Fair Distribution of Collaboration Benfits

António Abreu
New University of Lisbon, Portugal

Luis M. Camarinha-Mato
New University of Lisbon, Portugal

INTRODUCTION

The participation in a collaborative network of enterprises is commonly assumed to bring valuable benefits to the involved entities (Afsarmanesh, Marik, & Camarinha-Matos, 2004; Axelroad, 1984; Dussauge & Garrette, 1999; Nemes & Mo, 2004; Penã & Arroyabe, 2002; Pfeffer & Salancik, 1978; Tuomi, 2003). These benefits include an increase of the "survival capability" in a context of market turbulence but also the possibility of better achieving common goals (Camarinha-Matos & Abreu, 2004; Richter, 2000; Saveri, Rheingold, & Pang, 2004). On the basis of these expectations are, among others, the following factors: acquisition of a (virtual) higher dimension, access to new/wider markets and new knowledge, sharing of risks and resources, joining of complementary skills and capacities, and so forth. But it is also easily recognizable that collaboration introduces high overheads due to the transaction costs (Williamson, 1975, 1985, 1998) which induce higher coordination costs and also due to the diversity of working methods and corporate culture.

How will my organization benefit from embarking on a collaborative network? Will the benefits compensate for the extra overhead and even the risks that collaboration implies? These are some questions that many small- to medium-sized enterprise (SME) managers ask when the issue of collaboration is brought in (Camarinha-Matos, 2003; Camarinha-Matos & Abreu, 2005; Seifert & Eschenbaecher, 2004; Vallejos & Gomes, 2004). In order to address this problem, the issue of benefit analysis in collaborative networks needs special attention. This article illustrates and assesses the applicability of the Shapley (1953) value in determining a fair distribution of benefits from collaboration.

SOME BACKGROUND

The Shapley value is a result of the collaborative game theory that has practical usefulness as an index for distribution of benefits in collaborative networks. In other words, the Shapley value can be seen as a measure of the *utility* of players in a collaborative or cooperative game.

The basic assumption is that the benefits obtained by a certain number of enterprises will be lower than the benefits obtained when incorporating a new element in the coalition. The Shapley value determines the average value of each enterprise's contribution to the coalition (Shapley, 1953). In order to better understand the concept, let us consider the following metaphor (Myerson, 1997):

Suppose that we plan to assemble a coalition of three partners (a_1, a_2, a_3) in a room, but the door to the room is only large enough for one actor to enter at a time, so the actors randomly line up in a queue at the door. There are |A|! (3! in this example, as illustrated in Figure 1) different ways that the actors might be ordered in this queue.

For any set S that does not contain the actor (a_i),

$$A = \left\{ \underbrace{a_1, a_2, ..., a_{i-1}}_{|S|}, a_i, \underbrace{a_{i+1}, ..., a_n}_{|A|-|S|-1} \right\}$$

there are

$$|S|!(|A| - |S| - 1)!$$

different ways of ordering the actors so that S is the set of actors who are ahead of actors a_i in the queue.

Thus, if the various orderings are equally likely, the following equation,

$$\frac{|S|!(|A|-|S|-1)!}{|A|!}$$

gives the probability that, when actor (a_i) enters the room, he will find the coalition S there ahead of him.

If (a_i) finds S ahead of him when he enters the room, then his marginal contribution to the worth of the coalition in the room is:

$$(v(S \cup \{a_i\}) - v(S))$$

The Shapley value of any actor is the expected marginal contribution of that actor when it *enters* the coalition. This metaphor also helps in implementing a practical algorithm for computing the Shapley value, as illustrated in Figure 3.

The Shapley value, $\varphi_{a_i}(v)$, for an actor a_i in a coalition of value v is given by the following equation:

$$\varphi_{a_i}(v) = \sum_{S \subset A \setminus \{a_i\}} \frac{|S|!(|A|-|S|-1)!}{|A|!} \times (v(S \cup \{a_i\}) - v(S))$$

where:

$\varphi_{a_i}(v)$ - Shapley value for actor a_i in a coalition of value v

A - Set of actors members of the coalition

S - All subsets of A that do not contain the actor a_i

Benefits Concept

The actual meaning of a benefit depends on the underlying value system that is used in each context. It is

Figure 1. Different ways of ordering the three partners in a queue

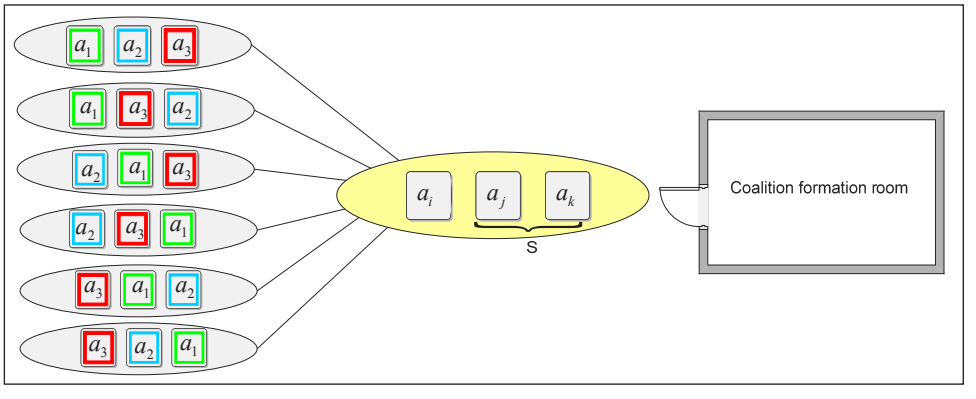

Figure 2. Example of benefit as a combined abstract value