Parallel Evolutionary Lines (PEL).

Autoreferat of Master TRIZ Thesis

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Introduction

Object of present dissertation is development of a forecast tool PEL, based on analysis of parallel development of two systems having some affinity. Presently, three types of such affinity have been found: (i) affinity by function; (ii) affinity by physical nature of two systems; (iii) affinity of operation principle; and (iv) target consumer group – market-niche.

Analyzing evolution in the system-analog and adapting found principles and technologies to original system, one can build Evolutionary Line of the original system and transfer a technology, ready to be implemented.

Sometimes PEL can point on necessity of principle operation change in the original system.

In the thesis author analyzes interaction between PEL and other TRIZ forecast tools, such as TESE and Development Lines (DL), as well as Function-Oriented Search (FOS). The method is being illustrated by numerous examples from the author's consulting practice.

The problem of engineering systems evolution forecast presents in TRIZ from very beginning. Originally, following G.S. Altshuller [1], forecast methods were associated mostly with a high-level inventive problem solution. However, in recent years a certain shift occurred as a result of consulting on Western market. TRIZ forecast methods “out of the shadows” of the problem solving. According to S.Litvin [2], “the TRIZ paradigm change is Theory of Engineering System improvement instead of Theory of problem solving. And what they write Zlotin B. and A. Zusman, [3] in connection with problems arising in consulting practice : "The solution to these problems in the TRIZ forecasting of has been a shift from high-level solutions for a realistic prediction of the next steps of development."

Thus, the development of production technology, new products and services forecast is perhaps the main task in demand at the intersection of TRIZ and business. Not surprisingly, these issues are an extensive TRIZ literature [4-20] and others.

1. Method of Parallel Evolutionary Lines (PEL) analysis

Very often, technological and market systems/processes manifest some affinity passing through similar development stages. In some of those systems/processes the affinity originates from the fact that (i) the systems perform a similar function; (ii) the second type of affinity stems from the common physical nature of those systems; (iii) the third type of affinity is affinity based on the same principle of operation; yet (iv) the fourth type of similarity, found so far, is similarity of target consumer group. In all the development similarities mentioned above we could describe systems/processes development as following Parallel Evolutionary Lines (PEL).

As a rule, one of the systems is more advanced along the evolutionary path than other systems. Therefore, identifying the PEL of a given system/process could be used as a tool for predicting technological and market future developments of relatively less advanced systems/processes.

1.1. Functional affinity

Which system to choose as an analogue of this system? How many of them to be? First of all, the more analogues, the better. "Copying" should be taken of the system, performing the same function, but more advanced. This does not mean that the system must necessarily be high-tech or something like that. Here the word "advanced" means a system in which the function has big significance, so the system in terms of this function was more developed, that is passed on to its line of evolution. Compile a list of functional analogues can, starting with systems in the same super-system.

Example. Assume the analyzed system is a car. The supersystem of a car is means to transport people, and functional equivalents will be a motorcycle, bus, plane, etc. An even more generalized function - transportation in general. In this series of analogs will be a truck, an aircraft, submarine, etc.. As to neighboring analogues it is easy to understand. However, just far analogues have a better chance to give a non-trivial and beautiful result. To find them, they should formulate Generalized Function of the system. As is known, Generalized Function can be by the object and by the action. In our case, by the object – to do something with someone (or rather, for someone), for example, deliver the person a sense of pride. Then the analogue of the car would be villa, jewelry, etc. By the action will be - to move something. In this sense, an analogue of the car will be, for example, a pump.

Functional affinity can be considered on the following types of functions:

• Explicit function, as a rule - Main Function of the system

• Hidden Functions

• Generalized Function

For a functional similarity can be attributed to the commonality of the target group of consumers of that product or service. Parallel lines of evolution of a product or service in this case is based on the psychology of a particular group of consumers. If this group responded in some way to the emergence and evolution of a product or service, we can assume that it will react similarly to the situation related to other goods or services. Here, in principle, one can speak of functional affinity between the two systems at the highest level - to meet needs, deliver a sense of satisfaction and pride

1.2. Affinity of Physical Nature of the systems

Functional commonality, however, is not the only source of parallel lines of evolution. Another such source could be a common physical nature of systems. By this we mean that the systems have a common set of physical properties.

Example. Ultraviolet radiation (UV) has the same nature as visible light. Both phenomena - is electro-magnetic waves. Therefore, the forecast of, say, a UV source development can be formed by tracing, an evolutionary line of light sources: filament → gas discharge → emission of photons in a semiconductor – (LED). Knowing that the UV sources have already passed the stage of thermal radiation, and are now at the stage of a gas discharge, it is logical to begin to probe the soil in the direction of the UV LED.

Example. Bread. Physically - it's kind of hard (elastic) mass with a pore system. What is it like? Sponge, or, in general, foam. Thus, the line of evolution of methods of production of foams in the industry can be projected to the production of bread and bakery products. For instance, the technology of solid foam production is moving from foaming simply using gas-generating agent to accelerated foaming, which uses external influences, like vacuum or ultrasound. In accordance with the method of PEL, we can expect a corresponding shift in the technology of bread baking, i.e. we can expect the emergence of technology, based on the use of vacuum, sound or ultrasound.

1.3. Affinity of the Operation Principle

Finally, the third a source of commonality, identified so far, is Affinity of the Operation Principle. How can be the same principle of operation of systems with different functions?

Example. Incandescent lamp and stove have the same operating principle - ohmic heating of the conductor, but a different functions - to provide light and to give warmth, respectively. One of the lines of evolution of the heating elements is a transition from surface heating - to the volume heating. Let's try to project this trend to light sources. Here we obtain a rather unusual idea - a source in which light is emitted not from the surface, but from the volume! What is it? We do not know, maybe something like a hologram.

But it is interesting and useful. The light source can be moved without moving anything. It does not disturb anything, you will never stumble on a floor lamp and not banging the head on a chandelier ...

In practice is often a challenge to find a new application (new feature) of the system. PLE method based on common physical nature and operation of systems can be one of the most powerful tools to find new applications and ideas for new products.

Example Mentioned above similarity of bread and solid foam. One of the trends in foams is the transition from porous structure to microporous (and now - to nanoporous). It turns that with reduction of pore size, increases the ratio of the strength of the foam to the mass. Therefore, you can increase the volume percentage of pores without sacrifying the strength. So, microporous bread will be much lighter than usual, but will not crumble. You can eat a whole loaf and not grow stout. In addition, the micropores have a phenomenal heat insulating ability, close to vacuum. So ice cream kept in a microporous waffle in the heat for a long time does not leave, and warm chocolate will stay warm even in freezing weather.
What are applications of solid foam? - Lightweight materials, absorbents, thermal insulation, silencers, impact absorbers, etc. You can trace the evolution of each of these systems and to project it into our system - the bread. For example, absorbents have ratio of absorbable liquid to the dry mass of 10:1; superabsorbent - 100:1 or more. Such materials are used in, say, diapers. What good superabsorbent bread? You can imbue it with something tasty and healthy and take and eat, and not afraid that everything will flow to the hands and dirty clothes. This will be both food and drink.

1.4 Similarity of the target group of consumers – Market-niche

Parallel lines of evolution of a product or service in this case are based on the psychology of a particular group of consumers. If this group responded in some way to the emergence and evolution of a product or service, we can assume that it will react similarly to the situation related to other goods or services

1.5 Algorithm of PEL method implementation

PEL analysis implies the following sequence of operations:

1. One should identify analogues - systems that have some commonality with the system

1.1. Functional affinity:

- formulate the system functions, including generalized and hidden
- for each function to find systems that perform the same functions. First - the same principle of action, then the rest.

1.2. Physical affinity:

- analyze a set of physical properties: essential - emulsion, porous structure, the wave and external – small, tidy and so on.

- find systems-analogues having similar features.

1.3. Affinity of Operation Principle:

- identify systems with the same principle of operation, but performing different functions.

1.4. Common Market-Niche

2. Analyze lines of evolution, select the system-analogues with bright lines of evolution, that is associated with some qualitative leap by the parameters (absorbent - superabsorbent), transfer to another principle of action, the appearance of other applications, and so on. This criterion is "Brightness" lines of evolution of the analogue system, is probably the main criterion for rapid screening of such systems.

3. These trends are projected onto the original system

4. Selected relevant and non-trivial results.

5. Items 1-4 are passed several times by a spiral from the nearby counterparts to the distant, yet the system will be found with "bright" a line of evolution, which gives non-trivial scenario in the original system.

As we move away from the original system, lines of development of other systems can become either irrelevant, or "slope" in the general laws with which TESE deal. In any case, the number of meaningful and non-trivial scenarios will be very limited. Further, these scenarios can be ranked by probability, or the time of implementation. It may also be that line of the system evolution will split in the future.

Thus, four sources of affinity (the parallel lines of evolution) are found so far:

• Functional affinity, including Generalized and Hidden functions

• Affinity of Physical Nature

• Affinity of Operation Principle

Common market-Niche.

However, he admits the possibility of finding in the future and other sources of affinity, which may be useful for finding effective and non-trivial potential lines of development of the technical system.

2. Special features of PEL method

Solution of the problem without her explicit formulation

It should be noted that in many cases explicitly address the problems of the original system is not required. it means that if the advanced system switched to a different technology, they apparently had to solve a problem of old technology. One can assume that similar problem is in the original system. Thus, an important feature of the PLE-analysis is that it provides a forecast of the system without an explicit formulation of its problems. Moreover, sometimes the real problems of the system can be identified after technology transfer from the system-analogue.

It turns out the original situation, when you can, in principle, to solve problems that are not stated, and even not identified. Moreover, the transfer line of evolution from another system, in principle, can help to identify previously hidden problems of the system.

It should be noted that the possibility of solving the problem without explicitly identifying, in principle, is present in other prognostic tools of TRIZ, and not just in the PLE. Ability to solve problems without its explicit formulation lies in very TRIZ paradigm change - from problem solving to improve the engineering system [2].

Pointing to the need for a qualitative leap, change the "principle of operation" in the original system to follow the identified evolutionary lines. Such an indication, is actually, due to the fact that as analogs of this system, we chose only systems with a "bright" evolution, in which, by definition, occurred change of the operating principle.

3. PEL and other TRIZ tools

3.1. TRIZ forecast tools: TESE – Development Lines - PLE

TESE - are the fundamental laws of development, which include virtually all systems. They tend to give general guidance, direction of improving the system.

Development Lines - more specific patterns relating to a particular class of systems. They provide more specific guidance. In fact, they specify the direction given by the law. On the scale of universality PEL are further away, they are rather narrow class of systems associated with a given affinity - the functional, physical nature or principle of operation. However, their instructions are very specific - down to the finished technology and addresses of the company, where to go.

3.2. PEL and Function-Oriented Search (FOS)

Te first and most natural type of affinity for PEL is commonality of the main functions of the two systems. At this point - relying on a functional commonality between the two systems, an analysis of the parallel lines of evolution comes into contact with yet another tool of TRIZ - the method of Function-Oriented Search.

FOS was developed as a tool for solving problems, not as a specific prognostic tool. However, it is capable of delivering strong solutions, and in this sense, following G.Altshuller, we can consider it as a prognostic tool.

According to FOS for the problem solving you have to find another system with the same Main Function as the original system. As an analogue it is desirable to find a system in which the function has a higher functional value or simply saying, more important. Therefore, it is very likely that in this system posed problem has been resolved. It remains only to project the solution on the original system.

It is clear that ideological approaches of methods PEL and FOS are very close. Only if the latter projects a point into point, the PEL method projects a line into line - the trends of development of different systems with similar functions.

Another feature, where PEL and FOS are close, is that both instruments give very specific instructions. PEL method as FOP usually gives an indication of the ready-made technology.

Differences of the methods, except the above-mentioned project lines into line instead of point into point, are also in relying not only on Main Function of the systems, but also on Generalized Functions in the broadest sense, Hidden Function, as well as other symptoms of similarity of the two systems, such as Physical Nature of and Principle of Operation.

Thus, the method of PEL as a forecasting tool is closely linked with other TRIZ prognosis tools not replacing, but complementing them.

4. Parallel Evolutionary Lines of biological and technical systems

We also addressed some aspects of the analogy of the evolution of living and technical systems. In particular, by analogy with "viral" direction of biological evolution, based on

their exceptional ability to proliferate, in the technology domain it can also be traced a line of development, based on mass production (that is, in fact, proliferation ability) of miniature and cheap items that can be integrated into conventional products to provide them with unusual properties. This line is well within the changed paradigm of invention [2]. There can be no bright insights related to the resolution of contradictions, but the resulting solutions give a ready technology, effective and economically justified in light of changing market realities.

5. Application PEL method to consulting projects

Among the different types of consulting projects [24]:

1. Improvement of functionality of the technical systems / processes,
2. Reduced cost of technical systems and processes,
3. Creating a new technical system / process, and
4. Forecast of development of the existing technical system / process.

PLE method is the most adequate for the 4th type. However, the 1st, and especially 3rd types of projects can also receive a substantial boost from the analysis of the evolution of a more advanced system. In fact, wherever there is a need to find a solution of inventive problems, the first thing is to do, try to rely on analogues. For example, if we are talking about creating a new technical system, according to the methods of FOS and PEL, we should find Main Function of the system, find the equivalent, and try to adapt it to the original. The method of PEL will not only help to solve, but predict the next step.

Thus, the method of PEL can be recommended as a working tool, virtually for any kind of consulting projects.

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