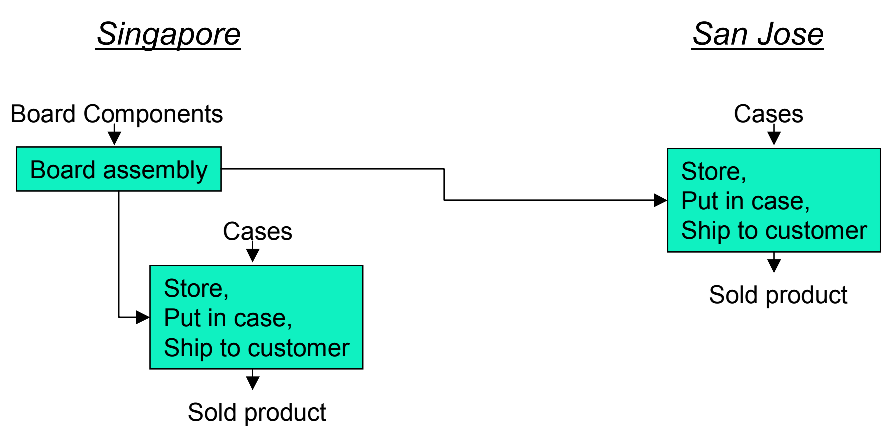
4. Conservation of Flow: The Fundamental Principle of Product Flow Planning

If you have studied physics, you know that there are several "conservation" laws, such as those for conservation of energy and for conservation of momentum. Energy or momentum may be transformed, but they don't easily disappear. There is a similar principle in planning product flow: that we move product through space and time, and we take some care as planners to not lose any of it.

Let us consider an example. We are a high-tech manufacturer with one simple product consisting of a circuit board and a case. We make the boards ourselves (how old fashioned) in Singapore, and either put them in a case there and sell them to customers in Asia or ship them to San Jose, California, put them in the case there, and sell them to customers in the Americas. We do keep a few weeks of inventory of the assembled boards in both Singapore and Jan Jose.

Thus our internal supply chain looks rather like the diagram below. What we have here is a simple distributed assembly system, and also a physical distribution system.

Topic 4, Figure 1: A simple internal supply chain



Let's get back to the point here. As we plan the operation of this network, we have to keep careful track of how much we have in inventory at each location, how much we have sold (which decrements inventory), how many boards we are moving from the assembly plant to the plant warehouse or the

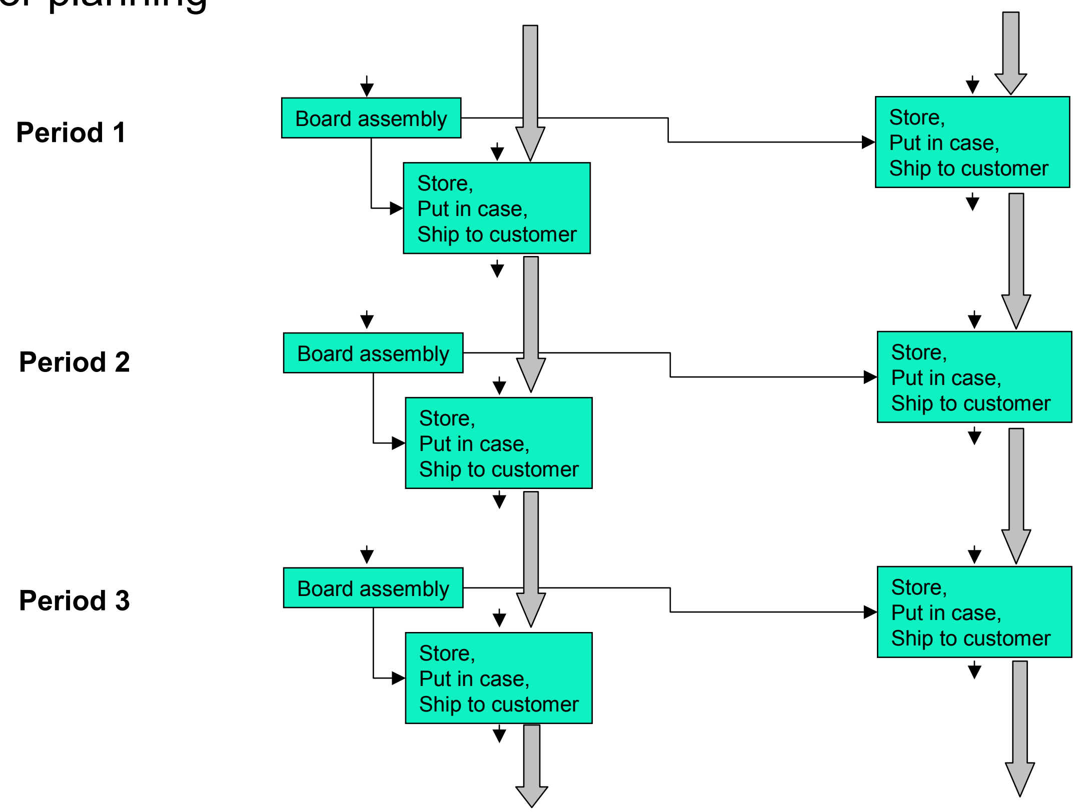
San Jose warehouse, and how many cases and board component kits we are consuming, at each location. That logic is handled by the inventory section of our ERP software, plus the bill of material functionality (noting that many traditional ERP systems did not really have a good way to handle the manufacturing-in-multiple-locations aspect of this simple example). So our inventory system can keep track of the product and components, but we still need to make planning decisions:

- Will we accept a given customer order, or will we hold our (potential) product for more important customers?
- Will we ship any product to customers from the wrong locations, e.g. to North American customers from Singapore?
- Will we put any boards into cases before we get customer orders, or just wait for orders?
- How much board inventory will we deploy from the board plant to each distribution center, and when
- How many component kits will we turn into boards, and when?
- How many cases, and how many board component kits, will we acquire, and when

Every planning question above has, explicitly or implicitly, a "when" associated with it. The planning questions are completely time-phased. Hence, to understand the true conservation of flow logic of planning, we have to add the time dimension. The easiest way to do that, and the way that most planning systems do it, is to build a multi-period planning model of operations, as shown in the figure below. The periods may each represent, say, a week.

Note that now instead of just thinking about product flow through space, we also have product flowing through time. Board inventory sitting in Singapore or San Jose flows from one period to the next, as well as potentially flowing through case assembly and out to a customer.

Topic 4, Figure 2: The multi-period internal supply chain for planning



For each one of the boxes in the diagram, flow in must equal flow out. In other words, the net of inventory coming in from the previous period, inventory flowing out to the next period, components or product flowing in physically, and product flowing out to another location must equal zero. Of course we can also add flows for expected losses of one sort or another if they are significant.

All product flow planning logic, be it incorporated in a spreadsheet, an ERP system, a mathematical optimization tool, or a simulator, have to basically respect these mechanics of product flow. If these tools are going to correctly help us plan, they need to support us with this fairly mechanical aspect of the process and let our human planners focus on the more decision-oriented aspects of planning.