Value-based Modeling of Supply Chains for Disclosure Risk Assessment

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Value Modeling and Business Ontologies
Stockholm, Feb 10th, 2009

Outline

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Disclosure risk assessment

- Risk assessment is not a key component of methodologies for supply chain (SC) management.
- Still, certain characteristics of a SC might increase or decrease the risk of negative outcomes [11, 13].
- Further, the available procedures do not focus on risks related to information disclosure.
- As in any collaborative alliance, SCs need to be founded on trust among parties.
- The perception of a risk by the actors could lead to their abandoning the SC.
- In a risky configuration, actors may be reluctant to share information [7].

Disclosure risk assessment

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- Collaborative SC management is the combined optimization of supply and delivery.
- SC optimization is necessary to sustain competition with SCs in the same business area.
- Optimization is based on data provided by each partner in the SC.
- The risks to be identified are internal to the SC.
- Misuse of shared information may damage the other partners.

Example: The introduction of fake information may direct the distribution of orders in favor of the disrupter.

Disclosure risk assessment

- Each actor participates to the coalition with its own objectives.
- These need to be reconciled with the achievement of the common good.
- If achieving such common good requires completely missing their objectives, actors may be tempted to adopt a non-cooperative behavior.
- This conflict of interest and the resulting risk can be described as an information sharing problem.
- A third party may not be equally trusted by all the actors for the SC master planning.

Disclosure risk assessment

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Our framework for disclosure risk assessment in the enactment of SCs is comprising:

- The SCM model describing the relationships among actors and the information exchanged by them;
- the corresponding value model enriched with the parameters that are not already featured by the e^3value ontology;
- the key performance indicators (KPI) ontology describing the entities and functions for risk assessment.

Indicators allows to point out how far an actor is from the optimum and prone to behave opportunistically.

Outline

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Modeling supply chains

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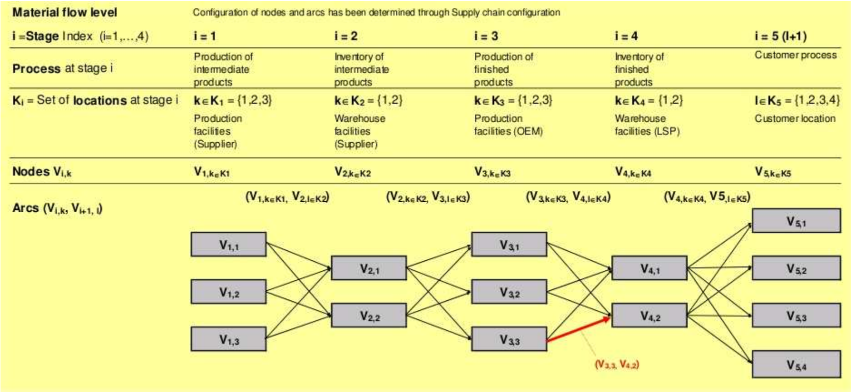
- Traditional SC modeling techniques may be awkward for the average business analyst to fully grasp.

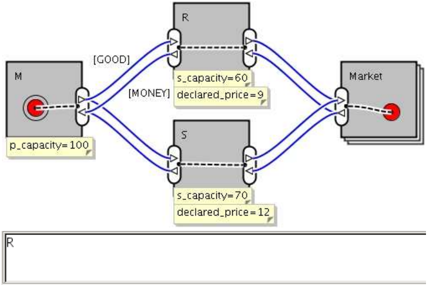


Modeling supply chains

- Topological features of the supply chain important for determining the probability and consequences of deviant behavior.
- Consequently, a prerequisite to an effective monitoring is a sound model for representing the coalition's value interchanges.
- As opposed to BPM, *value models* [14, 6] describe business coalitions at a higher level of abstraction.
- Value models depict always which entities of value are exchanged between stakeholders. Business decisions can thus be based on estimates of the economic behavior of the different parties.

Modeling supply chains

- We selected a modeling technique which also allows for a graphical representation, the e³value model [8].
- The primary motivation for adopting this formalism is the one-to-one correspondence of the model with logic-based data structures.
- The e³value ontology allows for the extension of its constructs with the data items characterizing the supply chain.



Attribute Name	E3_Expression
capacity	60
shapley_value	(e3{ElementaryActor("R").capacity...
revenue	e3{ValueInterface("vi33").ValueIn...
profit	e3{ValueInterface("vi33").ValueIn...
declared_price	9

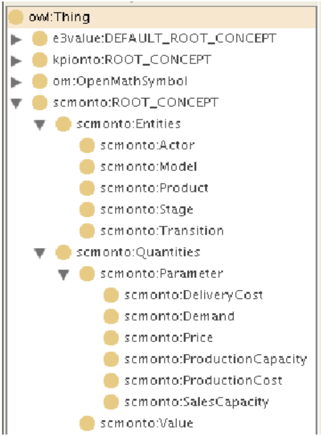
Modeling supply chains

In the ontology-based representation of the SC we integrate:

- The SC description (here shown expanded);
- the value model expressing it;
- the performance indicators to be applied in the analysis.

For the time being, we are using the Shapley Value:

$$u_i = \sum_{C} \frac{1}{n\binom{n-1}{k-1}} [v(C) - v(C-i)] \quad (1)$$



Outline

Supply chain analysis example

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- We want to evaluate which actor is prone to adopt an opportunistic behavior by knowing a certain information.
- In a whiteboard scenario all actors share the data that are necessary for the SC optimization.
- In this scenario, it is possible for R to calculate its Shapley value and decide that the supply chain configuration is unfair to it.

NAME	R	R
UID	4	4
profit	e3{#35.V	135
capacity	60.00000	60
revenue	e3{#35.V	270
declared_price	9.000000	9
shapley_value	(e3{#4.c	180

Supply chain analysis example

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- By knowing the manufacturer's allocation strategy (favoring resellers with the highest declared price), R may decide to adopt an opportunistic behavior.
- One possible attack by actor R could be lying on the sale price that is applied to the product.
- By declaring a price equal to 13, the actor would increase the overall profit toward its Shapley value.

NAME	R	R
UID	4	4
profit	e3{#35.V	150
capacity	60.00000	60
revenue	e3{#35.V	540
declared_price	13.00000	13
shapley_value	(e3{#4.ca	180

Then, the parameter declared_price cannot be shared among actors without increasing the risk of actor R to misbehave.

Supply chain analysis example

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- In real-world SC the analysis we carry out is more complex.
- The delta between profit and Shapley value is weighted according to the impact of individual actors (e.g., upstream Vs. downstream actors).
- The normalized result leads to a ranking of actors according to the criticality of deviant behavior by them.
- The costs associated with the application of secure computation in SC optimization are evaluated.
- Alternative incentive strategies are also evaluated.

Outline

Conclusions and outlook

- Our approach may serve more general purposes in the modeling of business coalitions and social behavior.
- The architecture aims at integrating with existing tools to enrich the range of results that may be presented to the business analyst.

Example: The profitability sheet generated by value modeling tools could be enriched by adding the calculation of the Shapley value.

- We are currently deploying our Java routine for calculating the Shapley value as an easily accessible web service.
- We also want to develop interfaces customizing the input to our web service according to specific data formats (e.g., the e^3*value* ontology).

Conclusions and outlook

Two possible integration scenarios:

- The e^3*value* editor introduces as built-ins the parameters for KPI evaluation.
- By doing this, SecureSCM-enabled supply chains can be created without relying on the underlying data model.
- The web service is invoked during calculation of profitability sheets, introducing a new, objective indicator for evaluating risk.

Alternatively, the other way around:

- SecureSCM data are translated into an e^3*value* ontology instance, embedding KPIs as custom properties.
- The generated profitability sheets will include the evaluation of KPIs.
- A custom application (or the human agent) derives the ranking of actors according to information disclosure risk.

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