify components that are necessary to create intelligent agents and investigates the interactions between these components. Such components may include mechanisms for perception and action, declarative memory, procedural memory, and working memory—these features have been formalized in the *Standard Model of the Mind* [Laird et al.(2017)], that derives from the analysis of influential cognitive architectures such as Soar [Laird et al.(1987)] and ACT-R [Ritter et al.(2019)]. Furthermore, other models for cognition exist and may provide valuable insight for the design of cognitive architectures, such as the Global Workspace Theory proposed by Baars [Baars(1993)] to explain consciousness and applied to the design of cognitive architectures such as LIDA [Franklin et al.(2012)]. An agent created based on these principles is capable of performing complex tasks in the environment to achieve its goals, is capable to learn from the environment, and is capable to adapt its behavior to continue pursuing its goals in a changing environment.

Unifying the two threads of thought of cognitive architectures and multi-agent systems, we may consider that research on cognitive architectures could be applied to the study and design of multi-agent systems in order to design organizations that integrate heterogeneous agents. Such a *cognitive organization* would enable agents to combine their (heterogeneous) knowledge and (heterogeneous) cognitive skills to perform tasks that isolated agents would not be able to perform, or to simplify the process of learning how to perform specific tasks.

I propose that the Web should play a key role in the construction of a Global Cognitive Organization by providing an open, distributed, and scalable

environment that is *inclusive* for heterogeneous agents. Indeed, this should provide the Global Cognitive Organization with a uniform way to perceive and act, which are key functions for cognitive architectures. The Web of Things, which enables the creation of interoperable systems of physical devices, can further be used to extend perception and action to the physical world. In addition, crucially, the Web may furthermore act as a Global Workspace [Baars(1993), Beigi and Heylighen(2021), Heylighen(2007)] to regulate the individual agents' access to the abilities of other agents in the Global Cognitive Organization, and to their knowledge (which may be represented on the Web as a Global Associative Memory [Heylighen and Bollen(1996)]).

2 From the Signifier Exposure Mechanism to a Cognitive Architecture for Web-based Multi-Agent Systems

Signifiers are pieces of information present in the environment that indicates to agents the affordances that are available to them, i.e. what the environment enables them to do to achieve their goals [Norman(2013), Lemee et al.(2022), Vachtsevanou et al.(2023)]. Agents are able to perceive information (through signifiers) about the affordances they can use in their environment. These signifiers might be filtered and adapted based on information provided in an agent profile and based on the current state of the environment through a Signifier Exposure Mechanism (SEM), defined in [Lemee et al.(2022), Vachtsevanou et al.(2023)]. This allows the agents to only perceive those signifiers that are expected to be relevant to the agent. Through this mechanism, agents might hence be enabled to more efficiently navigate an environment to achieve its goal.

The SEM also enables agents to add signifiers into the environment. As a result, the SEM could be used to broadcast information from one agent to all the other agents that would benefit from this information, which resembles the ability of a Global Workspace to regulate access to other agents' abilities and knowledge. As a consequence, I propose that the concept of a SEM should be explored further as a potential direction to create a *Web-based Global Workspace*.

In conclusion, I posit that Global Workspace Theory and the Standard Model of the Mind (among others) are valuable concepts that may be extended to create a cognitive architecture for Web-based Multi-Agent Systems. As discussed, this architecture would make efficient use of the hypermedia and distributed nature of the Web. It should be open enough to enable heterogeneous agents to join it and remain scalable to the size of the Web. This cognitive architecture should also be able to integrate humans: It should enable humans to interact with other types of agents, thereby benefiting from the knowledge and abilities possessed by these; and it should, vice versa, enable agents to access human knowledge and abilities (i.e., a human-in-the-loop approach).

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