Stabilizing the network in presence of agents using flow graph and Shapely value in B2B E-commerce

Samara Mubeen
Department of Information Science and Engineering
J.N.N.college of Engineering, Shimoga, Karnataka, India

Dr. K.N.Subramanya
Department of Industrial engineering and Management
R.V.College of Engineering, Bangalore, Karnataka, India

Abstract- B2B e-commerce is widely spread. One of problems is to identify the supplier who will manufacture sub product and send back to manufacturer for assembling it into a final product. After identifying the best supplier we want to transfer the information about the sub product to the supplier and supplier should respond to this via the agents. We are going to use a flow graph for designing the network having the supplier and manufacture and use Shapely value to check whether an exact sub product order by manufacture is reaches the back to the manufacture after manufacturing at the suppliers.

Keywords – Flow graph, Shapely value, B2B e-commerce. Agent.

I. INTRODUCTION

As competition from emerging economies puts pressure on global supply chains and as a new constraint emerges, it presents opportunities for new approaches such as the game theory approach to solving the transshipment problem. Recent real world examples of these principles illustrate how organizations have leveraged these ideas for competitive advantage. Dell Computer Corporation was able to overcome the strategic constraints of the bullwhip effect of increasing demand variation and forecast error in the upstream supply chain faced by the other PC manufacturers.
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In computer science graphs are used to represent networks of communication, data organization, computational devices, the flow of computation, etc. For instance, the link structure of a website can be represented by a directed graph, in which the vertices represent web pages and directed edges represent links from one page to another. A similar approach can be taken to problems in travel, biology, computer chip design and many other fields. The development of algorithms to handle graphs is therefore of major interest in computer science. The transformation of graphs has been often of major interest in computer science. The transformation of graphs has been often formalized and represented by graph rewrite systems. Complementary to graph transformation system focus on rule based in-memory manipulation of graphs are graph database geared towards transaction safe, persistent storing and querying of graph structured data.

A flow is a way of sending objects from one place to another in a network. The objects that travel or flows through the network are called flow units or units. For example, flow units can be a commodity, finished goods, or information. The network is presented as a graph with a set V whose elements are called vertices, and a set A of pairs of vertices called edges. The graph is denoted G = (V,A). In practice, we specify a flow as a directed graph. The vertices in a directed graph are commonly called nodes, and the directed edges are often called arcs. The nodes from which units enter through a network are called source nodes, and the nodes to which the flow units are routed to be called sink nodes. Source nodes offer supply, which is represented by the number of units available at the node. Sink nodes usually have demand, which is represented by the number of units that must be routed to them.

A Introduction to game theory

Game theory is the formal study of conflict and cooperation. Game theoretic concepts apply whenever the actions of several agents are interdependent. These agents may be individuals, groups, firms, or any combination of these. The concepts of game theory provide a language to formulate structure, analyze, and understand strategic scenarios.

A coalitional or cooperative game is a high level description, specifying only what payoffs each potential group or coalition, can obtain by the cooperation of its members. Cooperative game theory investigates such coalitional games with respect to the relative amounts of power held various players, or how a successful coalition should divide its proceeds

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The Shapely value is a tool used to various marketing problems. The Shapely value creates a score for each player in a game that represents that player's contribution to the total value of the game. The Shapely value is calculated across all possible models, that is, all possible combinations of predictors. This is what it different from measures of variable importance. The Shapely value has a useful property in that it sums to total R2 of the model with all of the predictor variables present. This means that it can be thought of as a decomposition of the total R2 into components associated with each predictor. The Shapely values are always positive. For a coalition S$\in$ C, v(S) is defined as the maximum flow value for coalition S and through the network of its members if it operates on its own. Which means that v(S) stands for the maximum flow that S can sustain using its own portion of the network. The function v just defined is called the characteristic function of the game. For a game (N, v), the core of v is defined by the set of all n-vectors X is satisfying ∑xiv(s) for all S$\subset$ N and ∑ xt-v (N). The constraints imposed on the Core(N, v) ensure that no coalition would have an incentive to split from the grand coalition N, and do better on its own. Meaning that an allocation of v (N) belongs to the Core (N, v) and is stable during the cooperation between the players.

The paper is organized as follows. Proposed model of b2b e-commerce using flow graph, Shapely value and. algorithm and results are presented in section II. Concluding remarks are given in section III.

II. Proposed Model of b2b e-commerce using flow grapgh and Shapley value

A. Flow grapgh model for two suppkier b2b model –

In case two supplier's b2b model supplier are selected randomly from among available ten suppliers. The manufacturer sends the information for manufacturing of the sub product to the supplier through the agents. The agents receive the information and pass it to the supplier the figure below shows the flow graph for the same.

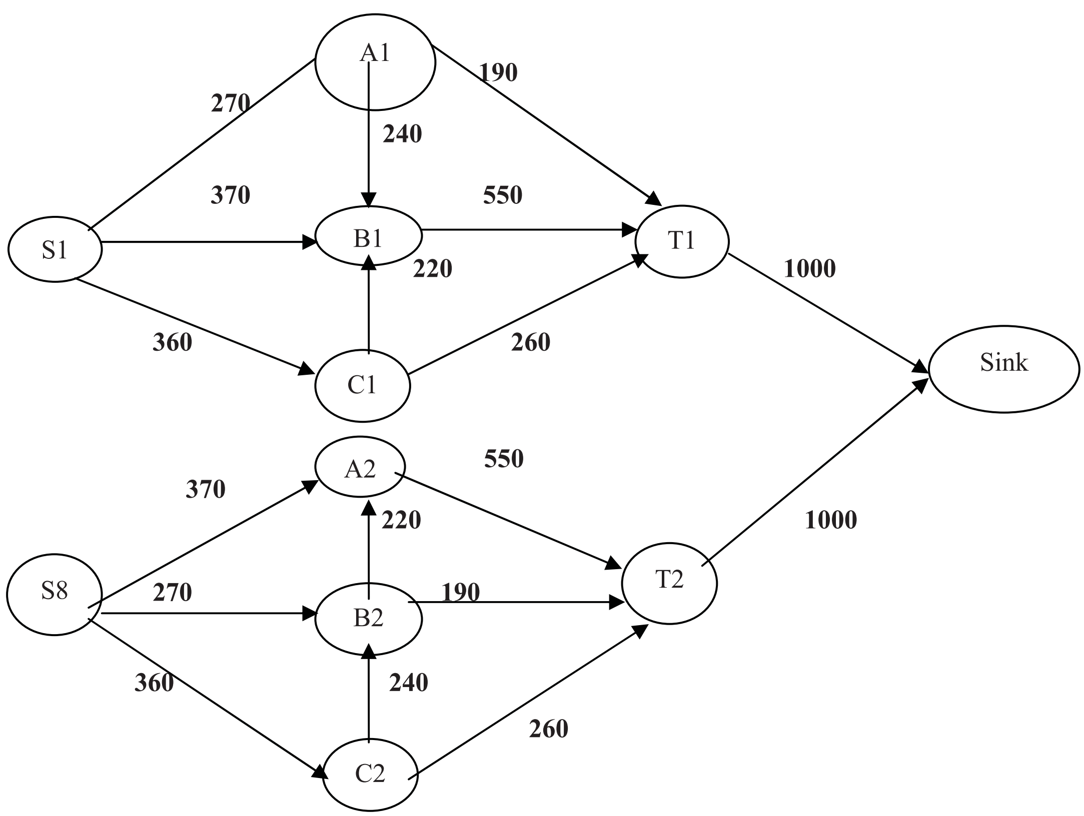

Figure 1. Flow graph for two supplier b2b e-commerce model

The figure1 shows the flow graph we consider the first sub flow graph having supplier s1 and three agents P1, P2, P3. P1 is agent owning upper arc (S1,A1) and (A1,T1), P2 is agent owning middle arc (S1,B1) and (B1,T1) ,(A1,B1),(C1,B1) ,P3 is an agent lower arc (S1,C1) and (C1,T1).Here one commodity i.e., product b is passing instantly from source S1 to the manufacturer the sink, the values written are the capacity value written. The values are obtained from the sub network from capacities given below:
V(s1)=190 V(a1)=370 V(b1)=260 V(s1a1)=640 V(s1b1)=450 V(a1b1)=730 V(abc)=1000.

Now that the game is known, a good question is how much of the 1000 order will be allowed to be acted by each agent. Suppose that the agents would solve this network problem, then by using the Shapely Value.

The second sub flow graph shows the second supplier s8 have three P4, P5, P6. P3 is agent owning upper arc (S8,A2) and (A2,T2), P4 is agent owning middle arc (S2,B2) and (B2,T2),(A2,B2) (C2,B2), P6 is agent lower arc are (S8,C2) and (C2,T2). The values are obtained from the sub network from capacities given below:

V(s8)=370 V(a2)=190 V(b2)=260 V(s8a2)=640 V(s8b2)=810 V(sb2c2)=450 V(a2b2c2)=1000

Shapely value of the game

For a game (N, v) the Shapely Value is the function SHi: (N, v) $\longrightarrow R^n$, which is given by

$$\text{SHI:}(N, V) = \sum (\{|S| - 1)!\,(n-|S|)!\,/\,n!\ *[V(S)-V(S-\{i\})] \quad (1)$$

For all $i \in$ N and V are the source.

For i = 1,the coalitions containing s1,are S = {s1}, {s12},{s13 },and {s123}.

$$S=\{1\};\quad |S| =1 \longrightarrow (1-1)!\,(3-1)/3!=1/3 \quad (2)$$

$$S=\{1,2\},\{1,3\};\quad |S|= 2 \longrightarrow (2-1)!(3-2)!/3!= 1/6 \quad (3)$$

$$S=\{1,2,3\};\quad |S|=3 \longrightarrow (3-1)!(3-3)!/3!=1/3 \quad (4)$$

Therefore for Shapely value are calculated as

For i=1, the coalitions S={1},{1,2},{1,3} and {1,2,3}

$$SH1 = (N,V)= 1/3[v(1)-v(0)] +1/6[v(12)-v(2)]+1/6[v(13)-v(3)]+1/3[v(123)-v(23)]$$
$$=190/3+1/6[640-370]+1/6[450-260]+1/3[1000-730]$$
$$=230 \text{ sub product.}$$

For i=2, the coalitions S={2},{1,2},{2,3}and{1,2,3}

$$SH1=(N,V)=1/3[v(2)-v(0)] + 1/6[v(12)-v(1)]+1/6[v(23)-v(3)]+1/3[v(123)-(13)]$$
$$= 370/3 +1/6[640-190] +1/6[730-260] +1/3 [1000-450]$$
$$= 460 \text{ sub product.}$$

For i=3, the coalitions S={3}{1,3}{2,3} and{1,2,3}

$$SH3=(N,V)=1/3[v(3)-v(0)]+1/6[v(13)-v(3)]+1/6[v(23)-v(2)]+1/3[v(123)-v(12)]$$
$$= 260/3+1/6[450-190]+1/6[730-370]+1/3[1000-640]$$
$$=310 \text{ sub product}$$

Hence the sub flow graph is calculated SH1+SH2+SH3= 230+460+310=1000 and the Shapely value for the cooperative game is obtained SH(N,V)=(230,460,310). The Shapely value for the second supplier s8 is calculated as Sh1+Sh2+Sh3=460+230+310 .The units which belongs to the three agents as they would travel the network are shown in the figure2 where on each arc the numbers written are the number of units allowable to each agents.

Clearly, what happens is that the second agent P2 accepts forty units from the first agent P1 on (a1,b1),(b1, t1) and fifty units from the third agent on (c1,b1), (b1, t1) of the sub flow graph of supplier s1. The second sub flow graph having supplier s8 in which first agent accept 40 units from second agent P2 and 50 units from third agent P3 on (a2,b2) and (b2,c2).

Finally, as Kalai and Zemel [8] point out, the core of the flow game is non-empty. We may check that the Shapely Value we computed is in the core. We check for the sub flow graph having supplier s1 and second we check for the second sub flow graph s8.

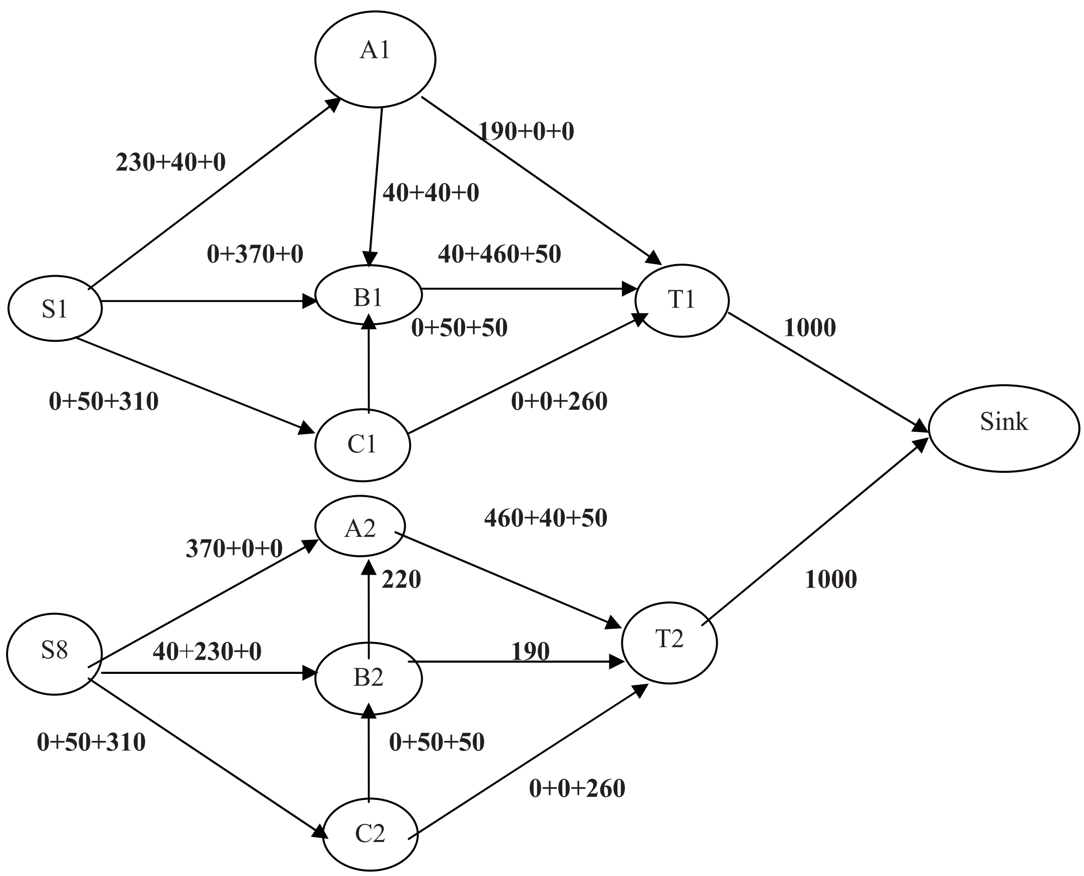

Figure 2. Two supplier flow grapgh with shapley value in B2B model.

Shapely Value for supplier s1 is within core is shown below

Sh1 230 > 190 v(1)
Sh2 460> 370 v(2)
Sh3 310 > 260 v(3)
Sh1+Sh2 690 > 630 v(12)
Sh1+Sh3 540 > 450 v(13)
Sh2+Sh3 770 > 730 v(23)
Sh1+Sh2+Sh3 1000 = 1000 v(123)

Shapely Value for supplier s8 is within core is shown below

Sh1 460 > 370 v(1)
Sh2 230> 190 v(2)
Sh3 310 > 260 v(3)
Sh1+Sh2 690 > 640 v(12)
Sh1+Sh3 770 > 740 v(13)
Sh2+Sh3 540 > 450 v(23)
Sh1+Sh2+Sh3 1000 = 1000 v(123)

B. Stablizing algorithm for b2b flow graph network –

An algorithm written below calculates the Shapely values and also checks for Shapely value within the core and the agents are cooperating or not.

1. Start
2. Store the demand in the input file.
3. Read the demand from the input file stored in row wise.
4. If demand[1][2]< demand[2][5]
5. Print v(1)
6. If demand[1][3]<demand [3][5]
7. Print v(2)
8. If demand[1][4] < demand[4][5]
9. Print v(3)
10. S=demand[1][2]+demand[1][3].
11. S1=demand[2][5]+demand[3][5].
12. If S<S1
13. Print v(12)
14. S2=demand[1][2]+demand[1][4].
15. S3=demand[2][5]+demand[4][5].
16. If S2<S3
17. Print v(13)
18. S4=demand[1][3]+demand[1][4].
19. S5=demand[3][5]+demand[4][5].
20. If S4<S5
21. Print v(23).
22. S6=demand [1][2]+demand[1][3]+demand[1][4].
23. S7=demand[2][5]+demand[3][5]+demand[4][5].
24. If S6<S7
25. Print v(123).
26. Print to find Shapely value.
27. For i=1 to number of agents.
28. Sh[i] calculated using equation 1..
29. End.
30. Print to check agent cooperate or not in communication
31. If Sh[1] > demand[2][5]
32. Print Sh1 > demand[2][5] else Sh1> demand[1][2].
33. If Sh[2] >demand[1][3]
34. Print Sh2 > demand[1][3] else Sh2 >demand[3][5].

35. If Sh[3] > demand[4][5]
36. Print Sh3 > demand[4][5] else Sh3 > demand[3][5]
37. SS1=Sh[1]+Sh[2].
38. SS2=Sh[1]+Sh[3].
39. SS3=Sh[2]+Sh[3].
40. SS4=Sh[1]+Sh[2]+Sh[3].
41. If SS1 > SS2
42. Print Sh[1]+Sh[2] > v(12).
43. If SS2 > SS3
44. Print Sh[1]+Sh[3] > v(13).
45. If SS3 > SS4
46. Print Sh[2]+Sh[3] > v(23).
47. If SS4==S6
48. Print Sh[1]+Sh[2]+Sh[3] = v(123).
49. End.

Figure 3. Algorithm for finding the Shapely value and check agent cooperation

The algorithm given works on any number of agents. The same algorithm is used by us for solving two supplier b2b and n-supplier problem to find whether the agents are cooperating or not cooperating. For two supplier b2b we got the same result as the manual result. After running the algorithm n-supplier or generic b2b model in which we had s2,s3,s4,s5,s10 suppliers was selected randomly from among 10 suppliers.

The result showing Shapely values is within the core and all the agents are going to cooperate for the transfer of information.

Supplier2 results are given below after running the Shapely value algorithm.

v(1)=250 v(2)=250 v(3)=400 v(12)=500 v(13)=700 v(23)=700 v(123)=1000
sh1 275 > 250 v(1)
sh2 275 > 250 v(2)
sh3 450 > 400 v(3)
sh1+sh2 550> 500 v(12)
sh1+sh3 725 > 700 v(13)
sh1+sh2+sh3 1000= 1000 v(123)

Supplier3 results are given below after running the Shapely value algorithm.

v(1)=100 v(2)=280 v(3)=200 v(12)=400 v(13)=700 v(23)=700 v(123)=1000
sh1 110 > 100 v(1)
sh2 490 > 280 v(2)
sh3 400 > 280 v(3)
sh1+sh2 600> 330 v(12)
sh1+sh3 510 > 400 v(13)
sh2+sh3 890 >880 v(23)
sh1+sh2+sh3 1000= 1000 v(123)

Supplier4 results are given below after running the Shapely value algorithm.

v(1)=150 v(2)=100 v(3)=550 v(12)=400 v(13)=900 v(23)=650 v(123)=1000
sh1 250 > 150 v(1)
sh2 175 > 100 v(2)
sh3 575 > 550 v(3)
sh1+sh2 425> 400 v(12)
sh1+sh3 825 > 450 v(13)

sh2+sh3 750 >650 v(23)
sh1+sh2+sh3 1000= 1000 v(123)

Supplier5 results are given below after running the Shapely value algorithm.

v(1)=100 v(2)=150 v(3)=550 v(12)=400 v(13)=650 v(23)=750 v(123)=1000
sh1 175 > 100 v(1)
sh2 250 > 150 v(2)
sh3 575 > 550 v(3)
sh1+sh2 425> 400 v(12)
sh1+sh3 750 > 650 v(13)
sh2+sh3 825 > 750 v(23)
sh1+sh2+sh3 1000= 1000 v(123)

Supplier10 results are given below after running the Shapely value algorithm.

v(1)=370 v(2)=190 v(3)=260 v(12)=640 v(13)=810 v(23)=450 v(123)=1000
sh1 460 > 370 v(1)
sh2 230 > 190 v(2)
sh3 310 > 260 v(3)
sh1+sh2 690> 640 v(12)
sh1+sh3 770 > 740 v(13)
sh2+sh3 540 > 450 v(23)
sh1+sh2+sh3 1000= 1000 v(123)

The following result shows that there are 15 agents who cooperate for smooth transfer of information from the supplier to manufacturer.

IV.CONCLUSION

Logistics and supply chain managers in the b2b e-commerce environment face many changes and challenges in their network environment. Performance measures such as high levels of efficiency, high levels of customer service, and the ability to respond to a changing environment are driving forces that continue to challenge these decision makers when compared to just a decade ago. Managing these logistic and supply chain networks involve more than developing a sourcing strategy. It was presented that the primary issue that the decision maker is challenged with is how to distribute and transport inventory under stable conditions. While traditional network flow problems have been extensively studied for analyzing such systems, this paper presented a game theory application, namely the Shapely Value for the cooperation game to the transshipment network problem. Concluding that once we verify the appurtenance of the Shapely Value, then we know that we have a stable solution for the cooperation of the players.

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