CONTRADICTIONS AND SYSTEM THINKING

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In TRIZ, contradiction is one of the key concepts which lets us formulate problems and guide towards really innovative ideas. A contradiction arises when two mutually conflicting demands are put on the same system or a situation. This happens quite often in our everyday lives. For instance, a hard drive in a portable computer must be as small as possible to enable portability, but at the same time it should have a large volume to enable large capacity. Usually we tend to solve such problems by thoroughly optimizing existing technologies, but at a certain moment we always reach a point where no further optimization can help since all the resources for optimization have been exhausted. To evolve a system or technology further we must resolve the contradiction. How to do it?

Once I needed to be at two places at the same time. I was simply unable to shift two events in time due to certain reasons. And could not cancel one of the events, because both were of high priority to me. What I did, I found the common features of both events and brought them together to one place, at the same time. We often do it, this solution sometimes comes to our mind naturally. A problem is that we do not often even think about a possibility to combine two seemingly different events. But what is even better: by combining the two events, we can share the same resources, we can share the same room, pay for the travel only once, etc. The result: we achieve our goal without loss and, on top of that, we save costs. And we achieve “win-win” result.

Many individuals and organizations face contradictions every day. For instance, two events can be conducted at the same time, but a budget available is enough for a single event only. So what do we do? Traditionally, if we are not able to raise an extra budget, we cancel one event in favor of another. But this is not a “win-win” situation. Contradictions should be solved wherever possible by meeting both demands. Solving contradictions is a driving force of evolution of any system, either technological or social, as ability of a person to resolve contradictions is an indicator of a “strong” innovative thinking. Contradictions can as well determine the quality of innovative solutions: the better a proposed solution eliminates the contradiction, the higher potential the solution might have.

Understanding what contradictions are solved (if any) by a new idea, helps as well to determine if a new idea has a high potential or low. For instance, take Apple’s iPod™: the device is hugely successful since it solves many contradictions: it has a large storage capacity and at the same time is small; It has long playback time even

with a hard drive; once you have iPod you know where to get new songs (thanks to the iTune™ service); you can change your iPod's outlook so you still have the same device as others but "different"; and so on.

A process of developing skills of formulating and solving contradictions is twofold: first, it enables us improving our products, services and technologies. Second, it helps us with developing our capability of system thinking. Thinking in terms of contradictions is not a natural way of doing things. To solve a contradiction, we have to break our mental inertia, to go beyond borders of our existing mindsets about technologies, products and services. But instead, our mind almost always tends to come up with compromises, or trade-offs: because this is safer and easier. To learn how to think and reason in a way that would help us dealing with contradictions, we must force ourselves, which is not an easy process, but inevitable if we aim at breakthrough solutions.

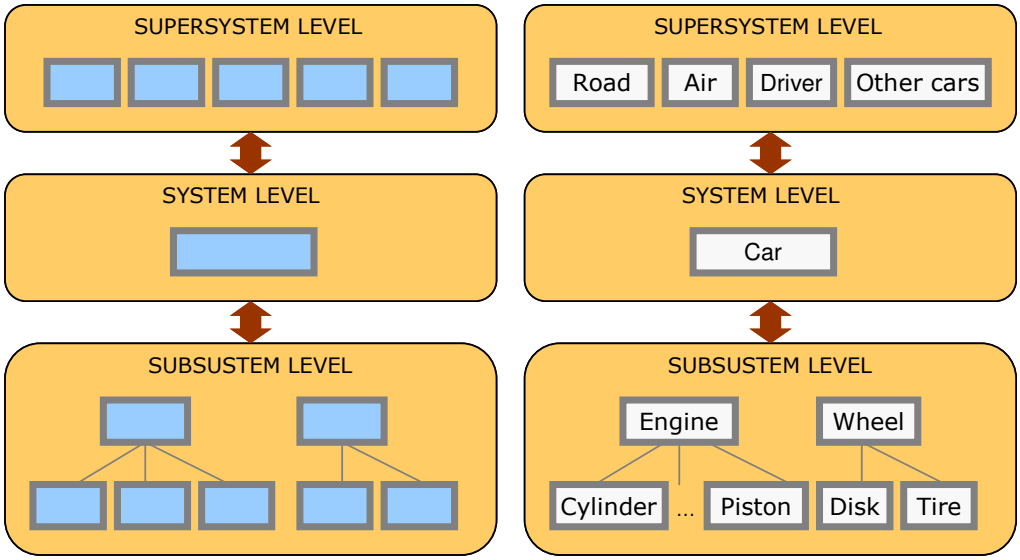
TRIZ offers several methods to solve contradictions. But just having TRIZ principles listed in the book on our desk is not enough: the way of thinking in terms of contradictions and their resolution should become our "habit". Luckily, this skill can be developed by virtually everyone, as indicated by numerous TRIZ studies.

Solving Contradictions: System Levels

How do we solve contradictions? In most cases, without knowing TRIZ, by what we call "insight", or by trials and errors approach. If a problem has existed for a long time, our mind is looking for a solution both consciously and subconsciously. And one day we might come up with "Eureka!" situation. If we are lucky. And if not? To cope with the situation, TRIZ and Systematic Innovation offer logical approach to attacking those problems that are stated as contradictions, in combination with generic patterns of "strong solutions" which had solved different types of contradictions in the past.

In general, any product, technology or social system can be represented at three levels:

- **System level**: a system itself.
- **Supersystem level**: everything that does not belong to a system but interacts or might interact with the system, or produce influence upon functioning of the system.
- **Subsystem level**: everything that belongs to a system, each system's component and assembly.



Once we face a contradiction in a certain system, we can solve it at each of the three levels. First, we explore if the problem can be solved at the subsystem level: by modifying, removing or adding components to the system. If solutions cannot be found at the subsystem level, next we explore the supersystem: how can we change a supersystem to ptovide the effect required? And finally, if no solution can be found at these two levels, this means that the main working principle of the system has no potential to evolve further to deliver its function as required and should be replaced with a new principle.

For instance, take a multimedia projector (beamer). One of the problems regarding the beamer is that we can see the image projected to the screen quite well under the darkened conditions. And if the room is brightly lightened, we have difficulties with clarity of the image. So what the contradiction can be? Well, we need light in the room to make notes, etc. and there should be no light in the room. Note, that the same situation might be expressed by several different contradictions, so we usually limit ourselves to the most important to us. We can solve the problem at three levels:

- **At the level of subsystem** (adding new or redesigning existing subsystems): making a very bright source lamp; adding more powerful optics.
- **At the level of super-system** (changing the surrounding system in such a way that it eliminates the problem): Making the whole room dark but installing light spots in places where we need to make notes; making the surface of the screen with tiny light concentrators (the screen is not a part of the system "beamer"); using several beamers instead of a single one; using illuminated notepads; etc.
- **At the level of system**: replacing the beamer with another system, for instance, a large autonomous LCD screen.

But still, solving a core problem might (and in most cases, will) generate other problems. If we increase the power of the lamp in a beamer, we need to install a more powerful cooling system which will consume a lot of energy and will produce more noise. Or, if to formulate a new contradiction: the lamp is hot since it should

be bright, but it must be cold to avoid large heat generation… Again, cooling systems that are known are mostly compromises: a core contradiction still remains with this solution. Can the lamp be very bright and cold at the same time? We need a new idea for the lamp, in this case the lamp becomes a new system we should analyze while solving the subsequent problems. Or, we should forget about the lamp and chose other directions mentioned above. But eventually, every direction should be explored: there might often be some "hidden" benefits in the ideas that are invisible during superficial analysis.

Let us have a look at another problem. Many road accidents happen when two or more cars collide at crossroads. What can be a contradiction here? We need cars to move fast across the crossroads to move as efficient as possible, and at the same time they should not move too fast since they might collide. How do we solve this problem? According to what is mentioned above, we can solve it at three levels:

- **At the level of a subsystem** (adding new or redesigning existing subsystems): bumpers (actually, a compromising solution: to soften symptoms rather then solving the core problem); ultrasonic distance sensors; etc.
- **At the level of a supersystem** (changing the surrounding system in such a way that it eliminates the problem): road signs; traffic lights; "sleeping policeman"; putting the crossing roads at different levels; fully automated road traffic control with feedback to the cars.
- **At the level of a system**: redesign cars in such a way that they do not experience collision when they collide. Examples are unknown yet since they do not seem to be physically feasible. "Flying cars" that jump over other cars during collision? Sounds more like science fiction, but many great ideas were born in science fiction (a submarine, space station, videophone, and so forth).

And still, this contradiction is not totally solved in some of the proposed solutions. For instance, traffic lights do not eliminate the contradiction in total: they still slow down the cars, and accidents still might happen. It has been hundred years since we have cars, but the contradiction is still there. Of course, we know 100%-reliable ways to solve this problem (e.g. putting crossing roads at different levels and connecting them as on highways), but we face another problem: how do we do it, say, in large, packed cities where it is simply impossible to redesign the existing road traffic infrastructure? We must formulate new contradictions and solve them. Solving a difficult contradiction usually identifies not a specific solution, but a solution strategy.

Contradiction Trees

In most cases, when we deal with complex problems, solving one, core contradiction is not enough. Sometimes finding another "working principle" generates dozens or more other contradictions that have to be solved in order to successfully implement this new working principle. Take, for instance, digital cameras. You all remember all these low-resolution, terrible quality of the first pictures. Yes, introduction of a digital matrix replaced the "working principle" behind image capturing but created many more other contradictions which were subsequently solved to bring modern low-cost digital cameras that offer

professional quality of imaging. The same happens in almost every area of human activity: first, a principal contradiction is eliminated (which is most difficult to solve), then all subsequent contradictions are being solved. This is very important to remember that in most cases, subsequent problems are easier to solve than the principal contradiction. If we do not remember that, we might reject a potentially breakthrough solution without exploring it; and it happens many times due to our fear to deal with all the problems that are generated by this new solution. But… is the "Flying car" mentioned above a science fiction?

See "The Flying (and Driving!) Dutchman" press release, at
http://www.sparkdesign.nl/actueel/20041013palv/20041013press.html

The bigger the area is in which a system operates, the larger "contradiction trees" arise. For instance, we all know that the existing oil resources are limited and soon might be gone for good. For this reason, many businesses today invest to develop alternative energy sources. A large domain of oil-based energy consumption is automotive industry. And no matter how much we optimize the use of oil to power cars, we do not solve a contradiction: we only deepen it, one day the oil will be over (at least, this is the most widespread opinion today among scientists; there are alternative views on oil reserves as well). We need thus to change the "working principle": the old system (natural gas powered engine) might soon disappear. There are a number of alternative technologies which are being explored today. If you learned the TRIZ basics, you will remember the "mono-bi-poly" trend of system evolution, and you can notice that some companies invest to create "bi-systems": by combining electric and gas-driven engines, for example. Nevertheless, this is only a partial solution to the problem. What we need, is a complete replacement, based on the fact that carbon-based resources are limited. Another alternative, for instance, is the fuel cell technology. They seem to be a good alternative "working" principle, but the fuel cells are still expensive and have limited applications.

But anyway, this might be a solution to the core problem since it resolves the contradiction: no more oil should be consumed to create fuel cells. Making fuel cells reliable and cheap is just a matter of time unless some other "working principle" is found to be more effective. Again, improving fuel cell technology means resolving a number of contradictions in the field. As an example, one of the problems with fuel cells is that until now the market introduction of solid oxide fuel cell has not occurred due to expansion and material compatibility problems related to sinter bonding and incompatibility of the different materials. Under high temperatures, different materials expand differently and the fuel cell might crack. Also, the use of different materials complicates manufacturing and recycling. Optimization and selection of "right" materials can help but the technology remains expensive. A new patented design, proposed at http://www.sofc.nl/help_design.html, offers avoiding these difficulties by omitting

sinter bonding by application of loose stacking of the cell elements, enabling free thermal expansion.

Features of a "strong" solution

By applying Systematic Innovation techniques to solve contradictions, we usually generate a number of alternatives. How to select a right one? Apart from specific criteria and constraints that might limit feasibility of proposed alternatives within a context given, we recommend the following set of criteria:

1. Contradiction is fully resolved: no compromise or trade-off.
2. "Win-win" situation is achieved: both conflicting demands are met, everybody is happy and nothing suffers.
3. Solution does not generate any other harmful or negative effects.
4. Solution costs nothing to implement or is low-costs.
5. Solution provides extra benefits.

Of course, meeting these criteria means that an almost "ideal" solution is found, which is not always the case. But still, applying this list of criteria helps to quickly recognize most promising ideas.

Summary

In this paper, I only highlighted certain, very general guidelines for formulating and solving contradictions, and explained how to separate between different system levels to direct a solution generation process. TRIZ and Systematic Innovation offer detailed techniques to identify and eliminate contradictions combined with specific patterns available for different levels. But still, even ability to recognize contradictions alone is a very powerful source for innovation, and especially answering the question "where should we go from now?" Skills with solving the contradictions considerably empower any individual and organization.

About the Author: Valeri Souchkov, TRIZ and Systematic Innovation expert, consultant and trainer with over 15 years of experience. He was among the first who pioneered promotion of TRIZ outside the former Soviet Union, and established the European TRIZ Association (*www.etria.net*). Currently he heads ICG Training & Consulting in Enschede, The Netherlands. Among his customers are many Fortune 500 organizations worldwide. He can be reached at valeri@xtriz.com