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A SITUATED MULTI-AGENT SYSTEM FOR URBAN FREIGHT IN THE RANDSTAD

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ABSTRACT

Multiple heterogeneous stakeholders with diverse interests and distributed decision making process add complexity and unpredictability in the large city logistics domain. This complexity demands well designed approach for policy analysis which cannot be achieved by traditional modeling techniques due to their restrictive hypothesis. This paper explores into the characteristics of city logistics decision making process and attempts to explain gap between current city logistics policy and practice. It points out the need for a methodology which is more appropriate to capture dynamics of city logistics domain. It introduces concept of multi-agent system and discusses conceptual framework for gaining insight into city logistics decision making process.

KEYWORDS

Urban freight transportation, multi-agent system

INTRODUCTION

City logistics associated problems have stirred research interest among government, researchers, companies and environmentalists equally for acquiring better knowledge about city logistics to aid policy analysis process. A variety of methodical approaches are identified for the similar challenges because of different level of importance (i.e. congestion, pollution, safety etc.) apropos to different country, however, no model covers dynamic of city logistics. Additionally, these modeling efforts mostly focus on infrastructure optimization and traffic improvement without considering the goods movement, which make them poor predictors of city logistics scenarios. Conclusively, city logistics policy mostly follows “Learning by doing” approach with very limited or no use of modeling or scientific approach.

CITY LOGISTICS

City logistics is very important for the economic and social activities of city life. Goods delivery using trucks causes problems like congestion, pollution, poor accessibility and safety. Frequent delivery, inefficient use of trucks, poor routing, improper/unauthorized (un)loading, high emission vehicles and less consolidated deliveries are primary reasons for above mentioned problem. Regardless of its importance in city life, city logistics always got less concern in policy making (Van Duin et al., 2007) (EU-Report 2006). Vehicle access restriction (size, time and emission), urban freight village, consolidation centers are some of the most tried policy measures and initiatives to solve these problems (Muñuzuri et al., 2005). Besides these policy measures and initiatives, problems created by city logistics are worsening. Multiple stakeholders with conflicting objectives and autonomy makes city logistics a distributed decision making system (Thompson et al., 2001). Interaction between different stakeholders is characterized by communication which is not constant, information sources and level change unexpectedly, even stakeholders appears and disappears frequently. This characterized city logistics as an open and dynamically changing system. The complexity of city logistics domain is also considerably due to its emergence phenomenon. Emergent behaviour in city logistics appears when number of stakeholders operates and forms a complex behaviour as collective (Puckett et al., 2007). Thus, large number heterogeneous stakeholders with their distributed decision making process adds complexity and unpredictability in the large city logistics domain.

Conventional methods used for city logistics domain modeling are optimization, statistical and probabilistic methods (Taniguchi et al., 2001). The characteristics mentioned above are difficult or impossible to capture using these conventional methods as they consider the abstract level of city logistics activities in the form of survey, estimation from OD metrics, traffic based calculation etc. These models are deterministic ones and cannot help to provide strategic knowledge about extreme events which affect the whole city logistics process with its tiny behavioural changes and the magnitude, timings and duration of which cannot be forecasted. Additionally, out of these existing models, no model covers dynamic of city logistics. Without considering the details of goods movement, these models are poor predictor of city logistics scenarios. Goods movement creates the traffic movement and so to it is vital to understand and record goods movements for the prediction of goods related traffic. Thus, the aim of the research is to: “Provide insight into decision making processes among heterogeneous city logistic stakeholders to identify and evaluate the importance of under what structures these forces play out, and how to measure these effects for sustainable urban logistic policy analysis” With this aim the research is an attempt to fulfill the gap between policy making and practice by dynamically modelling city logistics processes.

SITUATED MULTI-AGENT SYSTEM FOR URBAN FREIGHT

City logistics deals primarily with three different domains, i.e. supply-demand, transportation network and traffic, where urban goods is common entity in all three domains (Van Duin et al., 2007). Retailer, Suppliers, Logistics providers and administrators (i.e. municipality) are main actors (i.e. stakeholders). The social system created by different stakeholders act under several forces which, often, are not only reactive but proactive, goal oriented and conflicting. Mathematical reduction of such a complex urban freight system by conventional modeling would not lead to success, especially when the interactions between the micro level entities are manifold (Haken 1977). Establishing each stakeholder as independent entity can help exploring dynamics of interaction due to distributed decision making. This can be achieved by developing number of functionally specific and nearly modular objects who can solve particular problem aspect. Combination of their interactive movement results into emergent complex system. This modular objects are called "Agent" in the artificial intelligence lingo. A system consist of many different agents is multi-agent system. It can be defined as a loosely coupled network of problem solvers that interact to solve problems that are beyond the individual capabilities or knowledge of each problem solver (Durfee et al., 1989). Figure 1 shows the proposed framework for multi-agent based system for urban freight transportation. Multi-agent system for city logistics focuses on understanding urban freight movement not based either on buying-selling and supply-demand of commodities or aggregate totals of demand, but on importance of under what structures these forces play out, and how to measure these effects in order to get insight into city logistics decision making process. Situated multi-agent system consists of multiple agents representing retailer, supplier, and logistics provider agent. Here the word "situated" refers to agents with purely localized (situated) perceptions and actions in the environment, i.e. a selected group of municipalities, products or services (Wooldridge et al., 1995). These different agents have different factors and constraints in objective function. These multiple agents with different objective function interact to reach a common goal of goods delivery from production unit to retailer shop (or consumer, depend upon the scope of model). Interactions among different agents contain different mechanism like negotiation, adaptive learning, cooperation, co-ordination etc. The system can have more agents other than supplier, retailer and logistics provider agents like mediator agents, administrative agent etc. Conceptual framework as shown in figure 2 for understanding city logistics decision making using situated multi-agent

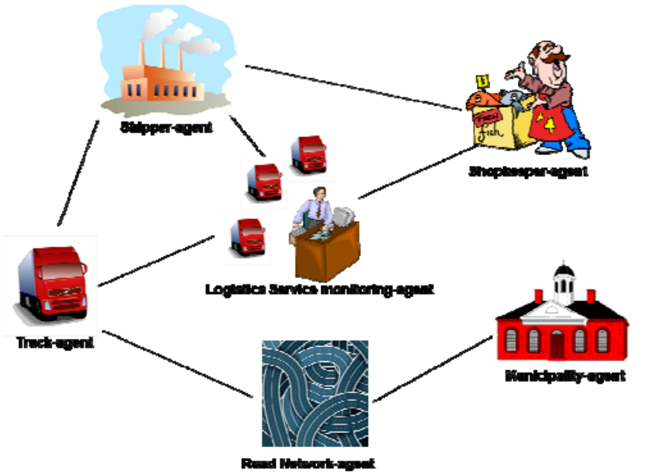

Figure 1: Proposed framework for multi-agent system for urban freight transportation

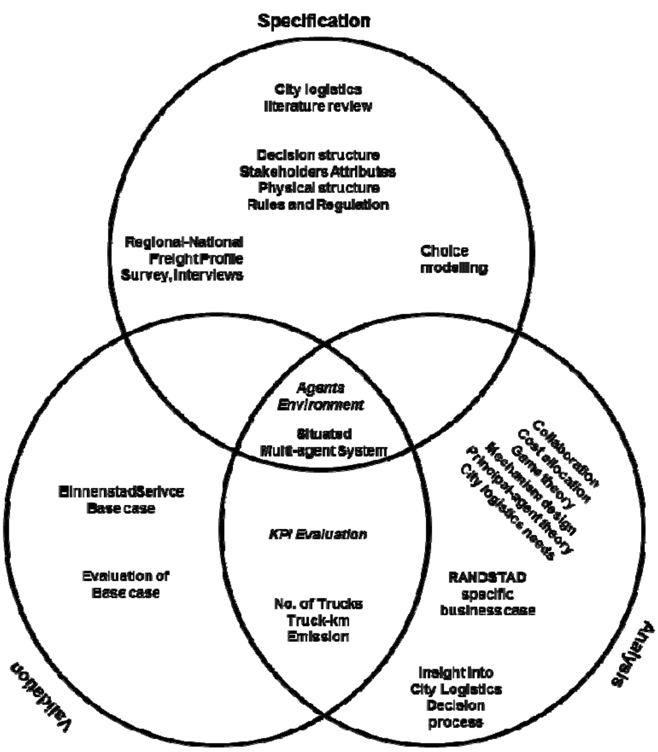

Figure 2: Conceptual for urban freight decision making analysis

system includes three stages in cyclic process, i.e. Specification, Validation and Analysis. Specification includes gathering information about decision structure of urban freight distribution and developing multi-agent system. Validation part consists of validating developed model with base case (i.e. BESTUFS, Binnenstad service). After validation, with different settings, scenarios and regulations, different business cases (RANDSTAD specific) can be created and simulated for to understand city logistics related decision making processes and forces governing them. Finally knowledge gained from this analysis can be used to recommend some policy measures for sustainable urban freight transportation system.

CONCLUSION

With the increasing significance of the city logistics, urban freight related decisions become more important. With multitude of stakeholders, their interactions and their dependency on each other, direct and indirect consequences of poor decision making become more severe. Conventional methods used for city logistics domain modeling are not sufficient to capture decision making processes of city logistics activities. This paper explains characteristics of city logistics domain and weaknesses of current policy making models/methods and addresses gap between current policy making and practices of city logistics domain. This demonstrate that there a need for a new approach for the city logistics modelling which can simulate the details of continuously changing city logistics characteristic in efficient way and coin emergent behaviour of the dynamically changing city logistics process. Multi-agent modelling is consisting of describing a system from the perspective of its constituent units (i.e. Agents) and has capability to overcome problems related with traditional methods. It has potential to capture dynamics of city logistics decision making process which in turn create knowledge base about the system. It can simulate the emergent behavioural processes for generating appropriate solutions of the problems associated with distributed decision making. Application of the proposed multi-agent system can provide sensitivity to a variety of technology trends, business trends, and policy scenarios that conventional approaches cannot achieve at the same extent.

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