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# Finding the Critical MAS(S): Resources and Representations Needed for Weaving a Web that Hosts Linked Multi-Agent Systems

Position Statement for the Dagstuhl Seminar 23081 “Agents on the Web”, Feb 2023

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**Abstract:** Linked Multi-Agent Systems (MAS) is a vision where MAS are linked through their resources and representations, supporting knowledge augmentation for human and software agents on the Web and the linking and interoperability of different MAS. The goal of Linked MAS should not be to have one MAS platform or one MAS system on the Web but to allow us to turn the Web into an architecture supporting a network of interoperable MAS. The different statements submitted by participants of this Dagstuhl-Seminar 23081 show the variety of challenges to face and in this short position statement I will add a few ones to the list: the need for a viral first use case, the metadata specifically needed for hMAS, the need to think the insertion of hMAS in the initiatives for (re)decentralizing the Web and the need to make hMAS a usable extension of the Web.

**A small but viral first hMAS.** I concluded my statement for the Dagstuhl Seminar 21072 in 2021 by reminding that one of the hardest tasks for Tim Berners-Lee in the early 90s was to make people imagine a world with a fully deploy Web and that we have the same cold-start problem with the Agents on the Web [A]. I still believe this to be a strategic question for the Dagstuhl Seminar 23081 in 2023. In Hypermedia Multi-Agent Systems (hMAS), agents operate on an homogeneous hypermedia fabric that interconnects heterogeneous resources. The Web is the distributed hypermedia that has become the primary software architecture for applications on the Internet but not for Multi-Agent Systems, at least not yet. We are getting closer but we are not there and, in my opinion, a key step is to identify at least one use case that, not only could demonstrate hMAS but, more importantly, that has the potential to reach a critical mass of usage, the tipping point of a network effect like it was the case in the past successes of the Web [B]. Therefore, together with a proposal of a standard architecture, we need to find incentives and added values for hMAS to be taken on by industry and developers. In my opinion, a catalogue of promising applications has less potential than a small but viral first application.

**The right metadata soil for growing hMAS.** A lot of effort has been invested in knowledge acquisition and knowledge publication. We participated to that effort, with methods to index (IndeGx) [M], visualize (Kartographi) and annotate (Metadatamatic) linked data(sets)[N]. But for a first viral hMAS to happen we need the right breeding ground, we need to target metadata that have an impact on targeted adopters, largest users’ community, etc. Moreover, with native mechanisms such as conneg (content negotiation over HTTP) the Web can do much more and support adaptative knowledge exchange of customized representations for human and software agents. The Web has the potential to support profile-based knowledge negotiation for AI methods. The definition of artificial intelligent agent profiles would allow them to rely on the negotiation mechanism of the Web to obtain or contribute the type of knowledge they can process. Such an open negotiation could also be a key enabler for forward compatibility in open hMAS.

**The position of hMAS in the effort of (re)decentralization.** As I already wrote somewhere else [AA], even more than AI, it is distributed AI that has a rendezvous with the Web. By nature, the distributed artificial intelligence paradigm of MAS can participate to the (re-)decentralization of applications and their architectures in general, and on the Web in particular with hMAS. This requires positioning hMAS w.r.t. other initiatives like [SOLID](#): while the notion of hMAS is being studied now, the prospect of a SOLID-hMAS should be part of these reflections. This also raises a chicken and eggs problem: do we need a course-correction to occur for the Web to be (re-)decentralized again before envisaging agents on the Web or should we work on hMAS systems to provide a course to (re-)decentralize the Web? Moreover, when we chase centralisation out the door it often comes back in through the window: we may decentralize the architecture, but witness the applications recentralize usage; we may decentralize the applications but witness they build data siloes; we may decentralize the data but witness imposed schemata creating a centralized conceptualization, etc. A decentralized Web, in general, has to work on all these fronts at the same time and hMAS, in particular, will have to consider all of them too.

**Extend and make easier the existing solutions.** To conclude I want first to insist on the fact that hMAS must be conceived as an extension of the Web and not as another Web or as a Web apart. The futures of the Web must be suited both for “software- and human-agents” [O] and it may reopen the discussion on the relation between humans and agents in MAS both conceptually and practically i.e. positioning software- and human- agents not only from an architectural or conceptual point of view but also in terms of interaction design or delegation for instance. This may also echo discussions on other current trends in computer science such as the topic of digital twins (for artefacts, for users, etc.). Finally, while I concur with many of the challenges and open questions identified in the other position papers of this workshop I would like to conclude on a “meta-risk”. In the history of computer science, we have many examples of a language, an architecture or a tool been reinvented because the previous ones had become too complex for newcomers, for simple use cases, etc. In what we will propose we must thrive to avoid the Déjà Vu of a technology stack that becomes too complex with an adoption cost too high and making the bed for the temptation to create something initially seemingly simpler on the side but that will end up being the first layer of a new technology stack continuing the cycle of reinventing languages, architectures, formats, etc. again and again.

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