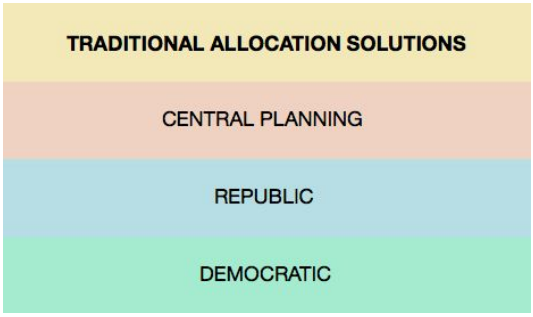
Self Organized Resource Allocation



Central Planning ~ Republic ~ Democratic ~ Self Organized

The vast majority of resource allocation procedures are done using central planning.[1] During central planning resource allocation, the resource is allocated to a work unit by a central planner using the power invested in them by the resource owners. An example of this would be a manager in car production plant allocating use of a robotic arm to the car door production team.

Whenever there is a resource and that resource is owned by an entity outside of those whom the resource will be allocated to, there are investment risks[2] and monitoring costs[3] associated with the management and distribution of the resource.

Central planning costs tend to be ones associated with bureaucracy costs[4] of the planner and opportunity costs associated with the lack of buy in of the receiving party.

When considering a self organized group, a democratically elected representative (i.e. a republic) can distribute the resource with the speed of a central planning owner. The costs would be those associated with setting up the democratic process and whatever inefficiencies, monitoring costs, or opportunity costs associated with the lack of ownership of the representative[5].

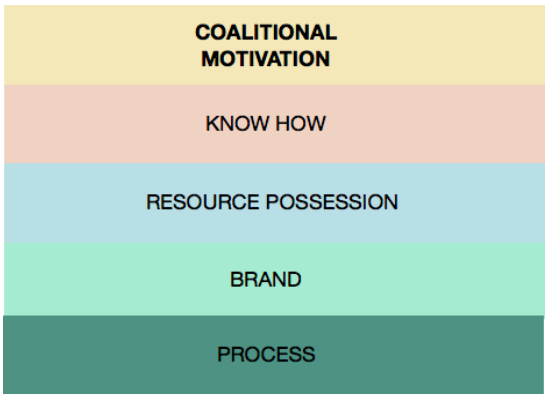
A more democratic form of self organization can be performed by having an all member vote where the resource should be allocated. The costs associated here are the accumulative costs of the central planner and the republic along with the lost speed resulting from having to tally a vote every time a decision is made[6][7].

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[1] "According to J. Bradford DeLong, a significant portion of transactions in Western economies do not pass through anything resembling a market.", https://en.wikipedia.org/wiki/Economic_planning#Intra-firm_and_intra-industry_planning
[2] https://en.wikipedia.org/wiki/Adverse_selection
[3] https://en.wikipedia.org/wiki/Moral_hazard
[4] https://en.wikipedia.org/wiki/Red_tape
[5] https://en.wikipedia.org/wiki/Republicanism#Democracy_and_republic
[6] https://en.wikipedia.org/wiki/Criticism_of_democracy#Administrative_criticisms
[7] https://en.wikipedia.org/wiki/Criticism_of_democracy#Efficiency_of_the_system

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With all of the costs of the more democratic ways of assigning resources, it is no wonder why self organized groups are more popular among teams where little to no resources have to be assigned (for example, professional service firms). The remainder of this work concentrates on the issues and solutions a self organized group faces with respect to resource allocation.



Work Unit -> Inputs ... Outputs

The process of economic activity within a work unit is to convert inputs into outputs[8]. The work unit's inputs consist of raw materials (e.g. iron or business requirements) and resources (e.g. welding equipment or a supercomputing cluster) which are then converted into outputs (e.g. iron rods or executive reports). With respect to distribution, resources can be categorized as non-diminishing, divisible, and non divisible. A non-diminishing resource can be allocated to as many agents as possible without diminishing the value. Non-diminishing resources, such as open source software, don't have problems of scarcity or resource allocation and so are not addressed here. A divisible resource can be split up and allocated across numerous agents with the threat of diminished value. A non-divisible resource can not be spread among agents but rather must be allocated to an individual agent or coalition. The problems addressed in this work cover divisible and non-divisible resources as they suffer from problems that arise from scarcity.

Value Creation -> Know How (Process) -> Inputs, Resources, Brand

The motivation for an owner of a resource to allocate that resource to a work unit stems from efficiencies related to know-how in the form of brand awareness and process execution surrounding the resource. A work unit with the ability to output something valuable to a market has intimate knowledge of a process surrounding the inputs and resources as well as value of the output created. The work unit can and should have the knowledge of how to position the

[8] https://en.wikipedia.org/wiki/Production_theory

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end product developed (while using a specific resource) in the market that will consume it. This same work unit would therefore put a higher value on obtaining the resource over another work unit that may not have this knowledge. Work units that can internally rationalize a value for a resource can then make arrangements to obtain that resource by presenting a return on investment to the resource owner.



Is <> Ought

The planning paradox is an application of David Hume's ethical is/ought[9] dilemma to resource planning. That is to say, how do we get from where a resource *is* normally assigned to, to where it ethically or rationally *ought* to be assigned to? When talking about resource allocation, the first confusion is often about fairness. Who owns the resource legally, and what do they want to do with it? Most people assume the owner of a resource *ought* to be the one doing the allocation. This opinion seems to change when thinking about the allocation of public goods, where people tend to believe in appointed (but not necessarily democratically elected) experts who can allocate resources better than the general public. If the resource is owned by an umbrella entity (e.g. a cooperative) and is going to be reallocated to a sub group, the situation turns into one of investment. The sub group is essentially an agent, who will give some kind of return to the principal[10] or perhaps eliminate the waste of an otherwise unused resource. In this case, it seems rational that the principal *ought* to allocate the resource to the agent with the best return.

This is all different when compared to how a resource *actually* gets allocated. Resource allocation is typically heavily affected by precedent (who has made use of the resource previously?), negotiation skill (which may incur lobbying costs), charity, and threat of reprisal.

Play Market -> Short Term Strategy, Empire Building

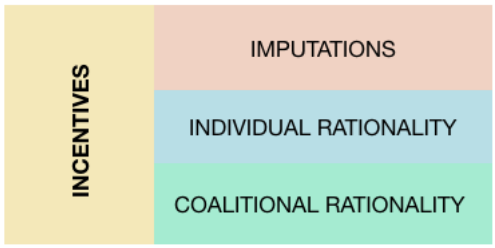
[9] https://en.wikipedia.org/wiki/Is%E2%80%93ought_problem
[10] https://en.wikipedia.org/wiki/Principal%E2%80%93agent_problem

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The question 'should we allow reallocation?' requires an investigation into the concept of a false or 'play' market. A play market occurs when actors in a market can have their resources taken away by a central planner. There are two situations that describe a resource being taken away:

1. The resource is *bestowed* upon a work unit by the central planner or umbrella organization and then is taken away.
2. The work unit *creates* a resource, and then has the resource taken away by the central planner or umbrella organization.

Both instances create an environment where short term strategies are preferred over long term strategies. The latter situation additionally creates an environment that is hostile to innovation and the creation of valuable resources.



Most Incentivized Agent -> Rational Resource Allocation

Since a work unit can and should have intimate knowledge of the value of outputs in the markets they output to, it follows that some kind of principal/agent or parent/work-unit contract is possible. If a principal (the umbrella group) is to allocate a resource to the best agent (work unit), the principal must have some idea of what outcomes would obtain if the agent were allocated the resource to the agent with the best incentives. The set of outcomes of all the agents in the umbrella organization need to be taken into account in order to find out if the agent is rational when making the decision to use the resource as an individual or as a coalition.

In game theory, a group that works together is called a coalition. A resource game that describes coalitions in characteristic function form[11] maps out all of the values of each coalition's output as if that coalition obtained the resource. This type of description of the resource allocation problem assists in reasoning about coalitional rationality. A simple example of a coalitional game would be a five person legislature with three people forming a coalition with respect to a vote. The value would be (3-person: 1, 2-person: 0) or (3-person: 1, 1-person: 0, 1-person: 0) because majority voting is a winner take all situation (see examples).

[11] "... characteristic function form. With each coalition is associated a number: the value of that coalition. The value of a coalition is analogous to the value of a game in the two-person case. It is the minimum amount that the coalition can obtain if all its members join together and play as a team. ", Davis, Morton D. (2012-07-31). Game Theory (Kindle Location 2497). Dover Publications. Kindle Edition.

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An imputation is a set of awards that cover all parties (individual or coalition) involved[12]. An example imputation would be (umbrella org: $1000, member A: $0, Coalition B (Member C, Member D, Member E): $5000). Imputations in characteristic function form can be used as a description of groups who would be incentivized the best if given a resource.

Five Person Legislature Vote In Characteristic Form, Imputation 1	
Coalition	**Value**
3-person	1
1-person	0
1-person	0

Five Person Legislature Vote In Characteristic Form, Imputation 2	
Coalition	**Value**
3-person	1
2-person	0

Individual Rationality <> Coalitional Rationality

When considering an individual's rationality, one way to consider it is through Pareto optimality. Pareto optimality is the state of allocation of resources in which it is impossible to make any one individual better off without making at least one individual worse off. The lack of Pareto optimality demonstrates inefficiency.

When considering a coalition of individuals, it becomes necessary to consider what is called the core[13]. If there are core imputations that incentivize one or more agents to act as a team when given a resource, that team has the internal incentive to form (i.e. self organize) and act appropriately with respect to the resource.

[12] "If you were asked to pick out a single imputation as the predicted outcome of a game, the most attractive candidate would seem to be that imputation which is not dominated by any other. There is a problem, however. There needn't be just one undominated imputation; there may be many. Worse still, as we have already observed, there may be no undominated imputation at all.", Davis, Morton D. (2012-07-31). Game Theory (Kindle Locations 2599-2600). Dover Publications. Kindle Edition.

[13] "The coalitionally rational imputations (if there are any), taken together, constitute the core. If a game has no core, it is unstable in the sense that whatever the payoff, some coalition has the power and motivation to break up the imputation and go off on its own." Davis, Morton D. (2012-07-31). Game Theory (Kindle Locations 2561-2563). Dover Publications. Kindle Edition.

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Rational Internal Contracts ~ Playing Market

When an umbrella organization has contracts in place that promote rationality in general, self organization can emerge without the threat of intervention and playing market.



Finding Incentivized Work Units

How do coalitions form? There are many ways to judge rationality of allocations. We will present three ways that each have unique benefits and drawbacks.

N-M Solution -> N Imputation Equilibriums -> N Incentivized Work Units

The N-M Solution was created by Von Neumann and Morgenstern who are the founders of game theory. It considers all imputations within a core and compares them to all imputations outside of the core. The N-M solution guarantees that no imputation is dominated (i.e. better than) another imputation inside of the solution. It also guarantees that every imputation outside of the solution is worse than every one that is inside of the solution. This creates a solution that is a set of imputations that are easy to reason about.[14] This set of imputations could make up the core of a contract promise of non-intervention by an umbrella entity when allocating a resource.

The drawback to N-M is that there are numerous imputations within the solution to choose from (a fact that was seen as a benefit by it's creators). N-M is good when attempting to answer who *should* receive a resource.

A-M Solution -> Predicting Work Units

The Aumann-Maschler theory attempts to predict what the payoffs would be within a coalition once a coalition is formed. The A-M theory is useful for determining the incentives for an

[14] "1) No imputation in the solution is dominated by any other imputation in the solution; 2) Every imputation that is not in the solution is dominated by an imputation that is in the solution.", Davis, Morton D. (2012-07-31). Game Theory (Kindle Locations 2612-2614). Dover Publications. Kindle Edition.

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individual to join a coalition, and then to possibly help resolve distribution of payoffs within the coalition given the power of it's players. Because of this, the A-M solution is normative in the sense that it helps with reasoning about the question of what value a resource *will* produce when a coalition forms.[15] This is in contrast to what *ought* to be produced when everyone is acting rationally.

Through a system of enforceable objections and counter-objections, A-M aims to predict which coalitions and payoffs will hold under player pressure, which very well may *not* be pareto optimal (i.e. rational).[16]

Shapely Solution -> Agent's Value Of Resource

The value of obtaining a resource with respect to an agent or work unit is explored in Lloyd Shapley's solution for n-player games. The Shapley Value is a good way to measure the marginal value an agent brings to the total cooperative effort. Put another way, the Shapley Value is the value of playing a game to a particular player. This technique has been used to calculate the amount larger and smaller airlines should contribute to the price of a large run way. Since a small airplane does not need the larger runway that a larger airplane would need, the the value of the larger runway was distributed to the larger airlines by allocating the extra money based on Shapley value[17].

Decentralized Allocation ~ Distributed Allocation

The more decentralized allocation is, the more monitoring must be in place in order to ensure bureaucracy costs do not create inefficiencies. As noted elsewhere, decentralization[18] is not distribution[19]. In order to obtain a more efficient *distributed* self organized allocation of resources without having a high bureaucracy cost, there must be a generalized way to view fairness in contracts. The N-M, A-M, and Shapely solutions provide a way to reason about the optimal allocation of resources within a self organized group.

[15] "The A-M theory does not attempt to predict which coalition will form; its purpose is to determine what the payoffs would be once a coalition is formed. The theory takes into account only the strengths of the players; all considerations of fair play and equity are put aside.", Davis, Morton D. (2012-07-31). Game Theory (Kindle Locations 2674-2675). Dover Publications. Kindle Edition.

[16] "A-M are very much concerned with determining which coalitions and payoffs will hold under the pressure of players trying to improve their payoffs." Davis, Morton D. (2012-07-31). Game Theory (Kindle Locations 2790-2791). Dover Publications. Kindle Edition.

[17] Davis, Morton D. (2012-07-31). Game Theory (Kindle Locations 2877-2878). Dover Publications. Kindle Edition.

[18] https://en.wikipedia.org/wiki/Discipline_and_Punish#Discipline

[19] "Protocol is a system of distributed management that facilitates peer-to-peer relationships between autonomous entities.", Alexander Galloway, *Protocol: How control exists after decentralization* (Cambridge, MA: The MIT Press, 2004), p. 243

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