# An essay on the Theory of constraints

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## 1. What is the Theory of constraints

Theory of constraints (TOC) is an overall management philosophy, introduced in 1984 in book "The Goal" by Dr. Eliyahu M. Goldratt. It is based on the application of scientific principles and logic reasoning to guide human-based organizations but can be used as an overall optimization guide.

Constraint in the context of the Theory of constraints is any machine, process, resource or anything else that limits the organization in reaching its goals. TOC assumes that at any given time there is at least one of these constraints and one of them is the most limiting, otherwise organization would have reached infinite effectiveness towards reaching its goals. These constraints can be internal, external or both of them.

In a nutshell – Theory of constraints is focused on looking for the most limiting constraint and exploiting this bottle neck as much as possible and over time evaluating whether the most limiting constraint has moved and starting anew. This is called a process of ongoing improvements (POOGI).

One whose field is informatics can now see that he is quite familiar with this theory – it is widely and almost naturally used when it comes to optimization of any software or algorithm – the slowest part is optimized first.

## 2. Predecessors

Although Dr. Goldratt hasn't stated this clearly in his first book, yet admitting it later, one can see that his theory was not built from the scratch. There's a lot of influence from just-in-time (JIT) method which is particularly visible at focusing on reducing work-in-process amount. However, unlikely as in JIT where one part of the organization relies on data from other parts of the organization, TOC introduces so-called "pull" principle – in ideal state work should just "flow" though. Another advantage of TOC over JIT is the TOC's philosophy of process of ongoing improvements and its DRUM principle which will be described in further text.

# 3. Main principles

Theory of constraints introduces 3 basic axioms; they have no proof, for they are axioms. These axioms have become a target of criticism and some people consider them flawed. More about this will be written in chapter “Criticism”.

### 1. Convergence

“Also called "Inherent Simplicity" states that "The more complex a system is to describe, the simpler it is to manage." Or that the more interconnected a system is the fewer degrees of freedom it has, and consequently the fewer points must be touched (managed) to impact the whole system. A corollary of this principle is that every organization has at least one constraint active in any given point of time.” [1]

### 2. Consistency

“Consistency, also called "There are No Conflicts in Nature" states that "If two interpretations of a natural phenomenon are in conflict, one or possibly both must be wrong". That is, when in an organization with a common goal, two parts are in conflict (or in a dilemma) this means that the reasoning that led to the conflict must contain at least one flawed assumption.” [2]

### 3. Respect

“Respect, also called "People are not stupid" states that "Even when people do things that seem stupid they have a reason for that behavior". In other words, this principle is stating that people are not inherently irrational.” [3]

Some might think that first axiom of convergence may not be true, but practice in the field of simulation and modeling has proven contrary. Although the larger the system is the more thinks can be adjusted there exist so-called leverage points. By effecting on these points we can achieve the greatest difference with just a slight change. These leverage points can be seen as bottle necks or constraints. [4] [5]

## 4. Steps in adjusting bottleneck throughput

*0. Articulate the goal of the organization .If we don't know, where are we heading to, it is impossible to get there.*

*1. Find and describe the most retarding constraint.*

*2. Decide how to exploit the constraint to the maximum level.*

*3. All other things subordinate to this decision (align all other processes to the decision made above)*

*4. Extend the constraint – buy more machinery, employ new people…*

*5. Move back to step 1 and repeat the whole process. Don't let inertia become a constraint.*

It is obvious – we can't identify the most retarding constraint if we don't know how to measure the retardation. Based on the criteria we choose, this constraint can lay on a different spot. In the real situations there mostly exists just one point of view – if for example we are managing assembly line, our goal will be production and the constraint will be the slowest part of the assembly line (chain).

Once having identified this constraint one has to focus on exploiting this constraint to its maximum potential. To make sure that the actual throughput of the slowest place meets its nominal throughput therefore utilizing this limited resource to its maximum. See more in DBR (DRUM) section.

"An hour lost at a bottleneck [BN] is an hour lost for the entire system; an hour saved at a non-BN is a mirage" [6] Therefore it is an imperative to make sure that the rest of the system is not slowing the bottleneck down. As the bottleneck is the slowest part of the system and the system is only as fast as its slowest part some slow down in other sectors in order to support the bottleneck won't negatively project into overall system performance. This is also called „the focus principle"– one should be focused only in exploiting bottleneck and subordinating everything else to it.

Once we have performed all the steps above and the constraints still remains the most limiting one and extension comes to a word. Either buying a new machine replacing the old one or employing a new person should do the job. It is important to not to do this step prematurely – extending the constraint before it is fully exploited leads to waste.

And last but definitely not least – start the cycle all over again. This is described in details in the POOGI section of this paper.

## 4.1. DBR (DRUM)

Drum-buffer-rope principle (also called DRUM) is a technique of managing work-in-process material, minimizing its amount thus cutting costs of warehouse facilities, material tracking, etc. There also exists S-DBR paradigm which differs in buffer's behavior and its placement.

Drum is defined as the current most retarding constraint – the slowest (weakest) part of the chain and therefore the work rhythm is defined by this drum. It would be useless to supply the constraining part with more work than it can process but it would also be waste to leave this constraining part in short supply. It is also important to mention that only useful drum's output is counted i.e. nothing processed by the drum should be wasted. [7]

To keep the drum working one has to ensure continuous amount of work flowing into it. The buffer is a device (virtual or the real one) which stores given amount of constraint's input, supplying the constraint. It can be said that buffer would not be necessary if the input of the line preceding the constraint had supplied it on-time (or just-in-time). Regrettably, due to nondeterministic nature of the real life this can hardly be achieved. The buffer capacity should be measured rather in time units than in amount of work it can store. [7]

And finally the rope. It is perhaps the most abstract part of DBR. The rope is a time interval defined on basis of experience and measurements. This interval controls the production pace of processes whose output is input for the constraint. The rope is necessary otherwise the buffer might get too full or worse – empty – resulting in starving the constraint. [7]

## 4.2. Inertia and the process of ongoing improvements (POOGI)

Main enemy of the Theory of Constraints is inertia. (Social) inertia is defined as "a term that applies the concept of inertia to psychology and sociology. It is used to describe the resistance to change presented by societies or social groups, usually due to habit. "[8]

As stated above, adjusting bottleneck's throughput isn't a onetime thing. Once the bottleneck moves so has to move our effort – to find a new bottleneck, exploit it to the maximum and start all over again. Application of the Theory of constraints many times led to significant increase in organization's productivity and this caused managers and workers to get too self-content thus stopping further improvements. Change and improvement has to become rather rule than exception.

## 5. Criticism

Theory of constraints has proven its usefulness in uncountable number of cases. Yet in accordance with its own POOGI principle, Dr. Goldratt has extended and revised his theory in subsequent books as “The Race”[9], “Critical chain”[10], “It’s not luck”[11]. There also exists “The Journal on the Theory of constraints” and plenty of books focusing on case studies – “Essays on the Theory of constraints” [12] for example and also academic publications – “The Theory of constraints: Practice and Research” [13].

In spite of this wide-spread acceptance and consensus that TOC is useful and well-tested theory, some “people claim Goldratt's books fail to acknowledge that TOC borrows from more than 40 years of previous Management Science research and practice, particularly from PERT/CPM and JIT. A rebuttal to these criticisms is offered in Goldratt's "What is the Theory of Constraints and how should it be implemented?", and in his audio program, "Beyond The Goal". In these, Goldratt discusses the history of disciplinary sciences, compares the strengths and weaknesses of the various disciplines, and acknowledges the sources of information and inspiration for the Thinking Processes and Critical Chain methodologies.“[14]

However, there even exists the more concrete critic. For instance Dan Trietsch states that DRM method is in inferior to other proposed in his paper.[6]

Trietsch doubts that TOC is a theory and points out some internal inconsistencies, proposing his own management by constraints (MBC) theory which – by his words – implements the correct aspects, removes DBR principle and introduces *balance* principle.

## 6. Literature


[1] http://en.wikipedia.org/wiki/Theory_of_Constraints#Convergence

[2] http://en.wikipedia.org/wiki/Theory_of_Constraints#Consistency

[3] http://en.wikipedia.org/wiki/Theory_of_Constraints#Respect

[4] http://www.sustainer.org/pubs/Leverage_Points.pdf

[5] http://www.public.asu.edu/~kirkwood/sysdyn/SDIntro/SDIntro.htm

[6] http://ac.aua.am/trietsch/web/WorkingPaper281.pdf D. Trietsch, From the Flawed "Theory of Constraints" to Hierarchically Balancing Criticalities (HBC), Department of Information Systems and Operations Management, University of Auckland, Working Paper No. 281, May 2004.

[7] http://www.goldratt.cz/ctrl.php?act=show,section,25

[8] http://en.wikipedia.org/wiki/Social_inertia

[9] Fox, Robert; Goldratt, Eliyahu M. (1986). *The race*. [Great Barrington, MA]: North River Press. ISBN 0-88427-062-9.

[10] Goldratt, Eliyahu M. (1997). *Critical chain*. [Great Barrington, MA]: North River Press. ISBN 0-88427-153-6.

[11] Goldratt, Eliyahu M. (1994). *It's not luck*. [Great Barrington, MA]: North River Press. ISBN 0-88427-115-3.

[12] Goldratt, Eliyahu M. *Essays on the Theory of Constraints*. [Great Barrington, MA]: North River Press. ISBN 0-88427-159-5.

[13] *The Theory of Constraints: Practice and Research* [IOS Press] ISBN: 978-1586035754

[14] http://en.wikipedia.org/wiki/Theory_of_Constraints#Criticism