477e Information Sharing in a Distributed Enterprise: Impact on Supply Chain Performance
Israel B. Owusu and Steinar Hauan
Current process systems research in planning and scheduling for multisite planning [2] have provided large-scale optimization models and corresponding algorithms, typically for simple, multistage supply network. These have been successful in providing insight into inventory management policies, capacity planning, and investment decisions [6]. Modeling of larger enterprise networks, however, is constrained by computational resource requirements and the need to effectively incorporate dynamic supply chain scenarios into such models. Dynamics in a supply chain are primarily a result of demand uncertainty, and complicated further by the discrete nature of business decision-making in response to perceived exogenous market conditions such as product sales price [1,4,7]. The computational requirements for incorporating dynamic events and parameters into an enterprise simulation can be substantial. The resulting models, linear or nonlinear mixed integer problems are very large. While model formulations and algorithms that exploit problem specific structure can result reductions in problem size and improve solution times, the problem of incorporating dynamics and flexibility into enterprise modeling still remains [4]. Recently, scenario-based approaches and Monte-Carlo type simulations have been used to address some of these dynamic effects [3,9].

This paper has a twofold focus. We provide a comparison of differentmodeling approaches for decentralized planning and scheduling and provide a framework for quantifying the effect of simple information sharing policies on performance metrics in a distributed supply chain. The systems we consider are simple two-stage enterprise networks consisting of only a centralized customer and a number of geographically distributed manufacturing plants. Manufacturing facilities have predefined production capabilities for specific products and are identical in their unit-task allocation structure using a State Task Network (STN) representation [5]. The primary difference between manufacturing sites is cost based; purchasing prices for raw materials and production costs can be different for different plants.

We initially consider a multiplant enterprise where production planning and scheduling for all plants are solved simultaneously in a single model. We analyze the results of this large-scale formulation with respect to the following metrics, computational cost, enterprise performance given as total operational costs, and demand satisfaction, over a fixed time horizon. This is followed by a comparison of the simultaneous scheme with two other approaches: sequential and distributed decomposition of the problem space. The sequential approach employs a vertical decomposition of the planning horizon into time periods. In each epoch, we solve the planning and scheduling problem simultaneously for all plants. The distributed approach is a lateral decomposition of the problem space based on plant location. Using the chosen valuation metrics above we draw inferences on the benefits of each method. The sequential and distributed approaches are implemented according to a two step algorithm. The first step is a decision-making step where a desired distribution of product-specific demands between manufacturing sites is generated. This is followed by solution of the short term scheduling for individual plants to satisfy the allocated demand levels to satisfy product due dates. Next, we consider the performance of a combined sequential-distributed model decomposition. The objective here is to quantify performance degradation, measured as the level of unfulfilled demand, due to the problem decomposition approach and the amount of information shared between manufacturing plants changes. The size of shared information is given as the subset of system parameters exchanged between enterprise subunits. By establishing the correlation between performance and level of information sharing, we aim to define a minimal set of data that needs to be shared between the distributed entities to achieve a desired level of system performance. We employed a database-driven computing framework built using a Remote Process Interface (RPI) [8], for remote execution of asynchronous computations on an in-house computer cluster.

References: [1] Perea-Lopez, E. and Grossman, I.E., and Ydstie, B.E "Dynamic Modeling and Decentralized Control of Supply Chains" 2001, Ind. Eng. Chem. Res., 15, 3369-3383 [2] Floudas, C.A and Lin, X "Continuous-time versus discrete-time approaches for scheduling of chemical processes: a review" 2004, Comp. Chem. Engng., 28, 2109-2129 [3] Gupta, A. and Maranas, C.D. and McDonald M.M. "Mid-term supply chain planning under demand uncertainty" 2000, Comp. Chem. Engng., 24, 2613-2621 [4] Gupta, A. and Maranas, C.D. "Managing demand uncertainty in supply chain planning" 2003, Comp. Chem. Engng., 27, 1219-1227 [5] Kondili, E. and Pantelides, C.C. and Sargent, R.W.H. "A general algorithm for scheduling of batch operations. I.MILP formulation" 1993, Comp. Chem. Engng., 17, 211-227 [6] Lee, H.K and Lee, I.B and Reklaitis, G.V "Capacity expansion problem of multisite batch plants with production and distribution" 2000, Comp. Chem. Engng., 24, 1597-1602 [7] Chen, F. and Drezner, Z. and Ryan, J.K. and Simchi-Levi, D. "Quantifying the Bullwhip Effect in a Simple Supply Chain: The Impact of Forecasting, Lead Times, and Information" 2000, Mgmt. Sci., 46, 436-443 [8] Siirola, J.D. and Hauan, S. "RPI: A Remote Process Interface" 2005, Comp. Chem. Engng [9] Jung, J.Y. and Blau, G. and Pekny, J.F. and Reklaitis, G.V. and Eversdyk, D. "A simulation based optimization approach to supply chain management under demand uncertainty" 2004, Comp. Chem. Engng., 2, 2087-2106