

Theory of Constraints Thinking Processes: A Copy Shop Case Application

Dr. Tony Polito and Dr. Margaret M. Capen, East Carolina University, Greenville NC

ABSTRACT

This paper illustrates an application of a portion of Eliyahu M. Goldratt's Thinking Processes, a set of tools that are part of his Theory of Constraints body of knowledge, by using them to examine the operational problems encountered by a local franchise unit of a large copy shop chain and to posit solutions. The problems noted by the local franchise unit were mapped into a Current Reality Tree, a diagramming process used to reveal the singular root cause of observed problems. That diagram deduced the problems were caused by the fact that the local unit had not embraced the corporation's recent repositioning strategy into its own activities, decisions and requests. The root cause was then, in turn, used as the basis to create an Evaporating Cloud, a diagramming process that reveals the logical conflicts interfering with root cause removal. The Evaporating Cloud deduced that the local franchise unit had not embraced the repositioning strategy because it believed that if it did so, the division of its resources would cause it to achieve neither short-term goals nor the repositioning strategy. An Evaporating Cloud also facilitates the generation of possible actions to resolve the conflicts and it was used to do so. Several secondary recommendations for improvement in efficiency were also made, based on the direct observation of routine operations while collecting the requisite information to conduct the Thinking Process analysis.

OVERVIEW OF THE THEORY OF CONSTRAINTS AND THE THINKING PROCESSES

1984, Eli Goldratt first published his perennial best-selling “business novel” titled *The Goal*. In it, he argues that operational problems can best be solved by a cycle of continually identifying and resolving system bottlenecks, a philosophy he titled The Theory of Constraints. *The Goal* underwent a major revision in 1992. Shortly thereafter, Goldratt extended his development of the Theory of Constraints by creating a structured approach to the identifying and solving of the causes of systemic operational problems. He first presented his set of tools for doing so in his 1994 book *It's Not Luck*, calling them Thinking Process Tools. These tools rely upon the problem-solver carefully constructing intricate diagrams that illustrate the causalities of the various events and facts surrounding the operational problems. These diagrams include a Current Reality Tree that illustrates the present state of the system, an Evaporating Cloud that illustrates the inherent conflict within the system that is preventing solving of the problem and The Future Reality Tree that illustrates the expected state of the system once the solution is implemented. Other tools include the Prerequisite Tree, the Transition Tree and the Negative Branch Reservations diagram. These tools have much in common with other popular root-cause analysis techniques such as Ishikawa Diagrams and “The Five Whys.” Over the years, the Theory of Constraints and Thinking Process Tools have gained increasing popularity with practitioners. While there are readily-available “textbook” examples of how these tools work, there is far less availability of examples of actual application in practice. This case indeed presents an actual application of certain Thinking Process Tools at a local unit of a copy shop chain, in an effort to recommend specific actions for resolving its stated operational problems.

OVERVIEW OF THE CORPORATION

Paul's Copy Shops (disguised), at the timing of this case, was a closely-held corporation in operation for twenty years, primarily comprised of a large number of American franchise units. Typically, the local franchise units targeted retail customers, especially university students and faculty; many franchises are intentionally proximate to large university campuses toward that purpose. As such, many units provided 24-hour photocopy and publishing services. Historically, corporate management practices had been highly decentralized in nature, with local unit management responsible for its own customer identification, pricing strategies and financial objectives. The company's franchising methodology was also decentralized and non-routine; each franchisee enters into its own individualized contract as agreed upon with the franchisee, often stipulating some degree of co-ownership.

At one time, university faculty course packets represented a significant percentage of revenue at many units. However, corporate management eventually identified the self-procurement of copyright permissions to be an intolerable bottleneck. It resisted usage of the established copyright clearinghouses, as their fees made course packet production much less profitable. It attempted, but was unsuccessful at, obtaining “blanket” copyright authorization

from major publishers. Consequently, the corporation excluded such services by company-wide policy. The events surrounding the dissolving of the course packet business precipitated a perception by corporate management that a much higher degree of centralized management decisions was required going forward. It defined and propagated a new centralized corporate strategy, specifically that its core services should be repositioned into telecommunication and information technology services, targeting corporate clients.

Toward that strategy, the company initiated a joint venture with a telecommunication equipment manufacturer and a bulk T1 provider. “T1” is a leased and dedicated telecommunications service allowing for a 1.5 million bits per second data transfer rate, which accommodates the volume of data associated with “real-time” videoconferencing. The intent of the venture was to provide commercial videoconferencing and related data services in meeting room facilities at franchise units with connectivity to other franchise units and to thousands of existing and compatible private videoconferencing rooms. The only previous significant effort to market corporate videoconferencing services, by a worldwide computer company during the 1970s, was unsuccessful. The videoconferencing service was only available at some 100 units with pricing of \$150 per hour. Other significant activities within this time frame relating to the redefinition effort included the company’s first television advertising campaign, which explicitly targeted commercial users. Other centralization efforts included implementations of a corporate POS system, a preliminary national sales force, centralized corporate security and certain environmental policies. (NOTE: The sources of this corporate overview information have been withheld from the references in order to preserve anonymity.)

OVERVIEW OF THE LOCAL FRANCHISE UNIT

The local unit under analysis was located adjacent to a rural campus with a population of 27,000 students, and was 60 miles east of a major metropolitan area. The unit employed mostly unskilled hourly associates to perform order entry and unskilled production, and several key operators to operate high volume production equipment. The local unit also maintained four management positions, each cross-trained as key operators. “Key operator,” or “KO,” is a term inherited from photocopy equipment manufacturers, referring to an operator trained to address non-routine problems and who is entrusted with access to physical or logical administrator keys. Paul’s Copy Shops used the term to identify skilled associates who operated the high-volume photocopy equipment. The unit did not offer the videoconferencing service, but was planned to do so at some point in the future.

The physical layout of the local unit was uncomplicated. Customers entered directly into a cluster of self-service areas that were faced by the order entry area. The production area was directly behind the order entry area, was inaccessible but observable by customers, and was fairly cellular in layout. An intentional physical demarcation between the production area for employees and the order entry area for customers was effected by a long counter referred to as “the glue table.”

There had been no significant revenue growth for the unit during the past several years. Lost revenue from course packets was only partially replenished by the addition of two recently added services, color copying and computer time rentals. Local unit management indicated a concern that certain franchise units that are coincidentally proximate to both universities and business districts possess comparative advantage with respect to the repositioning of the company.

SEASONALITY AND DEMAND PATTERNS

Seasonality and other patterns of variance in demand patterns were clearly perceived by local unit management. In general, these variances were identified qualitatively and were informally and effectively managed. Historically, seasonality was related to the retail university customer base. End-of-term peaks were primarily effected by demand of university faculty course packets toward the coming term; a secondary mid-term peak was generally related to mid-term project submissions by students. Significant demand troughs were perceived during the months of December, July, and August. To some extent, management tempered seasonal peaks with adjustments to labor capacity. A dampening of such seasonality was observed by unit management due to the recent omission of course packet services. Weekday demand pattern was perceived as level, with a Saturday and Sunday trough. Management primarily employed the trough for non-production activities such as preventive maintenance, stocking and general administration.

Daily demand patterns were perceived as containing two peaks, first at mid-morning (10 a.m. to 11 a.m.), the second at early evening (7 p.m. to 9 p.m.). A strong trough began at 9 p.m., continuing through 7 a.m. Like many retail service organizations, Paul’s Copy Shops’ service was primarily “on-demand” and “waiter” in nature, hence

services could not be inventoried and was resistant to significant backlog. Accordingly, management gave close consideration to the issue of daily demand variance. Production leveling was accomplished at order entry via a “triage” of jobs into the categories of “due now,” “due later,” and “due tomorrow,” which were batch-ticketed accordingly. Lower-priority jobs were queued to await openings in the schedule. Jobs only infrequently unintentionally passed the “due tomorrow” horizon. Unit management noted the queue of completed production awaiting the filing process is clearly visible at 7 a.m. The various seasonality and demand variance tactics of Paul’s Copy Shops imply an almost pure chase operational strategy.

CURRENT REALITY TREE

The local franchise unit, noting a number of operational problems, sought experienced advice toward their resolution. The primary analysis tools employed were two Thinking Processes diagrams, the Current Reality Tree and the Evaporating Cloud.

During the interview process, local unit management explicitly and implicitly supplied a number of Undesirable Effects (i.e., problems) within the local unit. Those Undesirable Effects and secondary statements were used as the basis for constructing the Current Reality Tree, which is created by diligently working to arrange and rearrange the Undesirable Effects until they are all connected within a cause-and-effect network that represents the current state of the system and made to converge upon a singular root cause at the bottom of the diagram. Most of the Undesirable Effects will tend to appear at the top of the diagram. Hence a Current Reality Tree will often take on the general shape of a tree, with the Undesirable Effects positioned as the “leaves” and “branches,” while the singular root cause positioned as the “stump” of the tree. The constructors of a Current Reality Tree often have to craft intermediary statements to apply between the given Undesirable Effect nodes in order to create a fully connected, fully logical and fully causal network. While it is generally considered much more beneficial to have actual scenario subjects construct the Current Reality Tree diagram, as the process aids in their comprehension of the problems and root cause, it is often not practical due to considerations of time and lack of familiarity. In such cases an experienced constructor will fabricate the diagram; in this study, the diagram was constructed by the researcher/author. The veracity of the crafted statements was generally verified with the subjects before finalizing the Current Reality Tree diagram.

The final Current Reality Tree is presented as Figure 1 and Figure 2. The Current Reality Tree is presented as two separate figures for the purpose of visual clarity. The “dummy” nodes, enumerated 1 thorough 5, identify the specific network connections between the two sections. The original Undesirable Effects are identified by thin solid border. The secondary statements and crafted intermediary statements are identified by thin double-lined border. The singular root cause is identified by a thick frame border.

The identified root cause was the that the primary local unit had not embraced the corporation’s recent repositioning strategy into its own activities, decisions and requests. Rather, it persisted in its effort to meet short-term revenue and profit targets through historical revenue sources. As long as the local unit pursued this goal while corporate management devoted its available resources to repositioning for the long-term, various manifestations of the constraint would persist. For example, the diagram reveals that the local unit wanted funds to buy another color copier because it generated revenue toward immediate targets from an existing and familiar revenue source. However, corporate management did not want to invest in it because it preferred investment in items that forwarded the repositioning strategy, viewing such as critical to its longer-term increase in revenue and profitability. Local unit management commented that other units with higher growth rates experience less difficulty in the procurement of new equipment and desired labor budgets, a fact which that likely only exasperated its clinging to its effort to increase throughput of traditional revenue sources. (Insert Figure 1 & 2 here)

EVAPORATING CLOUD

Given the singular root cause identified, its use toward the creation and completion of an Evaporating Cloud diagram provided insight into recommendations for solution.

The general construction of an Evaporating Cloud begins by placing resolution of the singular root cause at left. The constructors then work from left-to-right, developing two parallel causal paths, explaining why the root cause persists, until two directly opposing nodes in the network appear. At that point, the network represents the underlying conflict that is inhibiting removal of the singular root cause. Each node is then examined for underlying assumptions that is preserving the existence of that node.

essentially to the entire problem at large. Here again, due to time and lack of familiarity, the diagram was constructed by the researcher/author. The veracity of the Evaporating Cloud network, as well as the underlying assumptions, were generally verified with the subjects before finalizing the diagram.

In this analysis, the Evaporating Cloud deduced that the local franchise unit had not embraced the corporation’s recent repositioning strategy into its own activities, decisions and requests because it believed if it did so, the division of its resources would cause it to achieve *neither* short term goals *nor* the repositioning strategy. Said another way, fearing failure on both counts, local unit management persisted in committing all its resources to the traditional revenue sources and to the achievement of short-term financial goals. The Evaporating Cloud is presented below as Figure 3:

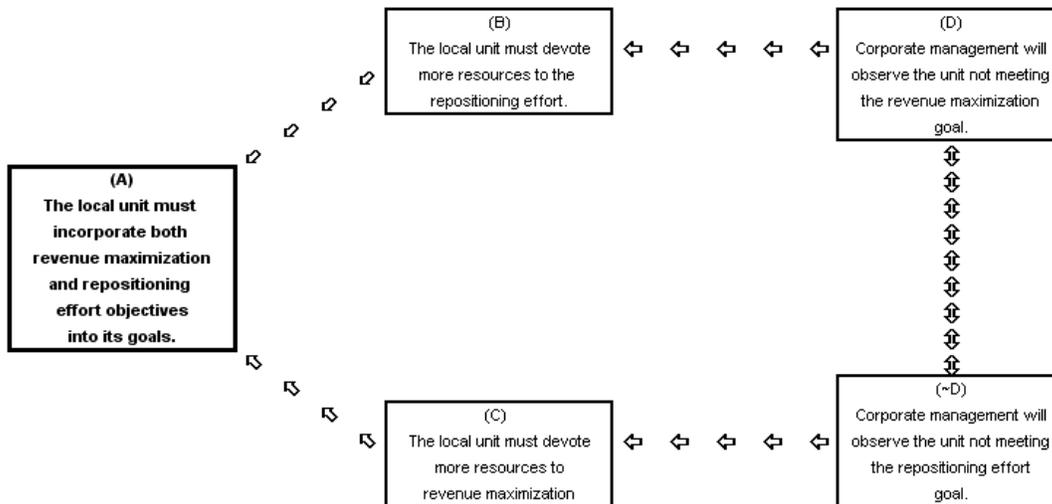


Figure 3: Evaporating Cloud

Analysis of assumptions and injections can take place on any or all nodes. However doing so at the terminal set of nodes, here labeled (D) & (~D), are viewed as the most appropriate for two reasons; injections at the key conflict are preferred in general, and, in this particular case, the solution will effect the involvement of both corporate and local unit management. Table 1 below reflects identified assumptions underlying the statements at the (D) & (~D) nodes and the associated injections that were presented to local unit management as solutions to their problem. Local unit management was instructed that the Evaporating Cloud could be examined by them for other possible assumptions and injections at all nodes.

Assumption:	Corporate management will not tolerate less revenue maximization and less effective repositioning efforts simultaneously.
Injection:	A transitional plan is developed jointly for the local unit with acceptable financial milestones.
Assumption:	Corporate management does not visualize revenue maximization and repositioning effort as a single goal.
Injection:	Execute a persuasive presentation that demonstrates to corporate management that resources devoted to repositioning efforts will likely slow revenue growth at typical units.
Assumption:	Corporate management will not tolerate the loss of one goal in preference to the other goal.
Injection:	Propose and obtain authority for the local unit to function as a discrete profit center with the objective of maximizing revenue through historical sources, with provision for alternate capital expenditure procedures.
Assumption:	Revenue maximization and repositioning efforts are mutually exclusive goals.
Injection:	Local unit management will identify, focus its scarce resources on, and close a contract with, a single large commercial client to provide the repositioned services.

Table 1: Evaporating Cloud Assumptions and Injections

SECONDARY RECOMMENDATIONS

While the Current Reality Tree and the Evaporating Cloud were intended to generate the “injections” that serve as primary recommendations toward solutions, several secondary informal recommendations regarding improvements in efficiency were also made, based upon the direct observation of routine operations while collecting the requisite information to conduct the Thinking Process analysis.

The Basic Order Entry Process

The order entry area also served as a delivery area and a self-service payment area. The customers exercising these areas did experience some of the order entry processes as outlined below, but these customers were disregarded with respect to analysis and recommendation. Other more tangent customer channels such as solid appointments, facsimile, electronically-submitted jobs, etc. were also disregarded. The remaining core order entry process for the bulk of customers was nearly linear.

Order entry typically began with walk-in customer arrival. The customer was directed by a dedicated greeter, usually to the order entry area. The customer queued until order entry staff began its need determination. Customers often ignored physical signals, queuing instead in the delivery area, and that caused them to be mis-sequenced by order entry associates. During the queue, the customer was proximate to key operators and unskilled associates involved in production, who were physically delineated from customers by the glue table. After needs determination, the order entry staff provided either firm or tentative price and delivery promises. The customer was often queued again to obtain a firm key operator estimate of price and/or delivery promises; such estimates were effected via a “back-and-forth” *kanban* on the glue table. Local unit management noted that customer dissatisfaction is much higher in these queues than during the actual production processes. After firm promising, the order was booked, then payment was sometimes taken for the firm pricing. Order entry associates then jacketed the order for production travel, triaged the order (as noted above) and batch-ticketed accordingly. “Due now” jobs were placed on the glue table, again to act as *kanban*. “Due later” and “due tomorrow” jobs were queued into a job box under the counter. There were no significant productivity measures in place relating to these order entry process.

The first recommendation involved this customer queuing. Service organizations usually experience customer involvement that requires that customer perceptions be managed as part of overall quality. As noted by unit management, the customers in the order entry queues perceived no processing, and therefore perceived low quality. This perception was heightened by the customer's clear view of the activity (or lack of activity) by associates in the production area and also by idle jobs queued upon the glue table. These processes were recommended for reengineering, in order to positively manipulate these perceptions. It was recommended that implementation could be effected along either of two strategic lines: either cause the customer to misperceive the total waiting time or cause the customer to perceive that he/she is not waiting. The specific tactics of such reengineering efforts were left to the discretion of local unit management, but a number of possibilities were suggested. Several seminal sources regarding the topic of waiting-line psychology are noted for the reader as reference. The actual and direct elimination of mis-queueing and the resultant mis-sequencing would also positively impact customer perception, and unit management was advised to seek ways to do so.

A second recommendation related to key operator promising. The key operator was observed to be the resource constraining revenue throughput and a variety of negative effects resulting from queuing at the key operator were observed. Accordingly, the key operator resource should be buffered where possible. The buffering and improvement of bottleneck processes, as earlier noted, is a key component in Theory of Constraints philosophy. One recommendation was to remove the key operator from the firm promising process. Key operator involvement in firm promising was likely based on an assumption that the accuracy of the promise should be as high as possible. However customers only required that the accuracy of promises be sufficiently adequate to make the booking decision. Accordingly, it was recommended that order entry associates should be trained and empowered to firm promise at that level of customer requirement. Specific tactics were again left to the discretion of unit management; however it was suggested that they include the ability to identify and resolve customer objections as well as the planned exceeding of customer expectation.

The Basic Production Process

The production process was job-shop in nature, therefore a full charting of all possible job paths would needlessly complicate this analysis. Unskilled, low-volume production processed by flexing unskilled labor was disregarded. Other tangent activities disregarded included non-camera ready and partial self-service jobs. The main flow for skilled and/or volume jobs in the production process was again essentially linear in nature, and that path also contained a bottleneck.

The production process initiated at the glue table *kanban* or by scheduled examination of the box queue by the key operator, who decided to pull the next job into production. The key operator also completed any setup for the job. A first unit proof was run by the key operator and inspected it for quality. When the proof met quality, the copy job was run by the key operator. Upon completion, the key operator placed the job into a generic work-in-process area to await further processing such as stapling, finishing, binding or boxing, where its presence acted as a *kanban*. These processes were

typically performed by unskilled labor who referenced the job ticket to determine the balance of the processing and then completed the job. At completion, the job would be returned to the key operator for a final inspection and a verification of the firm pricing, after which the job was stored in the completion areas.

Job productivity measures were minimal. No standards existed for low-volume jobs, while the key operator defined the time and material standards on a job basis for larger and more complex jobs. Local unit management stated it was aware there were significant variances, as they were being reflected at a higher, overall level in periodic reporting such as material ordering costs. These variances were not being subjected to any type of meaningful analysis or resolution efforts.

Here again, the buffering of the key operator, the constraining resource in the production process, was recommended. Unit management suspected that a significant portion of material and time variances related to rework caused by the abandonment of proof runs and final inspection processes by the key operator while under constraint. Accordingly, a fail-safing/fool-proofing strategy was recommended for implementation at the first unit proof process, to buffer the key operation from time-wasting rework. A tactical approach might require the filing of the first unit proof for managerial reference in rework or quality situations; the proof filing process will force the proof-running process, which should improve the rate of proof inspection taking place. It was expected that management would have to make extra effort verify proof run filing in the short-term in order to modify behavior. Also, though there should be a preference for ownership of quality at the process, current conditions dictated that a final inspection quality process be recommended, one that was external to the routine job production process, at least in the short run. Tactically, a “signature” final inspection at the filing process would insulate customer perception from bad lots, provide additional incentive for the key operator, and promote shared responsibility for quality.

The reader should note that these are process-based approaches to improvement, rather than outcome-based in nature. Said another way, additional measures of productivity and variance were not recommended, as it was expected that such measures would improve as a consequence of improving the processes, while simply installing measures would have contributed nothing toward actual improvement of the system.

CONCLUSION

Goldratt’s Thinking Process Tools, specifically his Current Reality Tree and Evaporating Cloud diagramming, proved to be effective tools toward identifying the primary root cause of numerous undesirable outcomes at the copy shop under study, as well as to recommend actions toward its resolution. Further, the core Theory of Constraint concept of bottleneck management—as well as other elements of the Operations Management body of knowledge such as waiting-line psychology, inspection philosophy and fail-safing/fool-proofing—facilitated further diagnosis and secondary recommendations for improvement in the basic order entry and production processes. Such tools can be readily, easily and equally applied in a wide variety of service and manufacturing scenarios to improve processes and outcomes.

REFERENCES

- Boyd, L. & Cox, J. 1997. A cause-and-effect approach to analyzing performance measures. *Production and Inventory Management Journal*. 38(3): 25-32.
- Chase, R. & Stewart, D. 1994. Make Your Service Fail-Safe. *Sloan Management Review*. 35(3): 35-44.
- Cox, J. & Schleier, J. 2010. *Theory of Constraints handbook*. New York, New York: McGraw-Hill Professional.
- Cox, J., Blackstone, J. & Schleier. 2003. *Managing operations: A focus on excellence*. Great Barrington, Massachusetts: North River Press.
- Davis, M. & Heineke, J. 1994. Understanding the role of customers in the operations for better queue management. *International Journal of Operations and Production Management*. 14(5): 21-34.
- Dettmer, W. 1998. *Breaking the constraints to world-class performance*. Milwaukee, Wisconsin: ASQ Quality Press.
- Dettmer, W. 2007. *The logical thinking process: A systems approach to complex problem solving*. Milwaukee, Wisconsin: ASQ Quality Press.
- Dettmer, W. 2003. *Strategic navigation: A systems approach to business strategy*. Milwaukee, Wisconsin: ASQ Quality Press.
- Goldratt, E. & Cox, J. 1984. *The goal: A process of ongoing improvement*. Great Barrington, Massachusetts: North River Press.
- Goldratt, E. 1994. *It’s not luck*. Great Barrington, Massachusetts: North River Press.
- Goldratt, E. 2009. *The choice*. Great Barrington, Massachusetts: North River Press.
- Katz, K., Larson, B. & Larson, R. 1991. Prescription for the waiting-in-line blues: Entertainment, enlighten and engage. *Sloan Management Review*. 32(2): 44-53.
- Maister, D. 1985. The psychology of waiting lines. In Czepiel, J. Soloman, M. & Surprenant C. *The service encounter*. Lexington, Massachusetts: D. C. Heath & Co. 113-123.
- Scheinkopf, L. 1999. *Thinking for a change: Putting the TOC thinking processes to use*. Boca Raton, Florida: St. Lucie Press.
- Schrageheim, E. 1999. *Management dilemmas: The Theory of Constraints approach to problem identification and solutions*. Boca Raton, Florida: St. Lucie Press.
- Tague, N. 2004. *The quality toolbox*. Milwaukee, Wisconsin: ASQ Quality Press.
- Wilson, P., Dell, L. & Anderson, G. 1993. *Root cause analysis: A tool for total quality management*. Milwaukee, Wisconsin: ASQ Quality Press.