SAND Number 2011-8675 P

Complex Adaptive System of Systems (CASoS) Engineering Initiative

http://www.sandia.gov/CasosEngineering/

Sizing Strategies in Scarce Environments

Michael D. Mitchell

Walter E. Beyeler, Robert J. Glass, Matthew Antognoli, Thomas W. Moore

Sandia National Laboratories

2012 International Conference on Social Computing, Behavioral-Cultural Modeling, & Prediction

University of Maryland, College Park MD
April 3 – April 5, 2012

Sandia National Laboratories

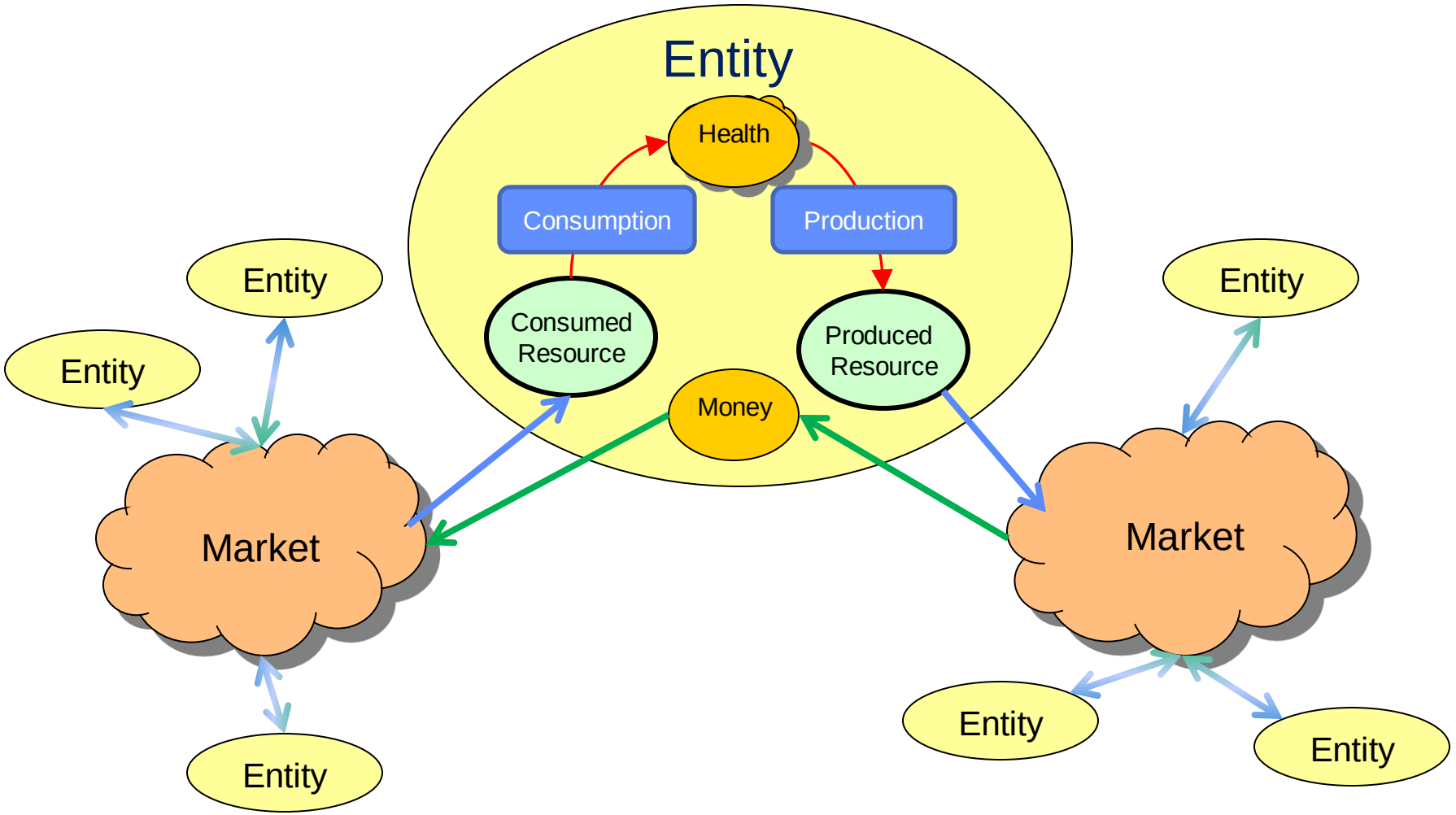
Complex Adaptive Systems (CAS)

- System: collection of interacting specialists that together serve a common objective
- Adaptive System: one in which complex adaptive system interactions among elements additionally produce emergent non-linear behavior

Study Overview

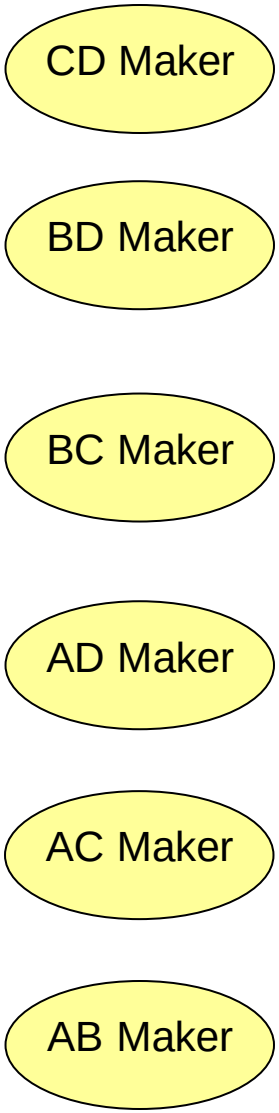
- Interacting Specialists (entities) with an ability to change size compete for resources in an environment subject to frequent periods of resource scarcity
- Common resource M which all entities require to survive, but none can produce
- Environment subject to varying episodes of scarcity
- Three sizing strategies: aggressive, moderate, and conservative

Exchange Model



Four-by-Six Configuration

Entity Type	Produced Resources	Consumed Resources
CD Maker	C,D	A,B,M
BD Maker	B,D	A,C,M
BC Maker	B,C	A,D,M
AD Maker	A,D	B,C,M
AC Maker	A,C	B,D,M
AB Maker	A,B	C,D,M



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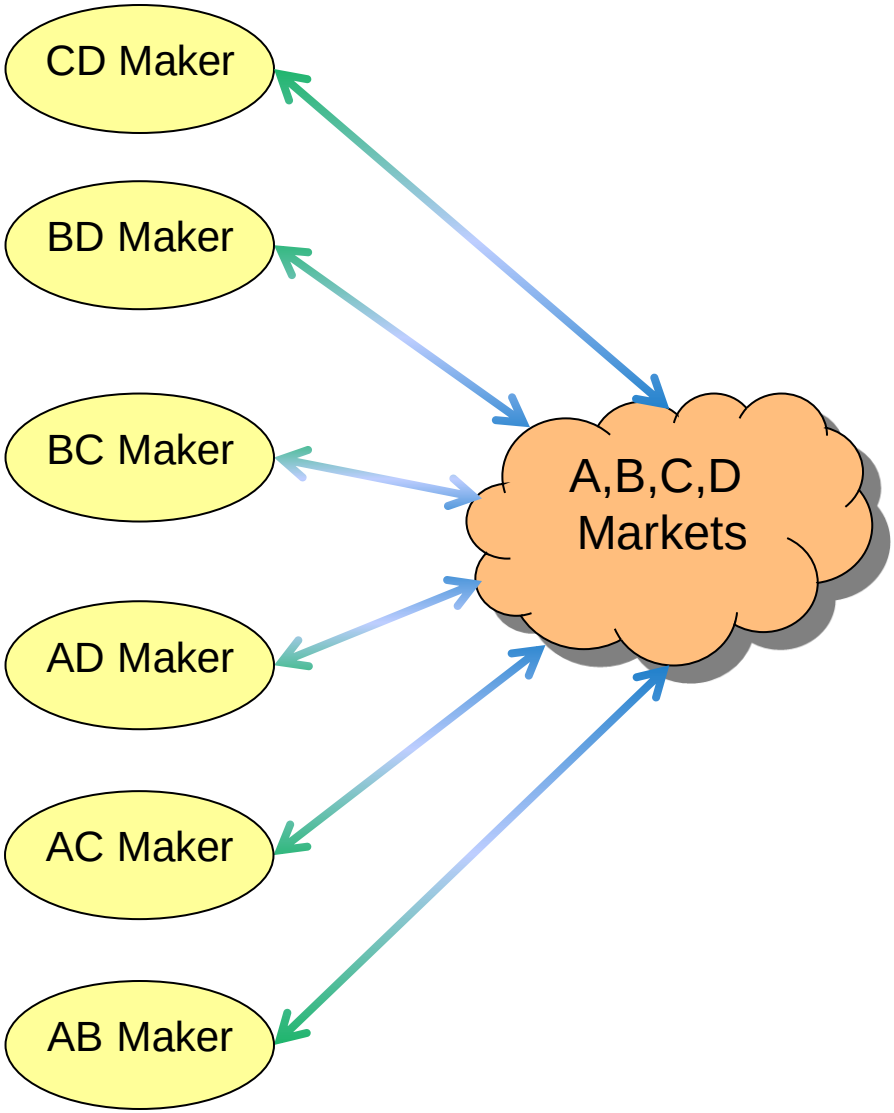

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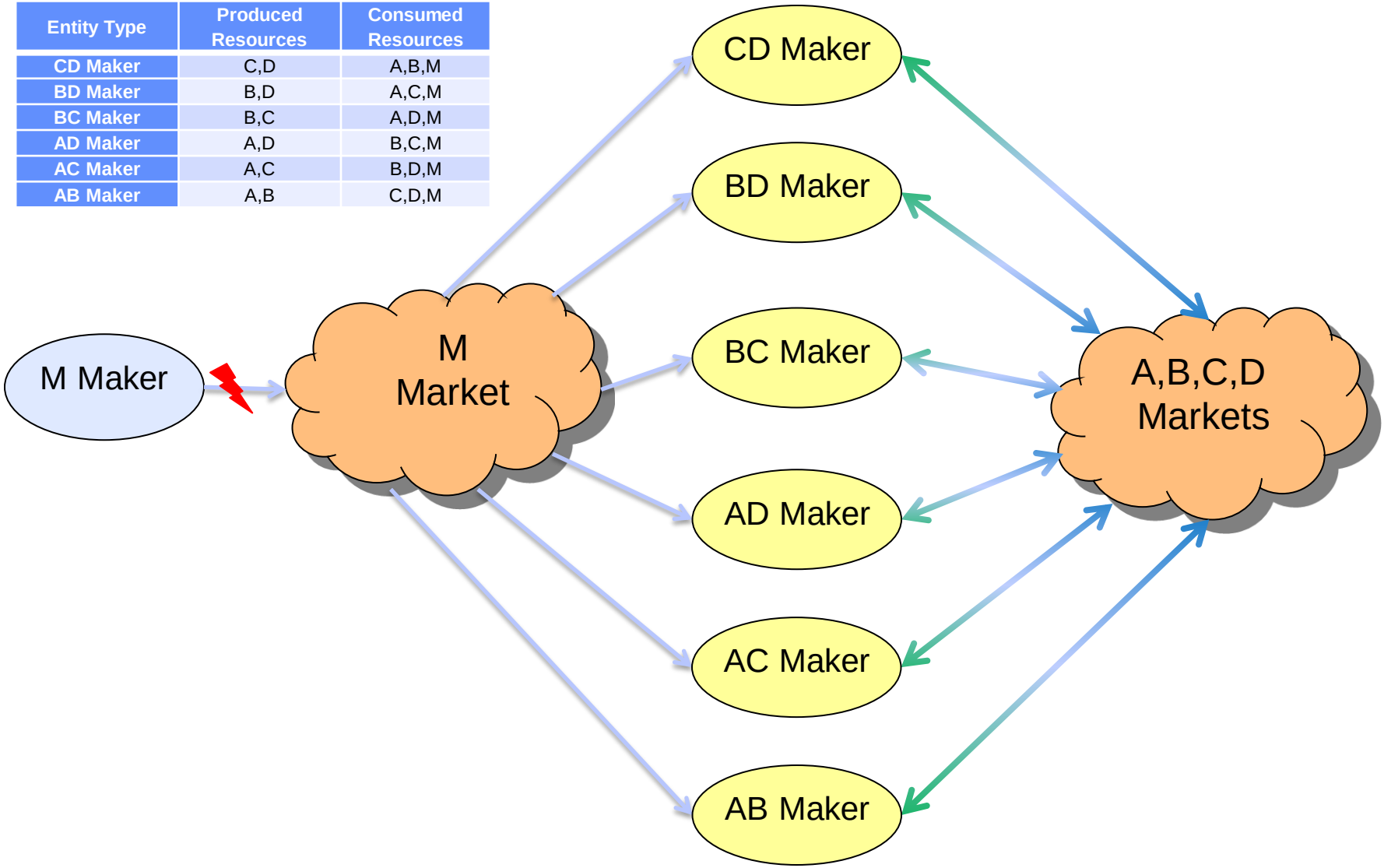
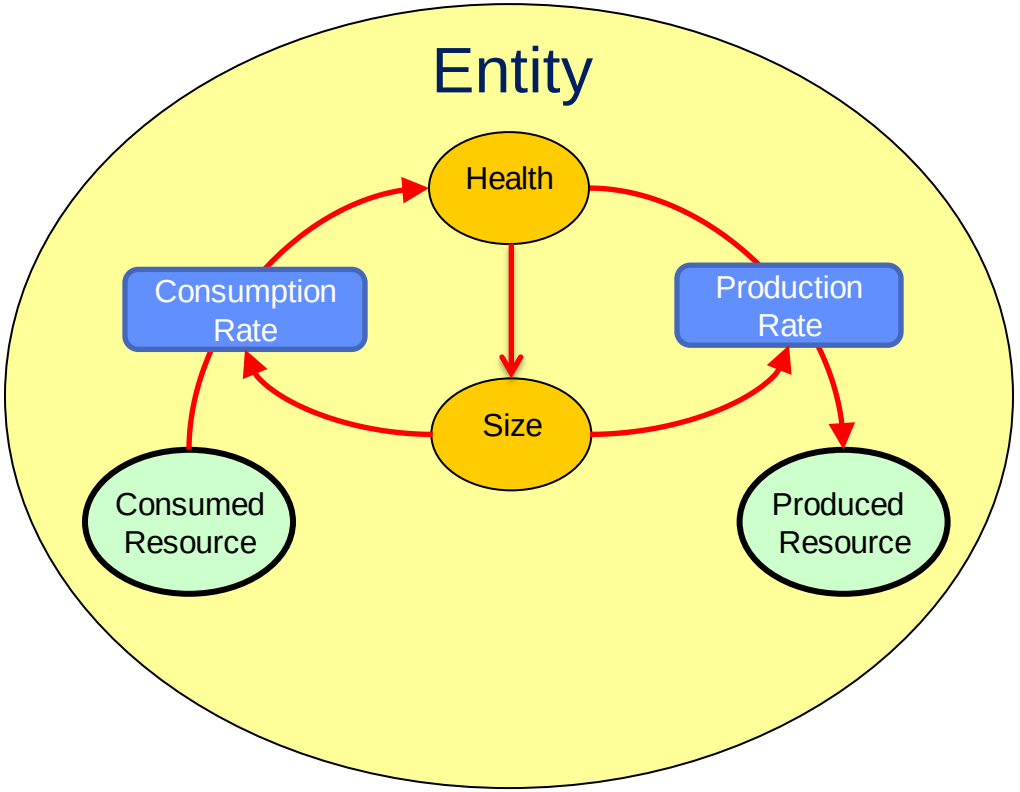


Growth

- Rate of growth is controlled by a time constant tGrowth
- Entities adjust to their environment by changing their size
  - $\frac{dS}{dt} = S * \frac{\left(\frac{h(t)}{h_0}\right)}{tGrowth}$
- Production and Consumption rates are a relative to the size of the entity



Simulation Parameters

Entity Type	Sizing Strategy	tGrowth
CD Maker	Aggressive	1.E+04
BD Maker	Moderate	5.E+04
BC Maker	Conservative	5.E+05
AD Maker	Conservative	5.E+05
AC Maker	Moderate	5.E+04
AB Maker	Aggressive	1.E+04

Three Sizing Strategies
- Aggressive
- Moderate
- Conservative

Disruption in the availability of resource M

Simulation ID	Frequency	Intensity
1	50%	10%
2	50%	20%
3	50%	30%
4	75%	10%
5	75%	20%
6	75%	30%
7	90%	10%
8	90%	20%
9	90%	30%

Market Share

Results are measured in terms of how much market share a strategy was able to capture

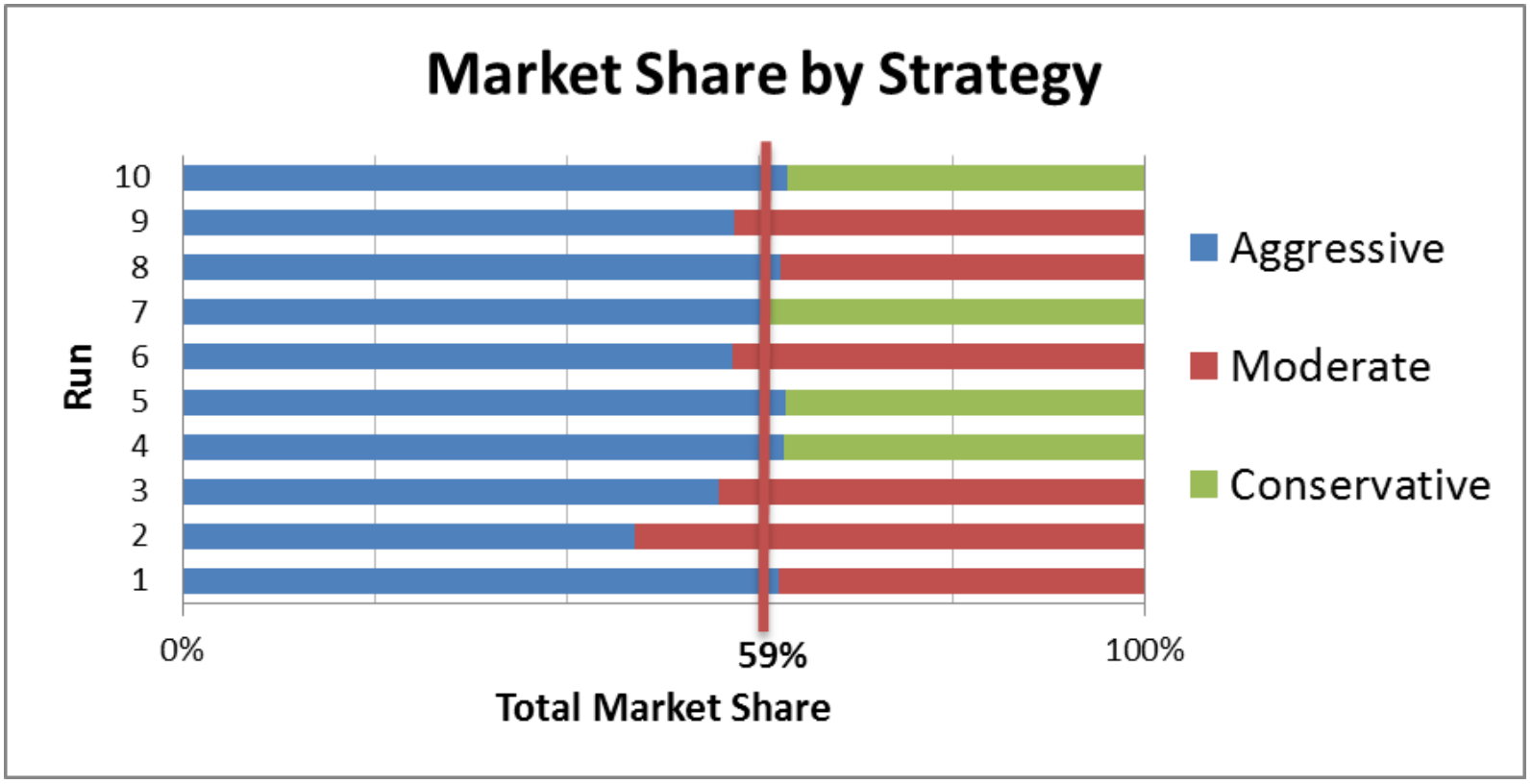
$$\phi_j \equiv \frac{\sum_{e \in T_j} \int_{t_f - p}^{t_f} h_{t,e} s_{t,e} dt}{\sum_{e} \int_{t_f - p}^{t_f} h_{t,e} s_{t,e} dt}$$

Intensity	10%			20%			30%		
Frequency	A	M	C	A	M	C	A	M	C
50%	**59%**	25%	15%	**52%**	35%	11%	**31%**	25%	23%
75%	**58%**	24%	17%	**63%**	21%	15%	26%	19%	**34%**
90%	31%	30%	**38%**	33%	**33%**	32%	28%	**40%**	31%

Totals do not sum to 100, due to some simulations where none of the strategies succeed

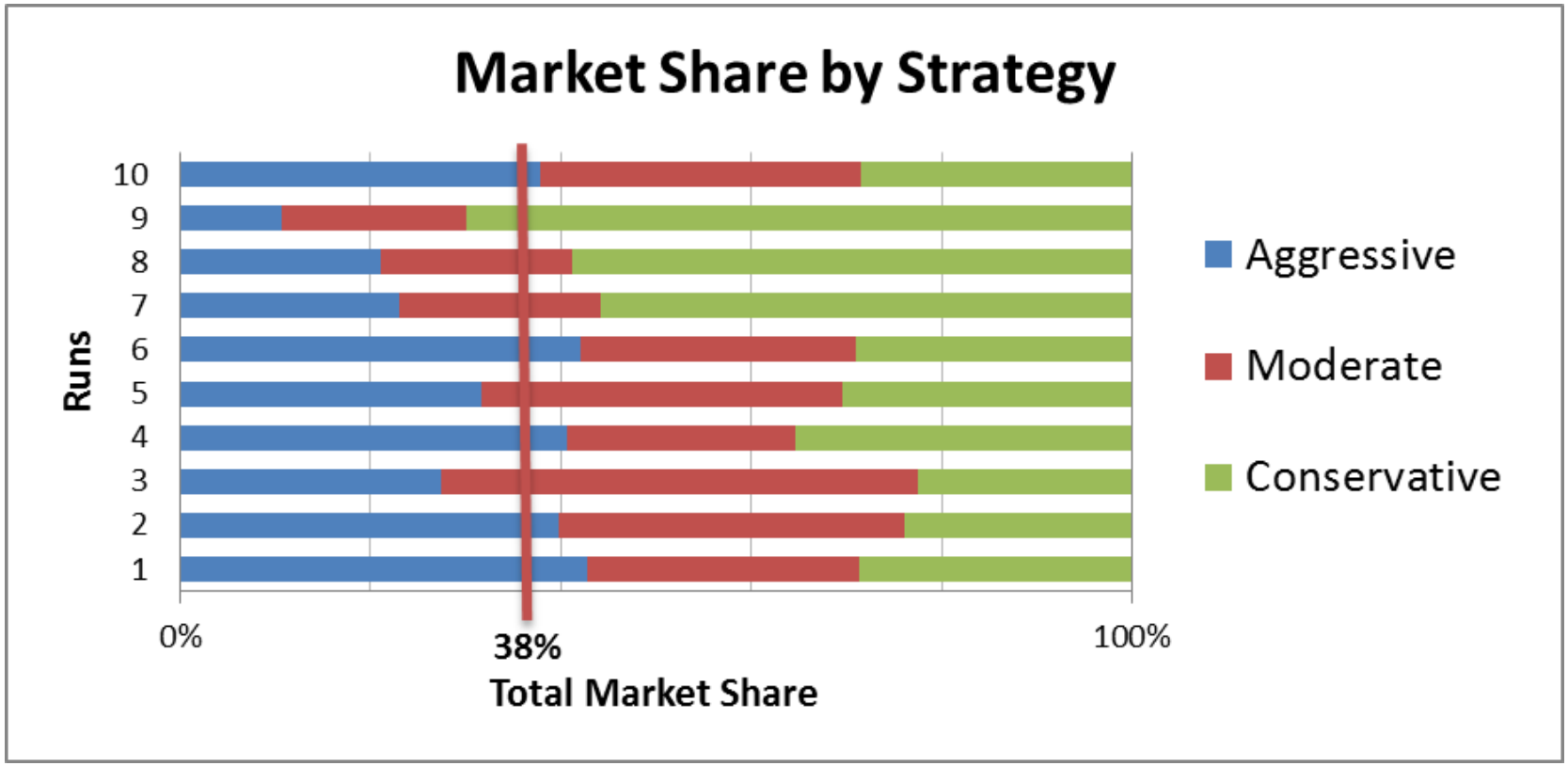
An environment 50% scarce, 10% intensity

Aggressive Strategy dominates by forcing a competing strategy out of the market



An environment 90% scarce, 10% intensity

Conservative strategy has the largest market share, but does not force a competing strategy out of the market



Summary

- The most successful strategies for periods of scarcity depend more on the duration of the recovery than the intensity of the scarcity
- Aggressive entities have an advantage during periods of recovery by using the first-mover preemption of assets strategy
- Longer frequencies of scarcity favor a conservative strategy

Questions