How to Invent Strong – A Framework

Navneet Bhushan

Crafitti Consulting Private Limited, Bangalore, INDIA, www.crafitti.com

Corresponding Email: navneet.bhushan@crafitti.com

Abstract: One of the most important outputs of human mind has been continuous stream of inventions over many eras of civilization. However, human mind has been inventing using what is called "trial and error" methods on its evolutionary journey. As our world becomes more complex, inventing through trial and error is unsustainable. Theory of Inventive problem solving (TRIZ in Russian acronym) has been developed through analysis of patents describing the logic of inventions. It categorized the inventions into five increasing levels of inventiveness based on sources of solutions and the quantum of change they created compared to existing systems. In this paper, we describe set of tools for thinking to invent strong, i.e., to invent at level 3 and above of TRIZ five levels. Thinking about new operating principles to deliver the functions, making the existing systems closer to an ideal system and resolving deeply embedded conflict in the system called physical contradiction are the key elements from TRIZ that we have included in the framework for invent strong. Three real case studies- for cracking of hydrocarbons, improving the digestive abilities of the cattle and choosing the stronger paths using Analytic Hierarchy Process (AHP) to invent – are described to give a flavor of how the invent strong framework can be applied. We propose using TRIZ for inventing strong is essential need of the world as it becomes more complex and requires stronger innovative solutions quickly. The human mind has to quickly learn to adapt to inventing strong. The how to invent strong framework described in this paper with its associated tools has proven to be an effective method to generate novel solutions and can be utilized for application in multiple fields.

Keywords: Invention; TRIZ; Patents; Levels of Invention; AHP; Physical contradiction; Laws of System Evolution

1. Introduction

For the purpose of this paper we define an invention to be a new and non-obvious technical solution to a problem. The concept of a generalized "system" is central to the technical solution. The textbook definition of a system is a set of elements interacting together to perform a function or achieve an objective. The technical solution typically results either in creation of a completely new system to deliver the function, change in the operating principle of the existing system to achieve the system functions, change in the structure of the existing system or subsystems, change in a subset of system or subsystem parameters, or just a simple addition of more functions to the existing system functions. Many times the solution depends upon the problem itself or the focus of the "inventor" on the specific part of the system or subsystem.

"Trial and error" to solve problems or to invent new solutions has been the standard approach humanity has used to solve problems throughout its evolutionary journey. As the set of problems encountered change, the skill, knowledge and experiences gained in solving problems in previous contexts are not of much use. The inventor has to do both - learn the new context and resort to trial and error again. Typically, he tries to force-fit the previous solutions to the new problems - a rather inefficient, time consuming and random process. To change this trial and error process into a systematic method and to find a better way of inventing strong solutions had not seen much focus, until Altshuller, a young engineer, in erstwhile USSR after second world war, started exploring the patent data of many inventions and formulated a general theory of inventive problem solving, now known by the Russian acronym TRIZ.

TRIZ (Theory of Inventive Problem Solving) classifies inventions into five novelty levels (For example see [1]). Figure 1 summarizes the 5 levels of inventions. At level 1 are inventions that are slight modifications of the existing systems on one parameter, for example, more reliability. Typically these are localized within a single sub-system. At level 2 are those inventions that resolve a system conflict or contradiction (called a technical contradiction between two parameters of a system), using usually inventive solutions or inventive principles used to solve similar problems in other systems. This is what resulted in the most used TRIZ tool of contradiction matrix and 40 inventive principles. In fact, since 77% of inventions were at level 1 or level 2, TRIZ in popular press and by many consultants/trainers have been reduced to exploring and explaining contradiction matrix and 40 inventive principles.

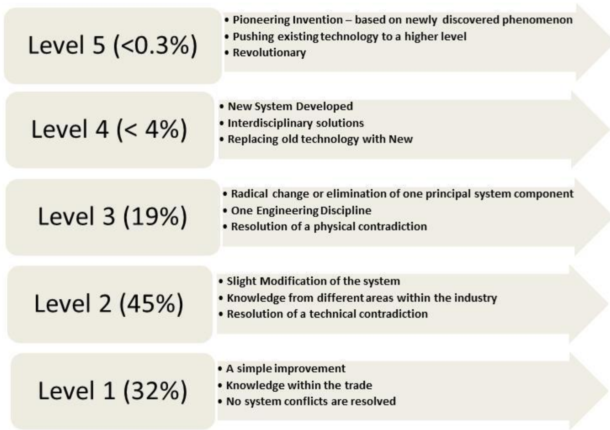

Figure 1: 5 Levels of Inventions based on TRIZ

However, it is with deeper understanding that leads to level 3 and above inventions, TRIZ can be very powerful. At level 3, the inventions change one subsystem or resolve the system conflicts in a fundamental way. TRIZ found that about 19% inventions were at level 3. At level 4, the invention gives birth to new systems using interdisciplinary approaches. Less than 4% inventions were found to be at this level. The level 5 inventions are closer to a recently discovered scientific phenomenon. They start a new engineering discipline and have long range impact on the technological development of human race. For example, [2] considers, agriculture, money, hammer, wheel, pump, lasers, etc, as level 5 inventions.

Recently, a new tool to quantify the levels and estimate the life of an invention using the level of inventiveness as described by TRIZ, has been developed [3]. Based on the change created in the new invention compared to existing or previous version of the system (usually called "prior art" in the patent related literature), a change score is computed. The weighted sum of all proposed changes in the invention is used to estimate the level of invention and map it to 5 levels defined in TRIZ.

In this paper, we describe a framework to invent strong along with three real life case studies. In Section 2, we describe the key pointers based on quantification of levels of inventions and laws of system evolution to indicate thinking paths to increase the strength of inventions. Section 3 describes couple of case studies to indicate the usage of the methodology. Section 4 concludes the paper with pointers for further applications.

2. Inventing using Levels of Invention

According to [2], inventive thinking has five distinctive features - the ability to present the world as a system with links between phenomena and objects; the ability to consider various resources; the ability to formulate contradictions, that is, to discern the core of the problem; the ability to consider each object in evolution (and trace its past, present, and future) to ideality; the ability to classify objects and to understand the relativity of any classification.

Key conceptual construct of TRIZ is a system – specifically a technical system. A set of elements that interact together to perform a function defines a system. The function is modeled as an interaction of two substances and a field – substances and fields are defined in TRIZ in very broad terms. The function to be performed or delivered identifies the system. In fact, most of the systems are developed based on what can be called the *operating principles* to deliver a function. For example, if you look at the function - cleaning teeth – the tooth brush or its variants are developed on the operating principle of *friction* to clean teeth. One can develop entirely new range of systems, hence products and services if one changes the operating principle. For example, if instead of friction we use ultrasound waves to clean teeth, we may have entirely new product or capability to clean teeth.

An invention is always studied and evaluated in comparison to the existing method, mechanism, system, problem, or, operating principle of delivering a function. Further, every system exists in an environment of super-systems, alternate systems, and even anti-systems. Also, the elements that constitute a system may themselves be considered as a set of elements delivering a function. Such sets are called sub-system, if they deliver a function that aids or contributes to the main or secondary functions delivered by the system as a whole. Hence, we have a hierarchy of systems – Subsystems, System and Super-system.

2.1 Changes in the System Hierarchy

To invent, the obvious, most strong and potentially disruptive way is to identify if new and different ways can be found to change the operating principle of the system to deliver the main useful function. This may lead to complete replacement of the current system with an altogether different system that delivers the same function in a different and usually better way. Various options exist to change the system hierarchy and interfaces of the system, subsystems and components of the current system hierarchy to explore new options for inventing. Table 1 gives different ways in which system hierarchy can be changed. It must be mentioned here that option *system removed function remains* under super-system changes, indicate changing the operating principle of the system to deliver the function. Once the operating principle is changed, the system has to be designed around the new operating principle.

Table 1: Ways to change system hierarchy for inventing

Changes in SuperSystem	Changes in System	Changes in SubSystem
System Removed Function Remains	Subsystem Changed Substantially	Component Changed
Systems Merged	Subsystem Removed	Component Removed
System Interface Changed	Subsystem Added	Component Added
New System Interfaces Created	Subsystems merged	Subsystem interface Changed
	Subsystem divided	
	New subsystem interface created	

To *invent strong*, understanding the operating principle of the system function and exploring super-system to find new operating principles of performing the same function is the key first step.

2.2 *Laws of Technical System Evolution*

TRIZ discovered the laws of system evolution. The key evolutionary goal of the technical system in TRIZ is to achieve a state of ideality. An ideal system performs the useful functions with no cost and no harm. TRIZ is based on the premise that the evolution of technological systems is not random but is based on evolution towards an ideal system. These laws help in the anticipation of the most likely next steps that will occur in the evolution of the technology and thus help in inventing stronger systems faster. The laws of evolution formulated in classical TRIZ [1, 2] are as follows:

- Law of increasing degree of ideality
- Law of non-uniform evolution of sub-systems
- Law of transition to a higher level system
- Law of increasing dynamism
- Law of transition to micro level
- Law of completeness
- Law of shortening of energy flow path
- Law of increasing substance-field interactions
- Law of harmonization of rhythms

The laws of evolution define a general direction for the development of next generation systems. However the predictive power of these laws can be greatly enforced by the lines of system evolution which specify the stages of a system's evolution along a general direction.

Recently a new law as well as new ideality in the new era of "information" has been proposed [4]. The new law for the information era that we are in is called Law of increasing intelligence of technical systems. This provides stages of how dumb systems are becoming guided, smart, brilliant, and potentially genius systems. Ideality in the era of information and future era of mind has also been described.

Classical TRIZ identifies the law of non-uniform evolution of sub-systems. Due to the different rates at which sub-systems and components have been evolving, system composed of such subsystems have evolution mismatch. This leads to what is called in TRIZ parlance Technical Contradiction. Many inventions are spent to resolve such contradictions in different systems. As mentioned such inventions are mapped to level 2 of the five levels. Technical Contradictions were organized into a contradiction matrix along with strategies that inventors used to resolve them. These invention strategies were termed Inventive Principles. Many TRIZ enthusiasts still use these to solve problems [1, 2, and 5].

Our aim in this paper, however, is to *invent strong* – how to invent to level 3 and above. At level 3 the invention solves many technical contradictions in the prior art and typically resolves a key physical contradiction. A Physical Contradiction (PC) in TRIZ parlance defines a situation when system demands a given subsystem should have a property A and also have a property Not A or anti-A. Resolving a physical contradiction requires application of what are called separation principles. Separating the system operation in time, in space or under different conditions can lead to resolution of a physical contradiction. Another way is to offer an alternative system which maps to potentially moving to an alternative operating principle of performing a function.

So we suggest the following key paths for invent strong

- Change the system hierarchy in some way including changing the operating principle of existing system;
- Move the system towards ideality through laws of system evolution. Select the key laws with higher probability of inventing using multiple criteria – especially – novelty, feasibility and business potential. And following the law of increasing intelligence, make it more intelligent; and,
- Find out and resolve a physical contradiction inherent in the system using separation principles.

In the next section we present 3 case studies when above process steps were utilized to generate/analyze higher order inventions.

3. Three Case Studies

In this section we show three real life case studies that helped us to explore and predict the next level inventions above the basic level 1 and level 2 of TRIZ.

3.1 *Fluid Catalytic Cracking (FCC) of hydrocarbons*

The crude oil available in its natural form has large chains of carbon and hydrogen molecules. These large molecular structures are not of much economic value. However, reducing them into smaller molecules that can be utilized gainfully can be done by heating the crude under control conditions. The field of hydrocarbon cracking, as the above process is called, specifically Fluid Catalytic Cracking (FCC) for Liquefied Petroleum Gas (LPG) and light olefin production has undergone major developments over the past decades and the process is continually evolving to become more efficient and productive. The main constituents of LPG are propane and butane. Light olefins consist mainly of ethylene and propylene and have high economic value as they are used in the production of various chemicals.

Fluid catalytic cracking (FCC) is primarily used in an oil refinery for the conversion of crude oils to lighter products like gasoline, diesel, LPG, olefins etc. The process was earlier mainly performed by pyrolysis; however, given the technical difficulties due to high temperature, *catalytic cracking* was later adopted given certain advantages such as more gasoline production with high octane number. The feedstock in an FCC process has an average boiling point of 340^{o}C and an average molecular weight of 200 to 600 or sometimes higher. The FCC unit consists of 3 major parts – the Riser, the stripper and the regenerator. During this process, crude hydrocarbon oils are reacted in the presence of a catalyst such that it favors their conversion to a desired hydrocarbon product. The catalyst gets deposited with coke in the process and is then transferred to a stripping zone, where the hydrocarbon products are removed from its surface via steam. The hydrocarbon products are then transferred to a reaction zone from where they are subsequently recovered. The catalyst is sent to a regeneration zone where the deposited coke is removed in the presence of a gas containing oxygen. The regenerated catalyst is then sent for further hydrocarbon conversion.

Upon doing a trend analysis of patents (See Figure 2) for FCC technology evolution using the three main International Patent Classification (IPC) classes, it was found that most of the important system components such as catalysts, equipment and processes for LPG and light olefin production are in the mature phase of evolution and the new inventions mostly involve only slight modifications in the existing system, such as increasing performance and reliability, therefore not resulting in significant improvement in the ultimate function to be achieved which is, increasing the yield of LPG.

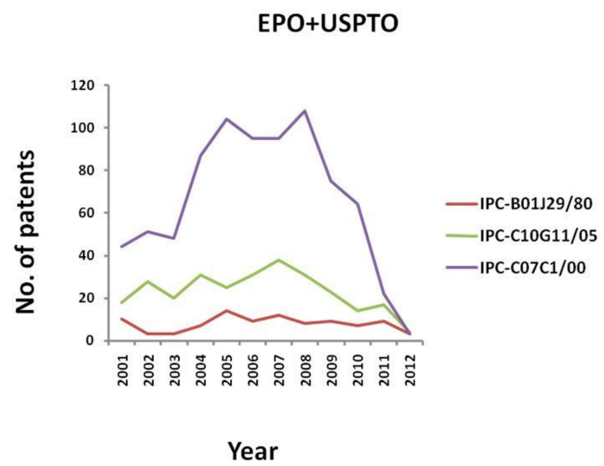

Figure 2: Patents filed in EPO and USPTO in 3 IPC classes

Table 2 gives key patents chosen from the search. Analysis of the key patents using TRIZ levels of invention indicates that there has been no significant invention to change the FCC process. This is a major inference. Table 2 gives the levels of inventions of key patents and as can be seen they are all at level 1 or level 2. *Therefore, the potential for further invention is there and needs for inventing strong in this field will lead to more efficient yield of light olefins and LPG.*

Table 2: Levels of Inventions for FCC patents

Year	TRIZ Level 1	TRIZ Level 2
1996		US5670051
1997		
1999		EP0922744B1
2000		US7102050
2006		US2006009349 (A1)
2007	WO2007094457A1	
2008	WO2008015995A1,US7585489	
2010	US2010174127 (A1)	US2010056648 (A1)

One can see that the key function in FCC is to break the strong bonds of large hydrocarbon molecules. Typically it is done by heat – increasing the temperature. Catalysts have been particularly effective to enable reduction of temperature in cracking. However, the saturation of inventiveness indicates that inventors *have not been looking at changing the operating principle of the function of cracking*.

TRIZ ask us to explore the question of achieving the function of *hydrocarbon cracking without FCC and without heating?* This is an important question from the super-system lens as described in Section 2 above. When we asked the same question to experts/scientists in the field who are deep into FCC, their answer was that they want to increase the light olefins and LPG production *only through FCC as* they are trained to do so - a typical problem that we call *psychological inertia of core competence*.

Although the experts wanted to pursue an incremental invention to level 1 or level 2 only, our inference from the trends of patent filings showed that *we need to find new ways of cracking the crude oil without increasing the temperature and without using the catalysts.* This key formulation of the inventive problem led us to search for operating mechanisms that can break large molecules.

Armed with this TRIZ lens we searched and found the US Patent number 8192591 B2, which describes *a new operating principle for cracking* that doesn't require catalysis and in fact can be done at room temperature. And it proves what TRIZ has been advocating; *the strong inventions will come from outside the field.* The patent discloses a new method based on using radiation beams on the crude for self-sustaining cracking of hydrocarbons. We reproduce the abstract below

"The present disclosure provides a simple and efficient method for the self-sustaining radiation cracking of hydrocarbons. The method disclosed provides for the deep destructive processing of hydrocarbon chains utilizing hydrocarbon chain decomposition utilizing self-sustaining radiation cracking of hydrocarbon chains under a wide variety of irradiation conditions and temperature ranges (from room temperature to 400.degree. C.). Several embodiments of such method are disclosed herein, including; (i) a special case of radiation-thermal cracking referred to as high-temperature radiation cracking (HTRC); (ii) low temperature radiation cracking (LTRC); and (iii) cold radiation cracking (CRC). Such methods were not heretofore appreciated in the art. In one embodiment, a petroleum feedstock is subjected to irradiation to initiate and/or at least partially propagate a chain reaction between components of the petroleum feedstock. In one embodiment, the treatment results in hydrocarbon chain decomposition; however, other chemical reactions as described herein may also occur." [6]

This is a new "operating principle" to achieve cracking without using the existing method of cracking. *It involves breaking the hydrocarbon chains by bombarding the crude with radiation beams. This changes the game.* Definitely this is closer to a level 4 invention. This should start a new technology for hydrocarbon cracking. The stronger inventions in future will emerge more in use of radiation to crack the crude rather than in the traditional fluid catalyst cracking process. This study not only provides a new invention, but also gives a predictive capability to the stakeholders to explore new operating principle for cracking – especially cold radiation cracking.

3.2 Bloating and Digestion of Bovine Cattle

In one of the recent workshops, we looked at a problem of feeding bovine cattle in large controlled cattle farms. Food for the cattle is given one time of the day and there is no control on how much each animal eats during the day. Feed is more than the capacity of eating/ digesting and there is no time for the cattle to drink water as it keeps on eating continuously. Inefficient daily distribution of food ingestion by animals and low amount of water drunk by animals leads to digestive disorders such as acidosis or bloating. This can lead to even the death of the cattle.

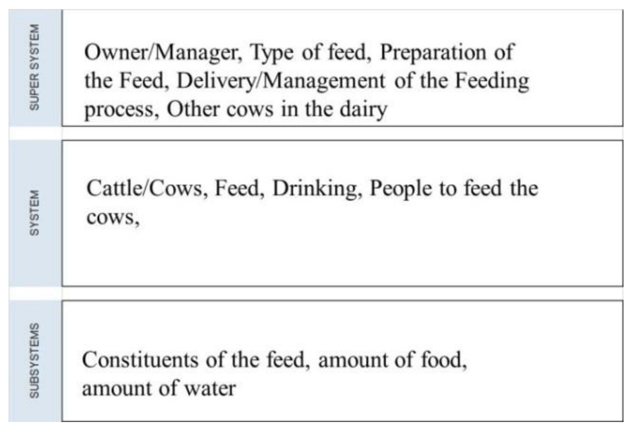

Figure 3: System Hierarchy for the Cattle Bloating problem

Using TRIZ, we organized the system hierarchy as shown in Figure 3. Next step was to map the key problems to the system hierarchy. Key elements of the problem and its impact on super system, system and sub system is given in Figure 4.

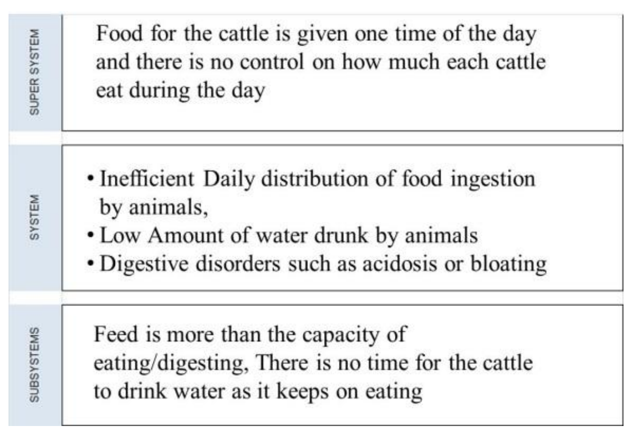

Figure 4: Mapping the key problems to System Hierarchy for the Cattle Bloating problem

The key contradiction or system conflict is that cows should be given food but they should eat only that much that they can digest in a specific time period. The problem, however is, that cows do not have a mechanism to *give themselves an indication of fulfilment of the food intake.* The physical contradiction can be stated that *"cows should eat but also not eat"*

From the definition of the problem above, can the subsystem (feedstock), system (cows) or the super-system (delivery of the feeding process) give the cows an indication of enough food being taken and asking them to stop and also drink water? One option is that we include something to the feed that actually gives an indication to the cows that they should take a break from eating. Armed with this conceptual solution, we did a patent search, and interestingly, found a patent application US 20100330187A1. The abstract of the Patent application is reproduced below.

Capsicum Food Additive and Uses Thereof

The invention relates to a food additive that includes, relative to the total weight thereof: about 3.5 wt % of capsicum oleoresin containing 6 wt % of a capsaicine and dihydrocapsaicine mixture; about 5.5 wt % of cinnamaldehyde; about 9.5 wt % of eugenol; the balance up to 100% consisting of hydrogenated vegetable oils. The invention also relates to the uses of said additive for improving the daily distribution of food ingestion by animals, for increasing the amount of water drunk by animals, or for preparing a food product intended for the preventive or therapeutic treatment of animal digestive disorders, such as acidosis or bloating. This food additive is particularly adapted for ruminants such as bovine cattle.

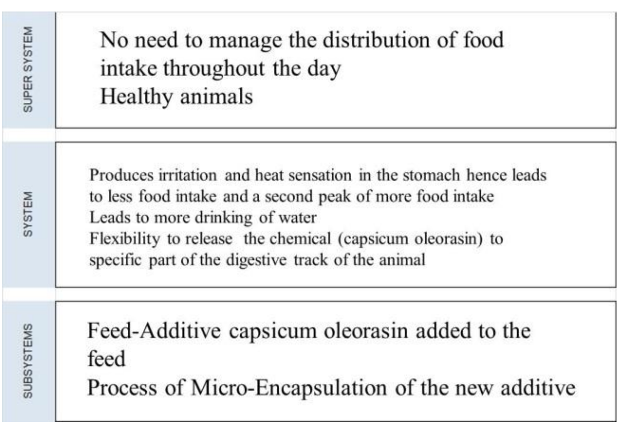

Figure 5: Capsicum food additive to feed impacts across the system hierarchy

Figure 5 describes key changes and impact due to the invention in the patent. Adding a capsicum based food additive to the feed has impacts and benefits across the system hierarchy. This gives an interesting solution to the problem of giving an indication to cows that they had eaten enough, by creating irritation and heat sensation in the stomach. This forces the animal to drink more water. In one embodiment, micro-encapsulation leads to more flexibility to release the chemical to the specific part of digestive tract of the animal.

3.3 The Optimal Path to Ideality

In the third case study, we present a new approach to select the optimal path to invent the next, which has higher probability of leading to stronger inventive solutions. This approach was utilized in selecting and ranking the laws of system evolution that has higher chances of reaching to stronger inventions for a consumer care product. The approach is based on the multi-criteria decision-making (MCDM) technique known as the Analytic Hierarchy Process (AHP) [7, 8]. The cardinal law, which guides the technological system evolution, is the law of ideality. The eight laws are subservient to the cardinal law. The second law, non-uniform evolution of sub-systems typically results in technical contradictions which can be resolved through inventive principles.

The remaining 7 laws of evolution define clear paths to ideality. One can pursue all directions simultaneously for ideation. However, for inventing strong, we need to evaluate the paths to ideality – the laws of system evolution – which will lead to higher chance of stronger inventions for a given product (function) in specific stage of evolution. For ranking the paths to ideality, we propose three criteria – Novelty, Feasibility and finally Business Potential. AHP invites opinions of experts in a pairwise comparison of the alternatives for each criterion. These pairwise comparisons on a qualitative scale are converted to quantitative rankings using a ratio scale that is organized in what are called reciprocal matrices. The normalized principal Eigen vector of these matrices gives a relative quantitative rank of each alternative.

For the specific case, we invite the pairwise comparison of 7 laws of evolution for each criterion. These are converted into a quantitative matrix for each criterion. Shown in Figure 6, Figure 7 and Figure 8 are the matrices for all Novelty, Feasibility and Business Potential. The second last column gives the computation of relative quantitative ranking of each of 7 laws of evolution on specific criteria.

Novelty/Technology Enhancement									
Laws of System Evolution	Increasing Dynamism	Higher Level System	Transition to Micro-levels	Law of Completeness	Energy Flow Path	Increasing Controllability	Harmonization of Rhythms	Category Weight = Average Row sum of normalized column entries	Eigen Value Computation Col
Increasing Dynamism	1.000	7.000	0.333	7.000	7.000	1.000	9.000	0.2314	2.238
Higher Level System	0.143	1.000	0.111	0.143	5.000	0.200	7.000	0.0703	0.565
Transition to Micro-levels	3.000	9.000	1.000	5.000	7.000	5.000	9.000	0.3863	3.446
Law of Completeness	0.143	7.000	0.200	1.000	1.000	1.000	7.000	0.1051	1.029
Energy Flow Path	0.143	0.200	0.143	1.000	1.000	0.200	5.000	0.0484	0.379
Increasing Controllability	1.000	5.000	0.200	1.000	5.000	1.000	7.000	0.1393	1.280
Harmonization of Rhythms	0.111	0.143	0.111	0.143	0.200	0.143	1.000	0.0191	0.142

Figure 6: Pairwise comparison matrix for Better Novelty/Technological Enhancement for 7 laws of evolution

BUSINESS POTENTIAL									
Laws of System Evolution	Increasing Dynamism	Higher Level System	Transition to Micro-levels	Law of Completeness	Energy Flow Path	Increasing Controllability	Harmonization of Rhythms	Category Weight = Average Row sum of normalized column entries	Eigen Value Computation Col
Increasing Dynamism	1.000	0.143	7.000	7.000	7.000	0.333	7.000	0.1949	1.743
Higher Level System	7.000	1.000	5.000	5.000	5.000	0.200	7.000	0.2406	2.717
Transition to Micro-levels	0.143	0.200	1.000	1.000	5.000	0.143	5.000	0.0753	0.608
Law of Completeness	0.143	0.200	1.000	1.000	1.000	0.143	5.000	0.0535	0.415
Energy Flow Path	0.143	0.200	0.200	1.000	1.000	0.143	5.000	0.0481	0.355
Increasing Controllability	3.000	5.000	7.000	7.000	7.000	1.000	7.000	0.3656	3.546
Harmonization of Rhythms	0.143	0.143	0.200	0.200	0.200	0.143	1.000	0.0220	0.172

Figure 8: Pairwise comparison matrix for Better Business Potential for 7 laws of evolution

READINESS & FEASIBILITY									
Laws of System Evolution	Increasing Dynamism	Higher Level System	Transition to Micro-levels	Law of Completeness	Energy Flow Path	Increasing Controllability	Harmonization of Rhythms	Category Weight = Average Row sum of normalized column entries	Eigen Value Computation Col
Increasing Dynamism	1.000	1.000	5.000	7.000	5.000	0.333	7.000	0.1959	1.867
Higher Level System	1.000	1.000	7.000	7.000	7.000	0.333	7.000	0.2189	2.091
Transition to Micro-levels	0.200	0.143	1.000	0.143	1.000	0.143	7.000	0.0535	0.403
Law of Completeness	0.143	0.143	7.000	1.000	1.000	0.143	7.000	0.0877	0.787
Energy Flow Path	0.200	0.143	1.000	1.000	1.000	0.143	7.000	0.0587	0.478
Increasing Controllability	3.000	3.000	7.000	7.000	7.000	1.000	7.000	0.3630	3.163
Harmonization of Rhythms	0.143	0.143	0.143	0.143	0.143	0.143	1.000	0.0222	0.162

Figure 9: Pairwise comparison matrix for Better Feasibility for 7 laws of evolution

Figure 10 summarizes the relative rankings of potential of the strong inventions on all three criteria. The numbers under each criterion sums up to unity. One can see, according to the experts, maximum novelty for the specific consumer care product can be created by pursuing ideation on *Transition to Micro Systems*. Second and third best alternatives are to explore *Increasing Dynamism* and *Increasing Controllability*. This guidance is not trivial and obvious. The use of AHP for guided inventive thinking on TRIZ laws of evolution is a unique methodology that we have used in this case study and described here.

Laws of System Evolution	NOVELTY/TECHNICAL ENHANCEMENT Relative Importance	BUSINESS POTENTIAL Relative Importance	FEASIBILITY Relative Importance
Increasing Dynamism	0.231	0.195	0.196
Higher Level System	0.070	0.241	0.219
Transition to Micro-levels	0.386	0.075	0.053
Law of Completeness	0.105	0.053	0.088
Energy Flow Path	0.048	0.048	0.059
Increasing Controllability	0.139	0.366	0.363
Harmonization of Rhythms	0.019	0.022	0.022

Figure 10: Relative ranking of each law of system evolution on novelty, business potential and feasibility

The final rankings can be obtained by combining the rankings on each criterion for each law of evolution using a weighted sum. Figure 11 assumes equal weight for each criterion and computes the final ranking for each law of evolution.

Laws of System Evolution	Final Ratings
Increasing Dynamism	0.207
Higher Level System	0.177
Transition to Micro-levels	0.172
Law of Completeness	0.082
Energy Flow Path	0.052
Increasing Controllability	0.289
Harmonization of Rhythms	0.021

Figure 11: Final ranking of each law of system evolution

It can be seen that *strong invention* can be created by moving on increasing controllability, increasing dynamism, higher level systems and transitioning to micro-levels. The clarity obtained using this methodology helps in inventing strong by focusing and moving on more stronger evolutionary directions.

The laws are mapped to a *Strategic Bubble Map* that we use to present various alternatives on the three criteria of Novelty, Business Potential and Feasibility. The x-axis maps the feasibility of the alternatives; the y-axis indicates the relative novelty of alternatives and finally the size of the bubble indicates the relative business potential (see Figure 12). In a single view, one can get the complete and comprehensive strategic direction to invent of the 7 laws of system evolution.

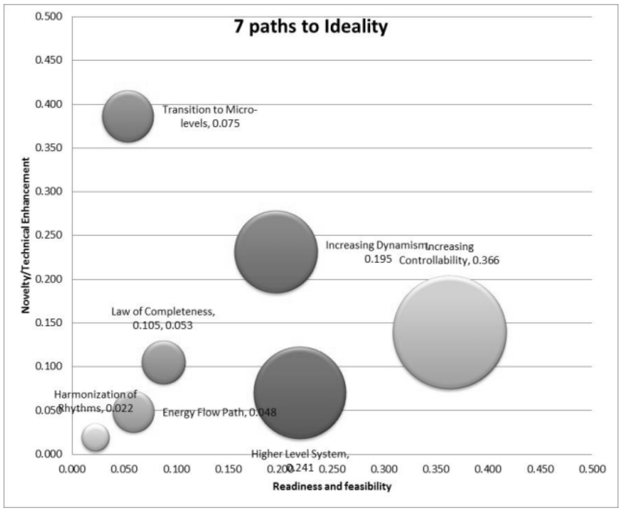

Figure 12: Strategic Bubble Map for Selecting the Laws of System Evolution

4. Conclusions

Human minds have been solving problems for inventing new solutions using trial and error. Theory of Inventive Problem Solving (TRIZ) developed after analysis of large number of patents, offers a radical change to the random trial and error. The theory classifies the inventions in five different levels of increasingly strong inventiveness. Using the levels of inventions and associated thinking tools of TRIZ, this paper provides a framework for *invent strong*. Three real life cases are described where we applied this framework to help identify and explore new paths. The key message of the case studies is that in the absence of TRIZ inputs, the inventors using the trial and error would have continued to remain at level 1 or level 2 **-** a mere improvement. Further, as part of this framework, we describe a new methodology that uses the Analytic Hierarchy Process (AHP) on three criteria of Novelty, Feasibility and Business Potential to map 7 laws of system evolution for higher and stronger inventions. The overall framework helps us invent strong in a more efficient manner. We propose TRIZ based framework described here should be used not only to invent strong but also to solve complex global problems.

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