DOI: 10.6977/IJoSI.201109_1(4).0003
Song-Kyoo Kim / Int. J. Systematic Innovation, 1(4), 19-26 (2011)

Innovative Design of Substance-Field Notations for Reformulating the Seventy-Six Standard Solutions in TRIZ

Song-Kyoo Kim
W. SyCip Graduate School of Business, Asian Institute of Management, Makati City, Philippines
* Corresponding author, E-mail: amang.kim@aim.edu
(Received 2 August 2011; final version received 13 February 2012)

Abstract

The substance-field model and 76 Inventive Standard were conceptualized by Genrich Altshuller who has built classical TRIZ. The paper shows the innovative notation methods so called Su-Field Notations which can indicate characteristics of TRIZ problems and solutions instantly. Intuitive understanding the characteristics of TRIZ problems is the main purpose of Su-Field notations (aka. Amang's notation). This innovative notation method makes possible to understand the Su-Field model based concept solutions only with minor knowledge of the Inventive Standards. The tractable results are used for demonstration in the real-world applications.

Keywords: TRIZ, TIPS, Su-Field Model, Innovation, Inventive Standard

1. Introduction

The substance-field model (Haijun, 2009; Soderlin, 2003) and 76 Inventive Standard (Domb, 1999; Domb, 2003; Soderlin, 2003) were conceptualized by the founding father of TRIZ, Genrich Altshuller (1984; 1997). Even though, 76 Inventive Standards do not provide graphic models for every standard and the standards are not new to the TRIZ community, they can help the TRIZ specialist find solutions concepts for many kinds of problems as a collection of methods to identify (Domb, 2003). The Standard Solutions are grouped by constraints, so they can help the specialists find appropriate solution concepts (Slocum and Domb, 2003). They are more accessible to TRIZ newcomers than ARIZ (Grace et al., 2001; Zlotin and Zusman, 1999), since the user is liberated from the ARIZ dictum of mastering every step before using any step. The 76 Inventive Standard Solutions are among the fundamental techniques that provide the foundation for most of commercial major TRIZ softwares but they are not currently being used widely (Domb, 2003).

There are several reasons why the Inventive Standards are not applied widely and two main reasons are addressed instantly. First, people learning TRIZ still must do a lot of case studies that illustrate the principles of TRIZ using terms and technologies before using Inventive Standard correctly. Second, the standards are categorized by physical interactions. The Inventive Standards (76 Standard Solutions) are well defined and organized (Domb, 1999). But it is still difficult to learn and complicated even for TRIZ specialists. More importantly, the 76 Inventive Standards are not intuitive (Soderlin, 2003).

Currently, TRIZ tools are applied not only in physical engineering but also in software (Kim, 2010; Kim, 2011), even in business area (Domb, 2003; Miller and Domb, 2002). Most of physical interactions are not have direct matches with the actions in software or business. TRIZ specialists must abstract the solutions to fit their area for solving their problems. The standards must be reformulated more intuitive way.

The special notations so called Su-Field notations (aka. Amang's notations, Amang is the alias name of the author) are introduced in the paper. The notations give intuitive explanations both problems and solutions based on the Inventive Standards. The core for Su-Field model notation is adopted by the queuing model notations also known as Kendall-Lee notations. Basically, Kendall-Lee notations can explain all kind of queuing model and users who know the rules of the notations understand the characteristics of the queuing model almost instantly when they see the notation (Tijms, 2003). Su-Field notations cover all of the Inventive Standards except for Group 5 which is the set of guidelines for other four groups. Someone who does not even have the full knowledge of the 76 Inventive Standard solutions can understand the problems and candidate solutions intuitively by applying Su-Field notations. The paper simultaneously offers an opportunity for the TRIZ community to contribute to improving global welfare.

2. Queuing Model and Its Notations

Before starting Su-Field notations (Amang's notations), Theory of Queuing system and its notations (Kendall-Lee notations) are introduced first (Tijms, 2003). Queuing theory is the mathematical study of waiting lines, or queues. It is generally considered a branch of operations research because the results are often used when making business decisions about the resources needed to provide service.

Queuing system is one of major topics in stochastic modeling to analyze the system. This mathematical model can be applied not only in McDonald but also in traffic engineering for Internet and mobile communications even human resource management. It is applicable in a wide variety of situations that may be encountered in business, commerce, industry, healthcare, public service and engineering. Applications are frequently encountered in customer service situations as well as transport and telecommunication. It is also directly applicable for intelligent transportation systems, call centers, network management, telecommunications, server queuing, mainframe computer of telecommunications terminals, advanced telecommunications systems and traffic flow.

There are many kinds of queues with various conditions but all of queues can be categorized by the certain notation schemes. Classification of the queuing models has been suggested by D. G. Kendall in 1953 as a three-factor notation of queuing system and it has since been extended to include up to six different factors by A. M. Lee in 1966. This queuing notation has been known as Kendall-Lee notation and it exhibits the summarized main characteristics of a queuing system.

$$(a/b/c):(d/e/f) \quad (1)$$

where the symbols *a, b, c, d, e* and *f* stand for basic elements of the model as follows:

a = arrivals distribution,
b = service time distribution,
c = number of servers (c=1, 2, 3, …)
d = service properties (i.e., FCFS, LCFS, SIRO)
e = capacity of the system
(a waiting room and servers)
f = population of input resources.

The standard notation replaces the symbols a and b for inter-arrivals and service-time distributions:

M = Poison input distribution or Exponential service-time distribution,
D = deterministic or constant,
E_k = Erlangian or gamma distribution with the exponential phases,
GI = general independent distribution,
G = general distribution.

For instant, M/G/1{/FCFS/∞/∞} is the open queuing system (i.e., population of input resources is unlimited) system with Poison input, general service

DOI: 10.6977/IJoSI.201109_1(4).0003
Song-Kyoo Kim / Int. J. Systematic Innovation, 1(4), 19-26 (2011)

property and unlimited waiting capability. M/G/1 queuing system is one of most typical queuing systems (see Fig. 1).

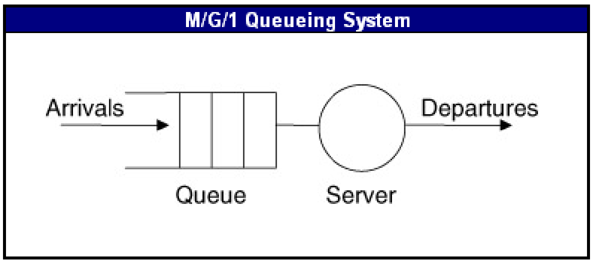


Figure 1. This is an example of a figure caption.

The queuing system and theories are attractive topic and required the in-depth study but it is not included in the paper because the research is only adopting the queuing notations.

3. Substance-Field Notations

The paper introduces the similar notation scheme to cover the 76 Inventive Standards. In addition, it is classified the Inventive Standards more simple way and users can be guided to the candidate solutions from the problems based on Su-Field model with the minimal knowledge of 76 Inventive Standard solutions. The notation for Su-Field model (Su-Field notation) is introduced (aka. Amang's notation,"Amang" is alias of author).

The Su-Field model for Inventive standard solution can exhibits the summarized main characteristics of a Su-Field model.

$$(x/s/f):(/a) \qquad (2)$$

where the symbols *x, s, f* and *a* stand for basic elements of the model as follows:

x = solution (or problem) types (*x* = 1, 2 or 4)
s = substance attributes,
f = field attributes,
a = strength of actions (*a*=0; *Normal* or *a*=1; *Stronger*)

The attributes of the substance *S* are as follow:

S^* = general terms of the substance that can solve the problems
S^+ = +1 substance from basic structure to solve the problems
S' = modify the substance (tool) to solve the problems without changing the number of components from basic structure
S^- = -1 substance from basic structure (i.e., tool is missed)
S^∞ = substance (tool) is divided infinitely (Technical System Evolution)
S'' or S^2 = adding the clone of the substance (+1)

The attributes of the field *f* are similar with substance attributes:

F^* = general terms of the field that can solve the problems
F^+ = +1 field from basic structure to solve the problems
F' = modify the field to solve the problems without changing the number of components from basic structure
F^- = -1 field from basic structure
F^∞ = field is divided infinitely (Technical System Evolution)
F'' = adding the clone of the field (+1)
$\overleftarrow{F}$ = reverse direction of the field

The attributes for fields and substances indicate how to modify the substances and the fields.

3.1 Basic structure of Su-Field Model

The basic structure of Su-Field model for the Inventive Standard consist one object (S1), one tool (S2) and one field (F) The basic structure can be notified as:

$$x/s/f\{/0\},\ x=1,2,4 \qquad (3)$$

where *x* is the types of problems or solutions (see Figure 2)

DOI: 10.6977/IJoSI.201109_1(4).0003
Song-Kyoo Kim / Int. J. Systematic Innovation, 1(4), 19-26 (2011)

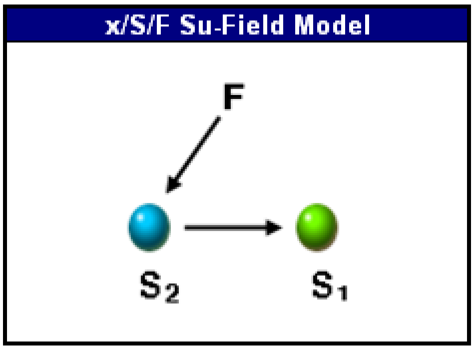


Figure 2. Basic Structure of Su-Field Model

Overall of 76 Inventive Standards except for Group 5, the problems can be categorized as three types. Type 1 is the problem that contains the weak useful action (or function) and the candidate solution of Type 1 is enhancing the strong useful action. Type 2 is the problem that contains the harmful action and the candidate solution of Type 2 is removing the harmful action. Type 4 is mainly measuring problem that is the separate group of 76 Inventive Standard solutions. Group 4 in the Inventive Standard are exact matched with Type 4.

For instant, *2/S/F* is the problem (see the Figure 3) contains the harmful action and the candidate solution is $2/S^{+}/F$ that means removing the harmful action by additional substance S^3 (remarked as S^+ in Su-Field notation). As seen above, Problem Types also represent Solution Types (i.e., same type number). So, it is same type in Su-Field notation regardless of problems or solutions. The following sessions provide the explanation of the solution types that matched with the problem type more detailed

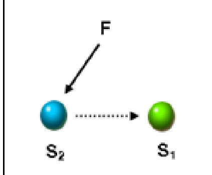
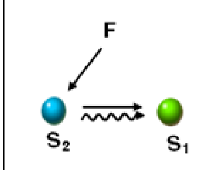
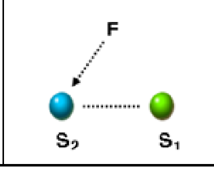
Problem Type	Su-Field Diagram	Solution Guideline
1 (1/S/F)		Enhancing the useful action
2 (2/S/F)		Removing the hamful action
4 (4/S/F)		Mesurement (Same as Group 4 in 76 inventive standards)

Figure 3. Types of the Problems

4. Solution Types Based on Su-Field Notations

This session gives the more detailed about the solutions based on Su-Field notations. There are 3 solution types based on the problem types. Comparing to the group of 76 Inventive Standard, Group 1, 2 and 3 are integrated to Type 1 and 2. Group 4 in the Inventive Standard is integrated to Type 4 that is much simplified and remained as Concept Solution.

4.1 Type-1 Solution

Problem Type 1 contains two sub types based on the problem conditions. Type 1-1 is the problem because of missing the substance (tool) or the field (action). Type 1-2 is the problem of weakness.

<u>Missing Substance and/or Field (Type 1-1):</u> the problem that is missing either substance or field can be solved by making the basic structure:

$$1/S^{-}/F \ or \ 1/S/F^{-} \rightarrow 1/S/F \quad (4)$$

<u>Enhancing the Useful Action within Basic Structure (Type 1-2):</u> the problem that is week actions can be solved by adding or modify the substance in the basic structure:

$$1/S/F \rightarrow \begin{cases} 1/S^{+}/F, & S^{*}=S^{+} \\ 1/S'/F, & S^{*}=S' \\ 1/S^{\infty}/F, & S^{*}=S^{\infty} \end{cases} \quad (5)$$

and Su-Field diagram for Type 1-2 can provide the clear picture of the solution models:

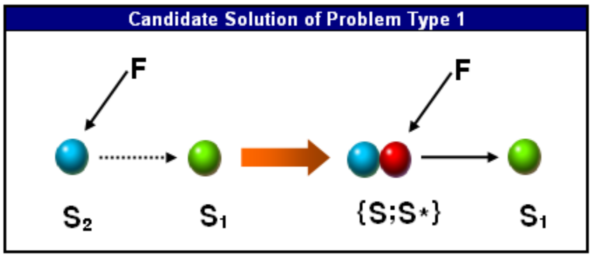


Figure 4. Su-Field Solution Diagram $1/S^*/F$

The $1/S^{\infty}/F$ that means the unlimited modifications of the substance and the field based on Technical System Evolution can be the candidate solution of Problem Type 1-2. There are the several candidates that be considered as the solutions for solving Problem Type 1 (see Figure 5):

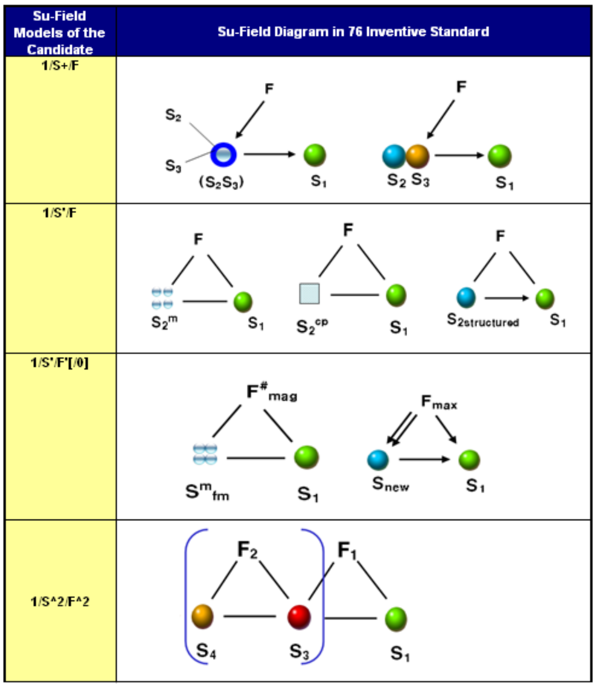


Figure 5. Su-Field Model for Type-1 Solutions

From (4) and (5), the solution for Problem Type 1 can be concluded as follow:

$$1/S^{\{-1\}}/F^{\{-1\}} \rightarrow \begin{cases} 1/S/F, & \because Type-1 \\ 1/S^{*}/F, & \{S^{*}|S',S^{+},S^{2},S^{\infty},S^{n}\} \\ 1/S/F^{*}, & \{F^{*}|F',F'',F^{+},F^{\infty}\} \\ 1/S^{*}/F^{*}, & \end{cases} \quad (6)$$

4.2 Type-2 Solution

Problem Type 2 is the problem that contains the harmful action and the candidate solution is basically removing the harmful function:

From Figure 6, the candidate solution of Problem Type 2 can be determined as follow:

$$2/S/F\{/0\} \rightarrow \begin{cases} 2/S^{*}/F, & S^{*}=S^{+}\ or\ S' \\ 2/S/F,^{+} & \\ 2/S/F/a, & 0<a<1 \end{cases} \quad (7)$$

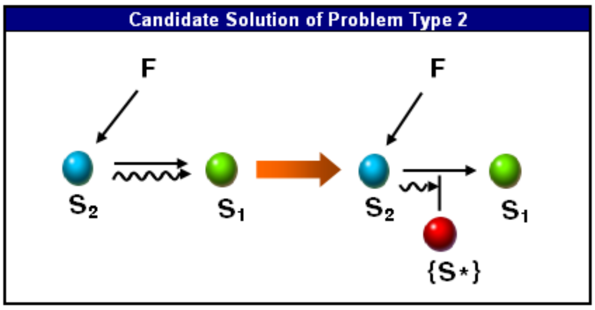


Figure 6. Su-Field Solution Diagram of $2/S^*/F$

More detailed description of (7) is provided on Fig. 7:

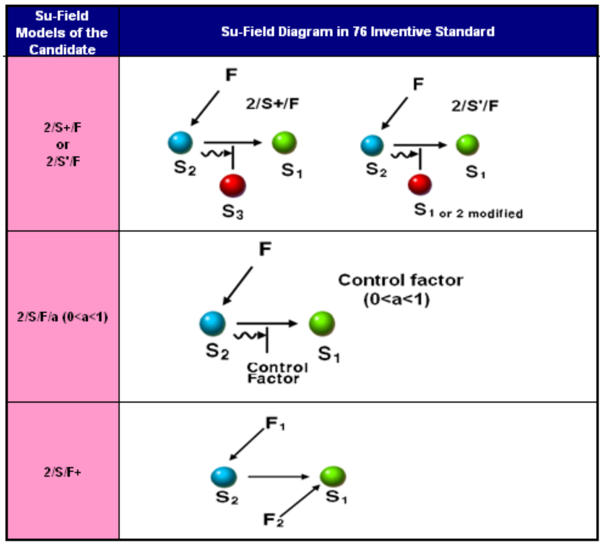


Figure 7. Su-Field Model for Type-2 Solutions

4.3 Type-4 Solution

Problem Type-4 is the measurement of the system. Even though Group 4 in 76 Inventive Standards can be applied Type-4 problems, Amang notation can be applied for the measurement problems. In case of Type-4, the notation for the action attributes is mandatory factor because the strength of the measurement signals:

$$4/S/F \rightarrow 4/S^{\{*\}}/F^{\{*\}} \quad (8)$$

and Su-Field diagram for Type-4 can provide the clear picture of the solution models:

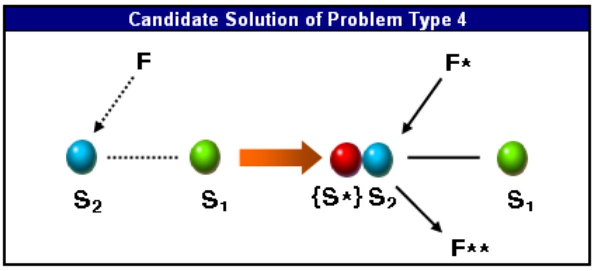


Figure 8. Su-Field Solution Diagram of *4/S*/F*/1*

One of the practical solutions for the Type-4 Problem is *4/S⁻/F⁻* that means removing the components requiring the measurement (i.e., Inventive Standard 4-1-1). From (6), (7) and (8), the Su-Field notations care simple but practically cover all of the Inventive Solution (Group 1-4). The concept solutions can be applied not only in the classical TRIZ problems but also in the problems of software and business more flexible.

5. Real-World Applications

There are several problems in each problem types and the session provides the potential solution for basic problems. The session gives the guidelines how to adopt Su-Field notation into TRIZ problems in real-world.

Several TRIZ applications in the mobile industry and the related research papers have been published in TRIZ Symposium (Kim, 2010) and IEEE (Kim, 2010) by author. The main solutions in the researches are developed by using Inventive Standard and the solutions in the research can be explained by using Su-Field notations (aka. Amang's notations.) Two real-world applications are introduced in this session as case studies. First case is the enhancement of user experience (Kim, 2010) and second case is LBS application in mobile industry(Kim, 2011).

5.1 Enhanced UX Based on User Behavior Data

The playlist in a MP3 player and a mobile phone is a basic user interface and recently user behavior has been changed because of memory expansion. Most of recent MP3 users can contain more than thousands of songs in one device and it is big changes when we compare with the situation of couple of years ago. Listing within thousand songs is heavy task these days.

According to Su-Field Notation, this is *2/S/F* problem (i.e., Type-2 Problem) which is the problem for removing harmful effects. The core problem is for building a playlist for MP3 player without extra operations. From (7), the conception solution of the problem is *2/S+/F* (See Figure 9.)

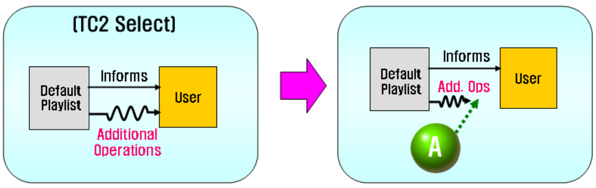


Figure 9. *2/S⁺/F* Solution for UX of Enhanced Playlist

The actual solution based on 1-2-2 in 76 Inventive Standard solutions from the previous research (Kim, 2010) can be also obtained by the concept solutions based on Su-Field notation. The actual solution of this case is that the priority factors are calculated based on the data from common user behaviors such as total player (application) running time, number of music player launching, total running time of actual song playing and so on. These data are very common from most of music players. After gathering these statistics, the playlist is considered as a set and proceeding couple of mathematical implementations, the songs can be ordered based on the weight factors and let be the index set of favorite songs based on the weight factors. The enhanced playlist is the playlist based on human behavior data via the truncated index set:

$$\Xi^* = \left\{ s_{w_1^*}, s_{w_{21}^*}, \ldots, s_{w_n^*} \right\}. \qquad (9)$$

Ξ^* is not only the ordered sets based on optimized weight factor w_k^* as mathematical perspective but also the actual playlist that contain the ordered name of songs based on human behaviors (Kim, 2010).

5.2 Enhanced LBS UX Design based Behavior

Location Based Service (LBS) is an information and entertainment service, accessible with mobile devices through the mobile network and utilizing the ability to make use of the geographical position of the mobile device by using Global Positioning System (GPS). GPS is a mandatory technology for LBS applications but it takes more than ten minutes to find the initial location position of a device. Assisted GPS (A-GPS) is design for gathering the initial position much faster but A-GPS is required higher application chipset process power. Currently, a LBS application is very common and it is embedded even in a low tier devices. The initial GPS position must be calculated before launching the LBS applications but required the additional process power.

The main problem is improving the determination of the initial position. According to Amang's notation, this is 1/S/F problem (i.e., Type-1 Problem) which is the problem for enhancing the useful effects. The concept solution for LBS application can be 1/S+/F of Amang's notation and it indicates the same solution guideline based on Inventive Standard 1-1-3 (see Figure 10.)

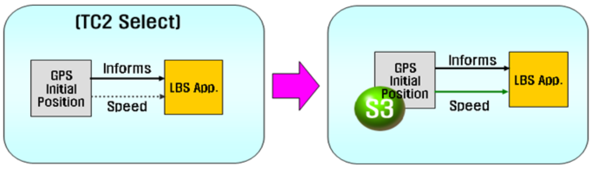


Figure 10. *1/S⁺/F* Solution for LBS Application Enhancement

The actual solution of this case is providing the pre-process before LBS applications starting and a user is not even notified the pre-process for enhancing the initial position for the LBS applications. The workflow for the implementations based on the concept solution is shown as Figure 11 (Kim, 2011).

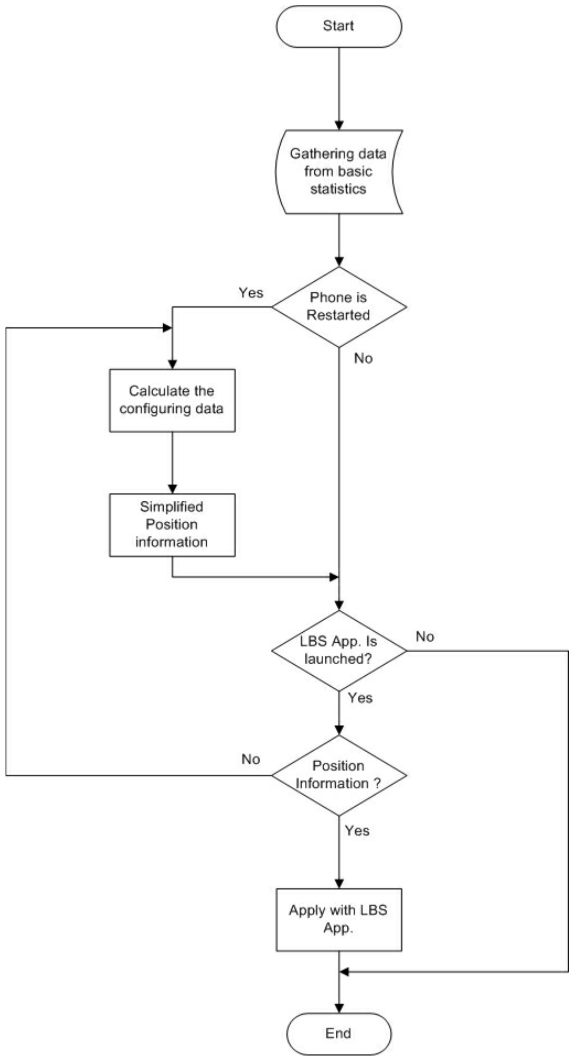


Figure 11. Workflow of the Enhancing the Initial Position for LBS Applications

DOI: 10.6977/IJoSI.201109_1(4).0003
Song-Kyoo Kim / Int. J. Systematic Innovation, 1(4), 19-26 (2011)

6. CONCLUSION

Su-Field notation (Amang's notation) is the generalization of the classic 76 Inventive Standard solutions and the reformulating of them on Su-Field model. Queuing notations are adopted to give intuitive explanations not only the characteristics of the problems but also suggest the candidate solutions because the notation by itself provides the concept solution that can be widely applied for various areas. The problem solvers can adopt the candidate solutions based on Su-Field notations without the full knowledge of 76 Inventive Standard solutions. In addition, the examples of the real-world applications for mobile industries will give you the guidelines how Su-Field notions to apply other areas of real-world problems especially in IT industries.

References

Altshuller, G. (1984). *Creativity as an Exact Science.* Gordon and Breach Science Publishers, New York, NY.

Altshuller, G. (1997). *40 Principles*. Technical Innovation Center, Worcester, MA.

Domb, E. (1999). The Seventy-Six Standard Solutions: How They Relate to the 40 Principles of Inventive Problem Solving. The TRIZ Journal, May.

Domb, E. (2003). Using the 76 Standard Solutions: A case study for improving the world food supply. The TRIZ Journal.

Grace, F., Slocum, M. and Clapp, T. (2001). A New TRIZ Practitioner's Experience for Solving an Industrial Problem using ARIZ 85C. The TRIZ Journal.

Haijun, L. (2009). Substance-field Models for Fourth Class Standards. The TRIZ Journal.

Kim, S. K. (2010). *Design of Regional Code Adaptation for Mobile* AD *by Using TRIZ/TIPS*. The Sixth TRIZ Symposium in Japan, Tokyo, September 9-10.

Kim, S. K. (2010). *Enhanced User Experience Design based on User Behavior Data by Using Theory of Inventive Problem Solving*. IEEE Proceedings of IEEM, 2076-2079.

Kim, S. K. (2011). Alternative Approach of Inventive Problem Solving for Location Based Service Implementation. *International Journal of Social Science and Humanity*, 1(2), 132-134.

Miller, J. and Domb, E. (2002). Comparing Results of Functional Modeling Methods for Agricultural Process and Implement Development Problems. The TRIZ Journal.

Soderlin, P. (2003). Thoughts on Su-Field Models and 76 Standards: Do we need all the standards. The TRIZ Journal.

Slocum, M. S. and Domb, E. (2003). Solution Dynamics as a Function of Resolution Method. The TRIZ Journal.

Tijms, H. C. (2003). *Algorithmic Analysis of Queues.* A First Course in Stochastic Models, Wiley, Chichester.

Zlotin, B. and Zusman., A. (1999). ARIZ on the Move. The TRIZ Journal.

AUTHOR BIOGRAPHIES

Dr. Song-Kyoo Kim is recenly joining the Asian Institute of Management faculty member as the Associate Professor. He had been a technical manager and TRIZ specialist of mobile communication division at Samsung Electronics. He is involved in IT industries more than 10 years. Dr Kim has received his master degree of computer engineering on 1999 and Ph.D. of operations research on 2002 from Florida Institute of Technology. He is the author of more than 20 operations research papers focused on stochastic modeling, systematic innovations and patents. He had been the project leader of several 6 Sigma and TRIZ projects mainly focused on the mobile industry.