The ecology of task allocation: costs and benefits of different algorithms

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Complex systems often need individual workers to spread over different tasks. In self-organized systems, these individual workers choose a task based on some set of decision rules (which we call the task choice algorithm). These internal algorithms typically should solve two problems at the group level. First, initially similar workers should end up in different tasks (load balancing); second, these workers might need to dynamically switch tasks when demands for work change. Both of these goals and the possible constraints to achieving them (e.g. switching costs, limited information) are general to task allocation algorithms not only in social insects but in other fields, such as distributed computing. Research in social insects has typically focused on the challenge of generating diversity (e.g. by employing developmental switches to make morphological castes or positive feedback through learning to generate behavioral specialists); however, if accurate task allocation matters, social insect colonies should also be under selective pressure to solve the second challenge, namely achieving a dynamic match between need for work and workers allocated to the task. Using proof methods from Distributed Computing, we show that achieving such a match optimally may be trivial or impossible, depending on the assumptions made about what information is available to individuals. We also argue that under minimal realistic assumptions, individually varying response thresholds to task-demand stimuli are not sufficient to achieve dynamic load-balancing. These results suggest that the problem of task allocation is more complex than has been appreciated previously.