Influence Strategies for “ Constituent-Competitive” Systems of Systems

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Motivation

- Many new systems use networks (information, transportation, etc.) and combine pre-existing components
- Compositions need to be considered to form systems
- Decision making is more diffuse as component development need not be synchronous with system development
- Traditional SE does not adequately address such systems
- Other research concentrated decision making and mapping that may not be present in these systems
- Need for approaches for both the technical and managerial challenges arising from the emerging class of systems
- Focus of research is management strategies for systems that are decomposed into subsystems, i.e., systems of systems, where the constituent systems are independent and interact, competing with each other.

Research Questions

Descriptive research
- What types of relationships and interactions occur among SoS constituents and how do they determine SoS behaviors?

Prescriptive research
- How can SoS influencers affect the structure of the SoS and behavior of the constituents?

Model of a Transport Market

Approach
- Research existing intermodal transport systems and identify opportunities for improvement
- Model a simplified transport network incorporating key characteristics of each shippers and carriers decision making
- Shipper’s chosen route based upon a variety of total expected cost and gets the least expensive and/or least delay
- Revenue, cost and profit to be assessed

Effect of Strategies on Stakeholders

- Total revenue, cost and profit are shown in $5
- Consider three stakeholder groups:
  - Shippers: Lowest transport costs under co-op strategy
  - Truckers: Make more in tax case. While their costs surely did increase, traffic moved to short-run routes where short-run operators had greater price leverage.
  - Railroad: More m-in-co-op case. They have control over the common portion of co-op routes and can get a better share than they would have to split with rail service.

AIR Framework for SoS

Anticipation-Intervention-Response

- Decisions on how SoS are structured among a set of constituents and SoS influencers
- Anticipation: To discriminate between those that result in changes (active) and those that lead to changes in SoS architecture and operations
- Intervention: To the feedback loop of the SoS: implement change(s) and see how the constituents respond to interventions
- Respond to the SoS constituents through anticipation or intervention

Approach
- As applied in a case study

Case Study: Intermodal Freight

Background
- Transportation system involves multiple modes (i.e. rail – road)
- Key issue in supplying the hinterland regions that are not easily accessible from border/seaports

Challenge
- Intermodal traffic is increasing due to improvements in technology and shipper’s pressure for lower costs – butter IT for coordination
- More efficient container handling
- Shippers want more choices with truck-like service quality and rail-like cost
- Governments have an interest in increasing intermodal freight usage to reduce logistics cost and encourage economic growth

How can a government or similar actor influence mode operators to change service offerings so as to increase the shipper traffic flow on underutilized intermodal rail lines?

Conclusions

- Decision making in systems of systems can be characterized as the interplay between a network of strategic interactions between constituents (and influencers) and a network of feedback mechanisms between systems that they operate and manage
- Influencers can use a variety of strategies to change the behavior of constituents including: incentives, information, institutions and/or infrastructures
- Modeling can aid in understanding the interactions between decision strategies that are being employed by constituent and their responses to influencers. However, it is unlikely to be fully predictive
- Successful implementation of influence strategies depends upon understanding the effect of strategies on all involved stakeholders

Research Opportunities

- What about constituent participation choice? Case study assumed fixed constituent population. What if constituents can enter/leave?
- Framework should look at the decision making is a value maximizing activity. What about stakeholders who are satisfying white minimizing risk? Potentially true for infrastructural elements in SoS
- What about multiple influencers who are acting at the same (or different) time either competitively or cooperatively?
- Does this approach scale out, or, if constituents needed to be grouped into populations as larger SoS are considered? How does the principal-agent problem change as the number of agents and/or principals becomes large?

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