Exploring Shared Situational Awareness in Supply Chain Disruptions

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ABSTRACT

Risk and volatility in the form of political issues, natural disasters, terrorism etc., are impending dangers to the normal functioning of today's world. Supply Chains (SCs) are the backbone to societal functions and are heavily affected when such events occur. SC professionals have limited preparedness to deal with disruptions. Shared Situational Awareness (SSA) by means of information sharing, coordination and collaboration among SC partners, can significantly improve the recovery capacity of supply chains from disruptions. To prepare SC professionals for disruptions, a serious game (a tabletop board game) has been developed. The game serves both as an instrument to explore SSA during disruptions and as a training tool for SC practitioners. The paper discusses the design, development and applicability of the serious game based on an SSA framework in multi-stakeholder systems.

Keywords

Shared Situational Awareness (SSA), Serious Games, Supply Chain Disruptions, Information Sharing, Decision-making, Supply Chain visibility

INTRODUCTION

'A Supply Chain (SC) is a system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer' (Bidgoli, 2010). The production, trade and movement of such products and services are the backbone of the economy of the world. Globalization and trade liberalization policies of the 90's brought a paradigm shift in management of supply chains. Competition and an ever-increasing trade volume pushed firms towards production outsourcing, off shoring, Just-in-Time systems, zero inventory, etc., to increase revenues and cut costs. These initiatives function very effectively in a stable environment (Meixell & Gargeya, 2005). In reality, supply chains are far from being stable, and are often affected by unplanned and unanticipated events, termed as disruptions, that affect the normal flow of goods causing financial and operational losses across SCs (Hendricks & Singhal, 2003; Svensson, 2000). Risk and volatility in the form of political issues, natural disasters, terrorism etc., are impending dangers to the normal functioning of a supply chain. SCs need to be resilient towards such disruptions, as they form the backbone of modern society. It is estimated that the daily cost due to disruptions affecting SCs of an average multinational company is roughly in the range of \$50-\$100 million, excluding indirect losses such as decline in market capitalization (Harrington, Boyson, & Corsi, 2011).

Although much research has been performed on general risk management, it is impossible to predict all the risks, therefore SC professionals need to be prepared to handle and mitigate disruptions in real-time (Macdonald, 2008). 'An unplanned event that disrupts a supply chain with the capability to quickly detect and disseminate pertinent information pertaining to the disruptive event is less likely to be severe than the same supply chain disruption affecting a supply chain with little or no capability to warn.' (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007). Several studies (Tang & Tomlin, 2008; Wang & Wei, 2007) show that Shared Situational Awareness (SSA) through information visibility, timely communication, and coordinated corrective actions among the stakeholders is necessary to achieve a supply chain that can quickly recover after a disruption.

However, in practice, SC visibility and control are insufficient due to the complex, dynamic, and inter-dependent nature of stakeholders in SCs. Therefore, these stakeholders have reduced SSA regarding the disruption, its impact on the chain, and the counter measures to be taken, which often need coordination and collaboration with internal as well as external parties. Survey research has also shown that only between 5 percent and 25 percent of Fortune 500 companies are prepared to handle crises or disruptions, and only 33% of SC executives pay attention to SC vulnerability and risk mitigation actions (Harrington et al., 2011).

In order improve the preparedness of SC professionals to mitigate disruptions and crisis situations, it is very important to gain insight into the SSA of SC professionals while they deal with disruptions and crisis situations. Simulation games or serious games are excellent instruments to learn about decision making during complex situations, where the problems are unfamiliar, information is inadequate, and where the cost of errors in making decisions is very high. Serious games are experimental, experiential, and educational. They encourage the participants to think innovatively, and help develop a shared view of their learning and behaviors in a safe and controlled environment (Dumblekar, 2004). Therefore a tabletop board game was designed to explore disaster/disruption management by SC professionals and to provide a training tool to improve their preparedness to do so. This paper presents the theoretical background, design, testing, and preliminary test results of the game.

SSA FRAMEWORK FOR MULTI-STAKEHOLDER SYSTEMS

The concept of situational awareness was developed after the Second World War to improve the reactiveness of fighter pilots to the dangers in the combat space. SSA is defined as "shared awareness/understanding of a particular situation" or "common operational picture" about a problem situation (Nofi, 2000). Though several theories and models are available to describe SSA, they all focus on hierarchical command and control systems and organizations (Kurapati et al., 2012). Since supply chain is a multi-stakeholder system without a centralized control structure, an SSA framework has been developed to define and understand the meaning of SSA in such systems. The framework provides an expected path of change of decision-making in multi-stakeholder systems with increased levels of SSA. It is designed to understand the objectives and requirements to scale up from individual awareness to a system level share situational awareness to enhance participative decision-making in a multi-stakeholder environment. This framework is briefly illustrated in Figure 1. For a detailed description refer to (Kurapati et al., 2012).

From individual towards participative decision making →

SSA Maturity levels ↑

	Individual	Group	System
Participation	Flexibility	Synergy; Inclusiveness	Innovation; Cohesion
Prescription	Compliance	Coordination; Synchronization	Network governance
Perception	Goal orientation; Focus	Team goal; Orientation	Positioning

Figure 1. SSA framework. Adapted from (Kurapati et al., 2012)

The SSA framework is designed based on Capability Maturity Models (CMM) and systems thinking. The aim of CMMs is to improve complex situations and processes in large organizations, whereas systems thinking is very useful to understand the different perspectives, and relationships among stakeholders (Humphrey, 1987; Reynolds, Holwell, & Beer, 2010). Based on the varying levels of the SSA framework, a serious game was designed to fulfill he following objectives: 1. To gain insight into the behavior of decision makers during disruptions and crisis situations, 2. To understand the requirements for participative decision-making during crises and 3. To develop a training tool to improve the preparedness of SC professionals to mitigate disruptions and crisis situations. The serious game will be henceforth referred to as the supply chain disruption game.

THE SUPPLY CHAIN DISRUPTION GAME

The supply chain disruption game is a 5-player role-based tabletop board game. The key elements of the SSA framework have been translated into contextualized game play, using the principles of 'reality, meaning and play' of the triadic game design method (Harteveld, 2011). The game was designed in an iterative fashion, with several prototypes and test runs.

Game overview

The supply chain disruption game is set in a multi-modal logistics hub in a supply chain. The Key Performance Indicators (KPIs) of the hub are safety, performance (profit) and customer satisfaction. The KPIs are introduced to define the objectives of the game play, integrate real world requirements in the game, and to provide an element of competition. Players assume roles related to planning, operations and public relations of the logistics hub. The players with planning roles are interested in improving the performance of the hub and to some extent customer satisfaction, whereas players in charge of operations are inclined towards safety and performance, and public relations is focused mostly on customer satisfaction. Players with similar interests are grouped as Team Safe (Safety), Team Happy (Customer satisfaction), and Team Profit (Performance). There are 2 planners, 2 persons in charge of operations, and 1 public relations officer in the game. The game consists of 3 levels, each representing the 3 maturity levels in the SSA framework: Perception, Prescription and Participation. Every player has an individual KPI, which contributes to the overall KPIs of the hub. A disruption scenario is introduced at each level to create a crisis situation and test the ability of the players to mitigate the disruption at an individual, group and system (overall) level. At the beginning of the game, when business is a usual and operations are normal, all the individual, group and overall KPIs have the maximum score. After disruption strikes, all the KPIs keep declining after every round, unless mitigation actions are performed. All the KPIs have a critical threshold for scores, and the players should make sure all the overall KPIs are above the threshold all along the game. The protocols for communication and information sharing are designed based on probabilities and costs.

Game set-up and play

A game master orchestrates the game play. The game play consists of 3 levels, and each level consists of 5 rounds. Every level of the game has a central game board, and individual game boards. The game pieces include pawns, dice, information cards, mitigation cards, joker cards and a stopwatch. At each level of the game play all the game boards are changed, to simulate different levels of SSA. The game leader distributes the game boards and corresponding mitigation, joker and information cards. Initially, the mitigation cards are placed face down in numerical order, and at the beginning of each round the mitigation card set (containing option A and B) are unlocked. The remainder of the game play is best described as it is designed for 3 different levels.

Game level 1 simulates the first SSA maturity level of the framework. SSA in this level is limited to awareness of individual responsibilities and goals. Players receive an individual board, with their respective KPI, goal, and decision steps based on their role description. There is a central board with the 3 overall KPIs visible to everyone, whereas individual boards are shielded from each other. Information exchange happening among the players is a black box. Communication occurs on one-on-one a basis with the exchange of information cards among players. The information cards can be communicated by ‘e-mail’ or ‘phone’, the latter option costing more tokens but having a bigger chance of reaching the recipient.

Game level 2 represents the second maturity level in the SSA framework. Players are more aware of the decisions of others and the impact on KPIs. For level 2 there is a shared board with goals and decision steps of all the players, and the individual KPI scores are open to be viewed by all. Additional options include the choice to randomly meet a colleague by rolling a dice and discuss information and coordinate plans with him/her within a limited time span.

Game level 3 represents the highest level of SSA in the framework. All the game boards are open to all players. Players are able to collaborate with each other, to work towards joint actions to mitigate the effects of disruption. In addition to ‘e-mail’ and ‘phone’, there is an option of conference call, where information can be disseminated to all players at once.

Game scenarios

Three scenarios described the game are based on different supply chain disruptions with varying severity. Every level of the game has a different scenario in order to avoid learning bias among players. These scenarios can be played randomly at any level with varying game boards. In scenario 1, an important handling device is broken down, and the cause is unknown. Owing to the massive size and automaticity of the equipment, a large part of the hub has to be sealed off, before any diagnosis and repair can take place. Many customers wait to be served, while the demand is increasing. If the situation is not mitigated, customers may choose competitors. ***In*** *Scenario 2*, A worker has been fatally injured in a crane accident, and all the operations of the hub come to a halt until further notice. Though safety has high priority, operations have to be back to normal as early as possible to avoid heavy losses in terms of productivity as well as customer disappointment. In *Scenario 3,*trucking associations strike indefinitely protesting against low wages. While negotiating truce with the union, it is very important to search for alternatives to move cargo outside the hub.

Game strategy

Against prescribing winning strategies, the game is designed to observe the dynamics of decision-making among players in a disruption-ridden environment. Therefore the strategy adopted in this game puts the players at cross roads, allowing them to confront with varying information access, associations with other players, dilemmas due to priorities etc. The 2 key elements in the game strategy are *communication and mitigation.*

Communication is essential for information sharing. Some of the questions that players could be confronted during communication are: What information do I need to make my choices? Who has the information I need? Who needs the information that I possess? Will I benefit from sharing information? Am I willing to incur costs for communication? Am I receiving/sending redundant information? Etc.

All the players have to perform *mitigation* actions to reduce the negative effects of the disruptions on all the 3 KPIs of the system. However, depending on circumstances, players have to balance their choices. A mitigation action of one player that increases his/her KPI could be counter- productive to other players. Typical questions that arise in player's mind are: Will my decision affect the scores of others'? Is there is a possibility to collaborate with other players for better results? What should be my priority now? Etc.

Results from test runs

The game was played several times in a controlled environment to test the mechanics of the game and playability. The two variables in different game levels were information visibility and communication options. A game master and 5 players, consisting of PhD researchers and academics played the game seated around a table in a safe and controlled environment: a classroom. The game play was recorded using a video camera for post-game analysis. The total playing time was 3.5 hours including the briefing, and de-briefing sessions. Instances of game play during a test run of the game can be viewed in Figure 2.

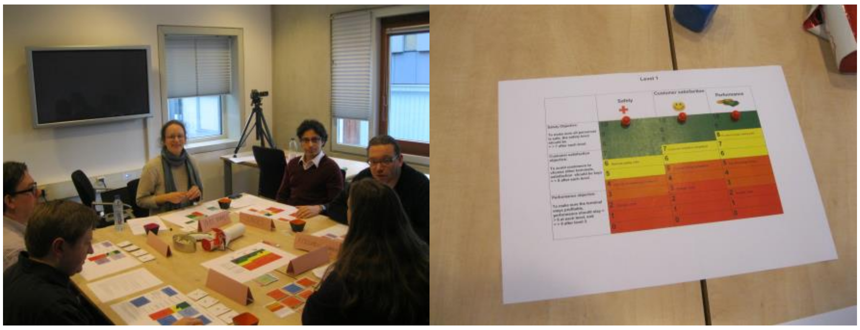

Figure 2: Impressions from the test runs of the supply chain disruption game

The post-game video analysis provided valuable insights into the behavior of the players while confronted with crisis situations. The manner in which they made several decisions while gathering information, weighing priorities, negotiating possibilities, finding allies and pooling resources, was very useful to understand the both the enhancers and inhibitors to make informed decisions during crisis situations. One of the most promising results that emerged from the analyses was the clear difference in the behavioral patterns of players at different game levels. In level 1 of the game play, all the players had limited awareness of the situation, the effects of their actions and their role in the game, therefore made individualistic decisions. There was a lot of confusion, distress and even frustration among players while having to communicate and take mitigation actions with limited SSA. Most often, information was being requested/sent to the wrong providers/recipients. In level 2, players had a higher awareness of the crisis situation, information necessity, quality and availability. They made good use of the available communication channels (phone, e-mail), as they understood who needed their information and who possessed the informed they needed. The flow of redundant information reduced compared to level 1. They tried to attune their plans, considering the decisions of others. Level 3 was the most eventful of the 3 game levels. The players made decisions truly participative in nature. Several discussions and negotiations were made among them during level 3. Players came up with innovative ways of teaming up amongst each other to jointly mitigate the situation. Sometimes, players compromised their individual KPIs to boost the overall KPIs. Well-informed and rational decisions were best made in level 3. Overall, the awareness of the impact of each other's actions, the opportunities to work together to perform joint collaborative actions improved considerably with increasing levels of game play.

CONCLUSION AND FUTURE WORK

SC professionals need to be prepared to mitigate disruptions in real-time. The developed tabletop board game provides a platform to gain preliminary insight into SC management during disruptions. It serves as a training tool to assess the preparedness of SC professionals to handle disruptions. The preliminary test runs have yielded positive results about the applicability, playability and usefulness of the game in spite of a few initial design glitches. The game will be used as a tool in training workshops for SC disruption management to trigger discussion on mitigation strategies among SC professionals. It will be played at a number of venues including universities, logistics companies, container terminals, and transport research institutes, for data collection and training purposes. The data from these sessions with professionals from the SC field is expected to yield valuable insights into SSA and its effects on decision-making in complex and critical situations. The future variants of the game could be computerized for large-scale data collection.

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