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`stigLD`: Stigmergic coordination of Linked Data prosuming agents

René Schubotz, Torsten Spieldenner, and Melvin Chelli

German Research Center for Artificial Intelligence
Saarland Informatics Campus D 3 2, Saarbrücken, Germany

Hypermedia multi-agent systems [1], sometimes also referred to as *Linked Systems* [2], are receiving increasing research attention. The hypothesis is that the Web provides a scalable and distributed hypermedia environment that embedded agents can use to uniformly discover and interact with other agents and artefacts. Following a set of design principles very much aligned with REST and Linked Data best practices, the design and deployment of world-wide and long-lived hypermedia MASs with enhanced scalability and evolvability is aspired.

In this context, we are specifically interested in *stigmergic coordination principles* for hypermedia MASs. Stigmergy provides an indirect and mediated feedback mechanism between agents, and enables complex, coordinated activity without any need for centralised planning or control, direct communication, simultaneous presence or mutual awareness.

A crucial part of any stigmergic system is its *stigmergic environment* given that "it is its mediating function that underlies the power of stigmergy" [3]. Accounting for this pivotal role, we thoroughly examine and confirm the suitableness of Linked Data for the realisation of sematectonic and persistent marker-based stigmergic systems in [4].

When considering some of the prime examples of stigmergy, e.g. ant or termite colony optimisation methods [5, 6], it becomes however apparent that a purely reactive Linked Data environment is insufficient for the implementation of *transient marker-based stigmergic systems*. In fact, the environments of such systems typically demonstrate some *endogenous dynamics*, e.g. diffusion, evaporation, or atrophy, and - in addition to being malleable and perceivable by all agents under coordination - *actively* drive the evolution of such agent-less dynamic processes.

In [7], we formally model aforementioned observations using a value-passing fragment of Milner's Calculus of Communicating Systems [8] and develop `stigLD`[1] , a Linked Data framework for facilitating the design and declarative implementation of sematectonic, persistent marker-based and transient marker-based stigmergic mechanisms within a hypermedia MAS.

We demonstrate the genericity and effectiveness of `stigLD` by tackling shopfloor scheduling [4] as well as shopfloor logistics [7] problems in a make-to-order fulfilment scenario. Our solutions are based solely on stigmergic principles, display emergence of self-

[1] `https://github.com/dfki-asr/stigLD`

organized coordination from simple agent behaviour and compare favourably against baseline strategies.

In ongoing research, we are concerned with benchmarking against selected problems from the International Planning Competition [9] and investigate evolutionary approaches for automating the design of stigmergic hypermedia MASs.

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