行政院國家科學委員會專題研究計畫成果報告

半導體供應網路決策品質促成技術研究（I）－ 總計畫

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一、中英文摘要

我國製造產業正在大力推動企業電子化，兩、三年後供應鏈與製造管理的資訊系統素質將普遍提昇，屆時擁有特定製造供應鏈軟體或資訊系統將不能帶給企業競爭優勢，企業資訊系統的競爭力要素將移轉至決策品質。供應鏈網路大致是分散式的組織，決策組織形式、業務程序設計、以及決策協調與整合將是品質的重要因素，對決策品質有很直接的影響。本計畫的四個子計畫將針對供應網路的虛擬企業、企業後端規劃作業、前端規劃作業、以及網路組態設計等課題進行研究， 發展製造服務的供給機制、網路組態設計方法、以及資源配置、供應鏈規劃與控制、工廠排程、需求規劃等方面的決策協調方法。本專題計畫的四個子計畫主題分別為：

[1] **虛擬晶圓廠製造服務提供機制及其促成工具之研究**
[2] **半導體製造廠網路之生產決策整合與投射**
[3] **半導體生產網路中之需求規劃策略**
[4] **半導體製造之供應鏈網路管理與資源分配**

總計畫的工作範圍是分析供應鏈製造服務、規劃、排程、資源配置等決策在整合上的問題，目標是提供各子計畫一個整體觀。在第一年，總計畫已經完成半導體供應鏈在生產規劃與控制方面的系統分析工作。

關鍵詞：半導體製造、製造服務、供應鏈管理、生產決策整合、服務投射、需求規劃、資源配置

Abstract

Due to the heightened investment in the last few years, it is expected that most domestic manufacturing enterprises will have an upgraded supply chain management infrastructure system in a few years. Owning particular planning or management software will no longer bestow a company differentiating competitive advantage. The driver of competitiveness will shift to decision quality. Because decision-making in supply chains are decentralized, the form of decision organization, decision process design, and decision coordination will be the major factors influencing decision quality. This project proposes to develop enablers for enhancing decision quality in the semiconductor manufacturing factory network. Three aspects of the network are addressed: virtual corporation configuration, back-office and front office planning operations, and physical network configuration.

This project is made up of four subprojects: (1) manufacturing service provisioning mechanism and enablers, (2) decision integration and decision service delivery, (3) demand planning strategies, and (4) network configuration and resource allocation. A dynamic manufacturing service provisioning mechanism will be designed and developed for configuring virtual supply chains. Decision quality enablers in the areas of resource allocation, factory master scheduling, supply chain planning, strategic capacity planning, and demand planning will be developed to enhance the integration of planning operations. Methodologies for physical network configuration will be developed for optimizing long-term partnership relationships between nodes of the network. Finally, besides the four subprojects, the main project will conduct system analysis and specify system requirements for the "to be" systems to provide a unified framework for integration. In the first year, system analysis on production planning and control in the network has been completed.

Key words: Semiconductor Manufacturing, Manufacturing Services, Supply Chain Management, Production Decision Integration, Service Delivery, Demand Planning, and Resource Allocation

二、計畫緣由與目的

Figure 1 illustrates the effect of decision quality in maintaining competitiveness. All management decisions face a tradeoff between timeliness and accuracy. As more time is spent in collecting or analyzing information, the accuracy of information will improve. At the same time, however, the timeliness of decisions will decrease. The accuracy and timeliness are represented by two solid curves. The intersection point between the two curves is the optimal point to make the decision (Point 1).

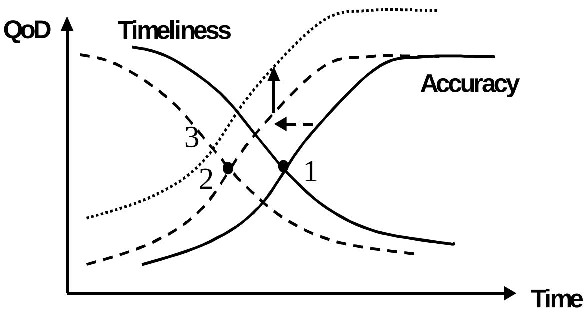

Figure 1: Quality of decisions as competitive advantage

Upgrading the information infrastructure in the supply network will speed up information flow and decision-making. However, most companies will benefit from this speed-up. The accuracy and timeliness curves will both shift to the left (indicated by the horizontal arrow and the dotted curved lines). The new optimal trade-off point (Point 2) will remain at the same quality of decision (QoD) level as that of Point 1. There is no competitive advantage gained. To gain differentiating competitive advantage, it is imperative to raise the accuracy curve vertically up (as indicated by the vertical arrow), thus moving the optimal point to Point 3.

The semiconductor supply network has three aspects: virtual corporation configuration, planning operations and physical network configuration. Configuring a virtual corporation is to dynamically interconnect nodes of supply chains, starting with customer demand, through design, manufacturing and distribution, and ending with after sales services. In contrast, physical network configuration is concerned with optimizing long-term partnership relationships between network nodes. For both virtual and physical networks, there are many operation decisions that can be roughly divided into back-office and front office planning operations. The former includes capacity planning, master planning, and factory scheduling (Figure 2). The latter includes those operations that have more direct contact with customers such as demand planning and demand fulfillment (Figure 2).

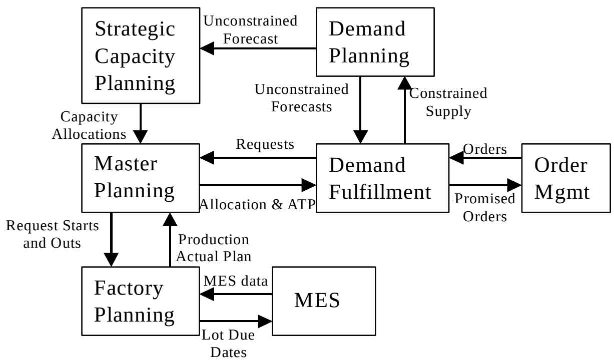

Figure 2: Supply chain management applications

The objective of the main project is to analyze the configuration, planning, and scheduling processes in the semiconductor supply network in order to provide a common framework of further analysis for the four subprojects.

三、研究方法

Figure 3 outlines the framework of virtual corporation to be developed in the first subproject [1]. Manufacturing services of foundry companies have been identified and defined. Two areas of services will be addressed: operation logistics and technology development. The order delivery commitment service will be developed for the operation logistics area using agent technology. The methodology will next be applied, and generalized, to business processes and service management of technology-development.

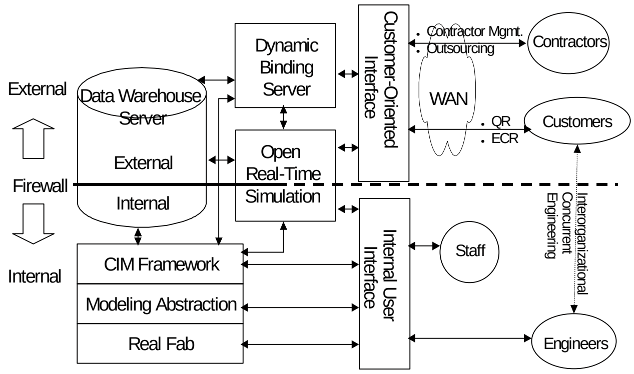

Figure 3: Architecture of virtual corporations

In the supply network, planners at different nodes need to coordinate their work to improve decision quality. Figure 4 illustrates the interaction between a supply chain planner and two factory planners. The supply chain planner will normally send a production plan to the factories, and the factories will report back the production progress. However, in a dynamic world, planners may be independent enterprise entities pursuing self-interest and abnormal events frequently occur. There will be query and negotiation going back and forth between network nodes, with respect to capacity, cost, lead-time etc. Therefore, decision integration occurs in a network as well as within a node. Decision integration across the network offers great potential for enhancing decision quality.

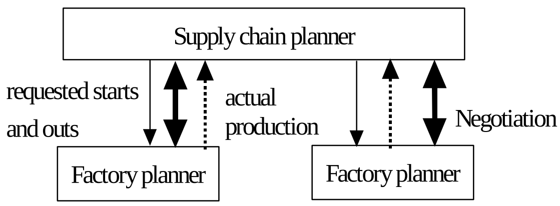

Figure 4: Planners interaction in a network

The second subproject will address the integration issues between capacity allocation, planning and scheduling processes in the supply network and develop a system for delivering decision-making as a service in the internet environment (Table 1).

Table 1: Research tasks and focus of subproject II

Research task	Focus and methodology
Constraint modeling	Theoretical framework and algorithms
Capacity allocation	Problem analysis and solution development
Service delivery	System development

Demand is affected by many factors such as demand fluctuation, inventory policies, order batching, fluctuating prices, and rationing game. It is well known that demand information that propagates throughout the supply network is the most unreliable information in the supply network and has been plaguing the quality of planning. The third subproject proposes to develop an integrated framework for demand planning with four important functions (Figure 5):

- Multidimensional demand planning strategies,
- Statistical demand forecast,
- Aggregation and granularity of demand information, and
- Synchronization of demand signals in the planning network.

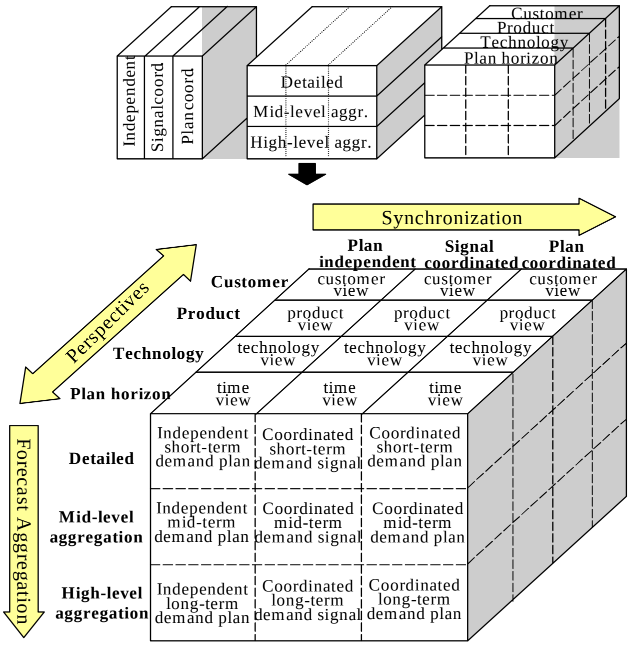

Figure 5: A framework for integrating demand planning

The fourth subproject will address the problem of configuring physical network. Plants in a supply network usually have different characteristics such cost, capacity, and response time. In this subproject, mathematical and algorithmic methodologies will be developed for optimizing network routes. The methodologies will be based on mix integer programming, graph theory and network flow algorithms.

For the main project, the approach of research will be to use user interview with our industry partners for the system analysis task and to use advanced planning at the university campus for the architecture design of the to-be supply chain management system.

四、結論與成果

In the first year, we have analyzed the planning processes and organization of TSMC and UMC. We have found out that the current state of process integration in the supply network is very primitive. Of the four major stages of the network, wafer fabs have advanced CIM and planning systems but the other stages are much weaker in capability. For instance, in quoting a due time to a customer, the cycle times for circuit probe, assembly and final test stages are fixed at three, five, and four days, rather than determined by analyzing workload and back orders. There is normally no visibility of capacity and backlog at the other factories. Figure 6 shows the planning processes and organization of UMC.

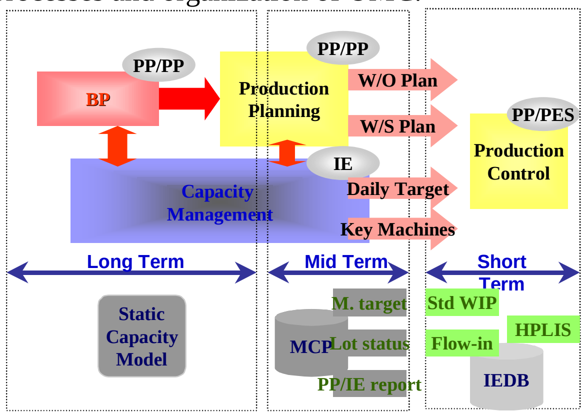

Figure 6: Architecture of site planning systems (curtsey of UMC)

In the first year, we have also analyzed the information system architecture for supply chain management from the perspectives of both software vendors and manufacturing corporation. I2 technologies and Adexa Inc. are two major software vendors in this industry. Both provide a similar suite of software products in the domain of supply chain management (Table 2).

Table 2: Software product suites

i2	**Adexa**
Supply Chain Strategist Value Chain Manager	Strategic Planner

Demand Planner	Demand Planner
Allocation Planner	ATP
Supply Chain Planner	Supply Chain Planner
Factory Planner	Plant Planner
Scheduler	Shop Floor Sequencer

Both TSMC and UMC are in the process of implementing or fine-tuning various elements of their supply chain management systems. Both of them have chosen to use commercial software products as much as possible. The architecture of supply chain management system at UMC is shown in Figure 7. TSMC has a similar architecture but with a different product configuration.

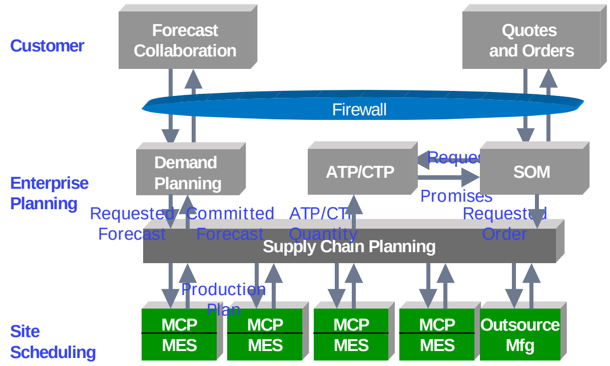

Figure 7: Architecture of supply chain management (curtsey of UMC)

In the second year, we will use the system architectures of both TSMC and UMC as a reference to design a to-be system based on the principle of distributed planning (as compared to centralized planning as is currently implemented). We will also analyze the problems in integrating various processes in their current supply chain management systems. There will be two thrusts, one for integrating network nodes and the other for integrating planning processes within a node.

五、參考文獻

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