Advances in information technology, instrumentation and communications are making it increasingly possible to devolve common-pool resource management to socio-technical systems (e.g. community energy systems, irrigation systems). Previous work has shown how the institutional design principles of Elinor Ostrom combined with Rescher’s theory of distributive justice can lead to fair and sustainable resource allocation in open computer systems.

However, these results were based on a single provision and appropriation system for one common-pool resource (CPR). There is clearly an issue of scale: the overheads of collective choice procedures, which are sine qua non for fairness and sustainability properties, are prohibitive for systems with hundreds, or thousands of appropriators. Fragmenting the CPR to deal with the issue of scale introduces a problem of co-dependence: a standalone subsidiary CPR risks wasting resources if it produces more than it needs, and risks shortfalls if it produces less. Therefore an efficient system of exchange between CPRs, in some kind of hierarchical structure, is also required.

Such a structure, of CPR institutions of a similar type, is characteristic of Ostrom’s design principle of nested enterprises, whereby local CPRs were aggregated into larger ones operating at a regional one, and so on. However, closer examination of large scale CPRs, for example operating at a city level, revealed that the system was actually composed of a wide variety of actors, mixing both public and private concerns, including policy makers and grassroots pressure groups, in a complex system of checks and balances that ensured that separate goals were met while maintaining its overall survivability. For this reason, Ostrom and colleagues recommended a polycentric system of self-governance (i.e. decision-making distributed amongst different actors at different levels), but they were less clear on the design principles required to achieve this.

Therefore, this project will address three successive but inter-related challenges. The first challenge is to develop a model of structured CPRs and a system of exchange that ensures fairness and sustainability. This will require converging existing models of self-organising electronic institutions and electronic social capital with software engineering methods for patterns of structuration based on holonic systems architectures. The second challenge is to extend this model to a holonic system for polycentric self-governance. This will require leveraging multi-agent simulation and animation tools to model the goals, strategies and interactions of the heterogeneous actors in large-scale resource management systems. This research will provide insight into the relationship between structure (and structural patterns) and (global) systemic properties such as sustainability, resilience, etc. The third challenge is evaluate these proposals, either by using Serious Games for, or gamified, socio-technical systems, or even a field trial, for example in community energy systems.

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