ISSN 1598-0170 (Print)
ISSN 2287-1136 (Online)
http://www.jksii.or.kr

Structural Dashboard Design for Monitoring Job Performance of Internet Web Security Diagnosis Team: An Empirical Study of an IT Security Service Provider☆

Jung-Gyu Lee[1] Seung-Ryul Jeong[1*]

ABSTRACT

Company A's core competency is IT internet security services. The Web diagnosis team analyzes the vulnerability of customer's internet web servers and provides remedy reports. Traditionally, Company A management has utilized a simple table format report for resource planning. But these reports do not notify the timing of human resource commitment. So, upper management asked its team leader to organize a task team and design a visual dashboard for decision making with the help of outside professional. The Task team selected the web security diagnosis practice process as a pilot and designed a dashboard for performance evaluation. A structural design process was implemented during the heuristic working process. Some KPI (key performance indicators) for checking the productivity of internet web security vulnerability reporting are recommended with the calculation logics. This paper will contribute for security service management to plan and address KPI design policy, target process selection, and KPI calculation logics with actual sample data.

☞ keyword : Dashboard, Key Performance Indicator, Vulnerability, Service Performance, Internet Security

1. Introduction

Company A in Seoul is a subsidiary company of Japan's largest security service provider. Its major area of business is to perform web security diagnosis targeted on remote servers and to prepare security vulnerability reports (SVR) for customers located in Korea and Japan. The Web Diagnosis Team (WDT) is responsible for this role in Company A. WDT Team Leader (TL) had used a table format report to manage workload. However, the table format failed to provide insight into job performance issues and to guide decisions for resource planning

As a resolution for the ineffective report format, the executive manager demanded WDT TL to design a one page dashboard report for weekly staff meetings with the help of outside professional. Authors will explain an empirical study process for creating a graphical dashboard and present a dashboard sample for human resource management of security vulnerability diagnosis operation, especially in situations when engineers have no prior knowledge of dashboard designs.

1 Graduate School of Business IT, Kookmin University, Seoul, 136-702, Korea.
* Corresponding author (srjeong@kookmin.ac.kr)
[Received 2 June 2017, Reviewed 12 June 2017(R2 18 July 2017), Accepted 27 July, 2017]
☆ A preliminary version of this paper was presented at ICONI 2016 seminar and was selected as an outstanding paper.

2. Research Background

The report format by WDT for weekly staff meeting in Company A originally looked like Table 1. It simply described customers, service type, total planned resource (man-day), used resource (man-day), and revenue amount (thousand dollars).

(Table 1) Prior Report Table

Cust. Name	Service Type	Planned Resource	Used Resource	Revenue (K$)
H Co.	Adv.	37	2	4
K Co.	Standard	14	1.5	3

This type of numerical table could not give a contextual view for executives or managers in deciding resource

http://dx.doi.org/10.7472/jksii.2017.18.5.113

commitment because of the table's lack of reference information as the followings. It does not provide;

- Daily personal workload information for resource planning.
- Any comparative information to prior period or bottom-line performance measurement.
- Timing information for resource recruit and member replacement.
- Any service quality index compared to allowance level.

This was the launching point for a project to redesign the structural and visual design of key performance indicators to facilitate better decision making. Although Company A engineers were very familiar with operational processes, they lacked comprehensive experience with dashboard design. As a result, authors implemented this project with Company A engineers.

3. Literature Study

In 1989, analyst Howard Dressner with market research firm Gartner Inc. coined the term "business intelligence"[1]. The greatest value of BI competency comes from being able to respond to market demands faster and more intelligently [2]. From a cognitive point of view, diagrammatic representation for BI system is easy to understand when compared textual or numerical presentation [3]. Graphical dashboard also belongs to representational styles of BI systems. In order to get an effective planning and control tool, management team should consider designing a simple perceptual model of graphical dashboard, which is oriented towards understanding and enhancing organizational performance.

Software development project managers use various project monitoring and management tools. The problem is that often these management tools are designed to meet the highly technical needs of an employee and not the big picture needs of management. As a result these tools are not good for group decision making processes, such as project monitoring or review session [4]. This trend is same in IT service sectors.

Visual analytics leverages on the remarkable capabilities of humans to visually identify patterns and trends in large datasets [5]. Highly perceptual graphical dashboard will increase decision speed because decision makers can detect warning signs faster than other types of data representation. This paper details the results of an empirical process model for dashboard design, and a dashboard sample for SVR service performance on remote web servers.

The dashboard design core relates key performance indicators (KPI). Bauer (2004) classified dashboards into a total of 25x14 matrixes which consist of 25 styles for graph, and 14 attributes for data series. He also emphasized that graph selection and presentation were critical to the success of corporate performance management (CPM) [6]. We will adapt some graphs, for example stacked bar, paired bar, line and dial/gauge from Bauer's dashboard framework for this study. Dashboard contents should present information that is personalized, actionable and meaningful - in short, relevant. Also, it needs to be fresh, efficient, credible, and convenient - in short, useful [7].

Maximum Process Capacity (MPC) means the threshold of process output under certain limiting factors governed by Liebig's law of the minimum. If job requirement is beyond MPC, then the due date will be delayed. This will be one of the risk factors for service companies. For risk evaluation purposes, risk classification 3x3 or 5x5 matrixes were proposed and well accepted by industry [8]. MPC functions similarly to a "Plimsoll Line", which is a visual disaster control scheme designed to protect a ship against sinking due to overage in cargo weight capacity. MPC serves as a milestone for an organization's sustainable operation.

Shewhart's control charts are the most important tool for statistical process control (SPC). These charts are very important since they indicate out-of-control conditions [9]. Control chart is very useful for monitoring the quantitative variation over standardization within certain periods of time. Operators can make immediate adjustments if the index passed over the lower or upper limit lines such as the MPC or Plimsoll line. This study will design calculation logic for proper engineering resource according to empirical view of team leader. If the job requirements move over the MPC, the overloading alarm alerts management to recognizing problem.

Tsiotras(1993) points out two kinds of meetings held

during the lifetime of the project. They are task team meeting and task team/supervisor meetings. This study offers a type of dashboard for the latter meeting [10].

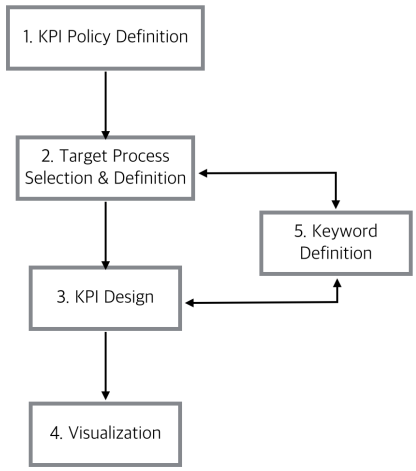
4. Empirical Process Modeling of Dashboard Design

After research study with Company A's TL, we proposed a total of 4 main processes and an additional supporting process as an empirical process model of dashboard designsuch as Fig. 1. At step 1, we had to define KPI policy. KPI policy guides us in the direction of following implementation works and provides a touchstone for checking KPI fitness. It should be agreed upon by practitioners and supervisor.

Secondly, we shall select and define a target process as a pilot. As there are many business processes in a company, so a narrowing down approach is highly recommended for job prioritization. During this process, we encountered new unnamed and undefined measurement concepts and needed to create new terminology, and define the meanings of these new terms. These activities were named as "keyword definition" process such as number 5 in Fig. 1.

Thirdly, we shall define the core KPIs of the target process, and design calculation logics. Similar to the prior process, where we also used to meet new measurement concept and needed to define the meaning of new terminology. That is the reason why keyword definition process connected to both of process number 2 and 3.

Structural performance measurement and visualization design shall be done at process number 4. One page dashboard design is highly recommended because it can be understood at a glance. It should present the critical KPI information by proper graphic format and structured layout. Recent information or urgent issues shall be positioned on the upper space and long-term and infrastructure information shall be posted on the lower space. In the next chapter, we are going to explain our heuristic dashboard design process according to Fig. 1 sequential numbers.



(Figure 1) Dashboard Modeling Process

5. KPI & Dashboard Design

5.1 KPI Policy Definition

Before designing, we established three policies to validate the fitness of KPI. These policies shall be compared and reviewed continuously in order to confirm the applicability and effectiveness during dashboard design process. Words in parentheses are some influential factors.

(1) KPI should be identified at a glance.
- Accuracy(Job speed, Frequency of Mistakes)
- Productivity(Level of difficulty, Overload)
- Relative performance compared to prior period or outside competitors.

(2) KPI should support decision making for the balanced resource management.
- The timing for resource recruit and member replacement.
- The timing for IT capital investment.
- The timing for new professional skill and additional service development.

(3) KPI should be useful for understanding market trend and customer needs.
- About new security issues driven by market trend in industry.

5.2 Target Process Selection and Definition

Optimal KPI design requires an advance understanding of business process. The starting point of KPI design process shall be with the drawing of a business process map. Fortunately, WDT standardized their business process such as Fig. 2. According to this map, we selected diagnosis process as the first target process for KPI design. It is the core process among WDT's jobs. The goal for the diagnosis process is to raise questions regarding the accuracy of security vulnerability reports (SVR) on customer web servers.

The following data were utilized for judging the accuracy of SVR.

- Log data which has evidence.
- Occurrence of missing evidence.
- Inconsistent log between similar servers or in the same server.
- Findings by peer review.

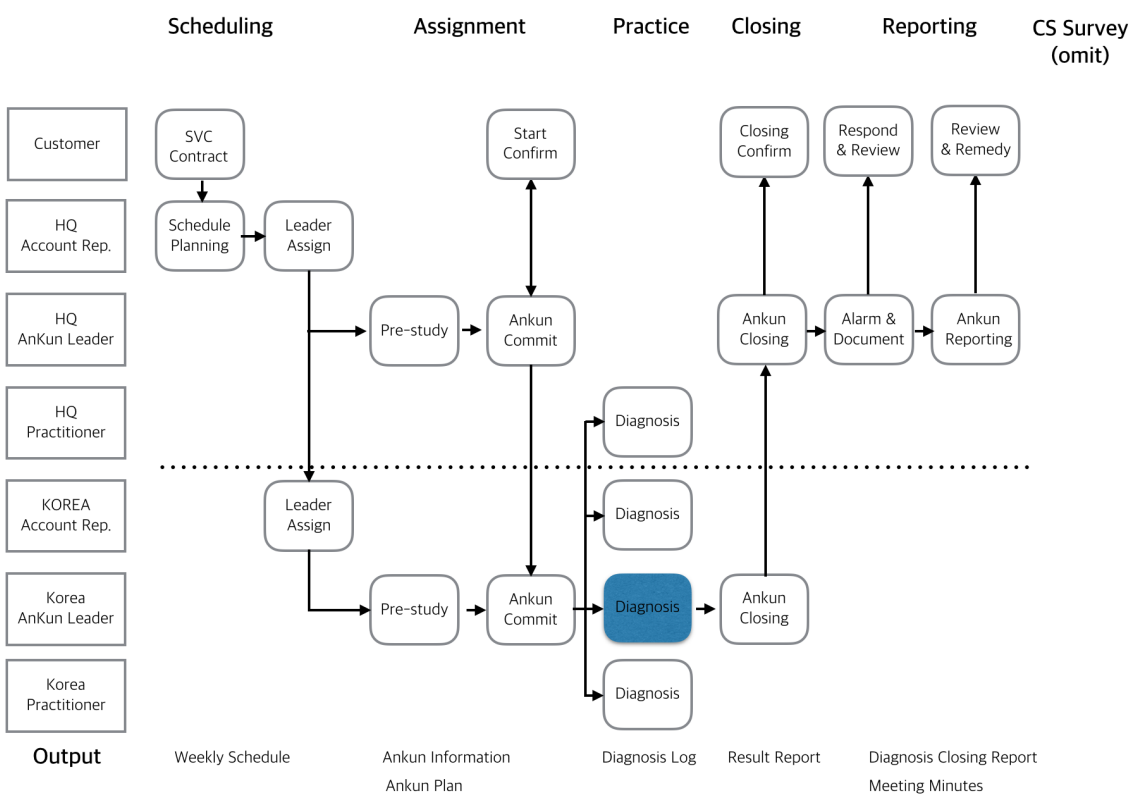
There are two types of diagnosis work.

- Diagnosis by automatic tools.
- Manual diagnosis.

Also, there are two types of vulnerability according to job attributes.

- Vulnerability discovered: It shows the health condition level of customer web service and is measured by (Vf) number.
- Vulnerability not discovered (or missing): It related to the accuracy of diagnosis and measured by (Vm) number.

Total sum of Vf point ratio and Vm point ratio makes 1(100% total vulnerability).



(Figure 2) WDT's Work Process

We arbitrarily assigned measurement points to five risk levels for the above two vulnerability types as the following Table 2. Symbol N stands for not classified yet, but a potential risk in the future.

(Table 2) Risk Measurement Table

RISK LEVEL	Symbol	Measurement Point
High Risk	A	10
Medium	B	5
Low	C	2
Reference (Potential risks)	R	1
No classification	N	0

5.3 KPI Design

Because Company A is a Japanese subsidiary, some terminology adapted from HQ in Japanese. For example, "AnKun" means a contracted SVR job per each customer. We are going to use the term "TASK" instead. Task is an input parameter for calculating practitioner workload. The term "ACTION" stands for unit web page which has multiple hyperlinks over internet. Generally, one TASK has multiple ACTIONs assigned.

Company A offers three kinds of SVR service, namely Advanced, Standard, and Light services. Workload weight among the three services is 1:0.5:1. Advance and Light spend the same amount of resources. But, Light has small scope of service than Advanced. On the other hand, Standard service needs only 50% resource, meaning two Standard jobs closing to every Advanced or Light job completion. Each Actions workload number can be easily measured when service contract was made.

In Table 3, we listed major KPIs for WDT. We selected three KPIs for measuring WDT's performance. The most critical performance is 'Ym' meaning average number of vulnerability missing per web server. The lower Ym is preferable. The other 'P' and 'Hp' are used to calculate the resource shortage or over-run. We will explain how to calculate KPI step by step.

(Table 3) KPI's Principal Parameter Lists

Symbol	Description	Key Parameters
Nt	Total Action Number in a Task	Na: Number of Advance Action Ns: Number of Standard Action Ni: Number of Light Action En: Headcount of Practitioners
P	Daily Personal Workload	Nt: Total action number En: Headcount:
Hp	Headcount Requirement	Nt: Total action number P: Personal Workload Va: Number of Vulnerability Vs: Number of Vulnerability(prior)
Vm	Average number of vulnerability missing	Am : High risk missing number Bm : Medium risk missing number Cm : Low risk missing number Rm : Reference number missing
Ym	Avg. number of vulnerability missing per server	Vm: Average number of vulnerability missing Sn: Number of web server

(Notes) The term "ACTION" stands for unit web page which has multiple hyperlinks over internet. Generally, one TASK has multiple ACTIONs assigned.

According to Legend 1, average personal workload is calculated as the following. Sample data are used to help interpretation according to a real TASK case.

(1) Calculation of daily personal workload (P): This can be calculated by using total action numbers and total number of practitioners.
- Nt = Na / 1 + Ns / 2 + Ni / 1 = 5/1 + 20/2 + 17/1 = 32
- P = Nt / En = 32/11 = 2.9

Legend 1: For Calculation of Personal Workload (P)

- Action weight: Advance(1), Standard(0.5), Light(1)
- Nt (Total Action Number in a Task) can be calculated by weighted numbers 1:1/2:1(Advance: Standard: Light).
  - Na: Number of Advance Actions(ex, 5)
  - Ns: Number of Standard Actions(ex, 20)
  - Ni: Number of Light Actions(ex, 17)
- En : Headcount of Practitioners(ex, 11)
- P: Unit daily workload per headcount (personal workload). Unit is action number.

(2) Calculation of headcount requirement (Hp): After calculation of personal workload, then total headcount requirement can also be determined. Hp number can be utilized for the team performance measurement, the timing of resource recruiting, and the calculation of optimal workload per capita.

Practitioner in Company A spends working hours performing two types of diagnosis work. The first one is general diagnosis, and the second is evidence documentation. Work distribution ratio between the two work styles is 70%: 30%. So, SVR TL asks us to weight the numbers in the calculation logic of headcount requirement as legend 2. The following calculation is based on weekly volume, but it can also be calculated daily. The former part [Nt (P*5day)] is for general job, the latter (Va/Vs) is for evidence securing work.

- Hp = [Nt/ (P*5day)] * 70% + (Va/Vs) * 30% = (230 / 2.9*5) * 0.7 + (50/32) * 0.3 =11.58

Legend 2: Headcount Requirement(Hp)
• Hp: Headcount Requirement. Unit is per capita. • Nt : Total Action Number(Weekly Target, ex, 230) • Va(V actual): Number of Vulnerability discovered in this week(ex, 50). If increased, workload should be also increased. • Vs(V standard): Number of Vulnerability discovered in latest quarter. Weekly average.(ex, 32) • Va / Vs : Difficulty correction factor • 70%: 30%: Heuristic weight for difficulty distribution ratio • P: Unit workload per headcount

As current headcount (En) is 11, that means SVR team overloaded beyond MPC capacity with 0.58 headcount for the specified week.

(3) Service Quality index: Average Vulnerability Number (Y), Number of Vulnerability Missing (Vm), Average Number of Vulnerability Missing per web server (Ym): These numbers indicate SVR service quality measurement.

Average number of vulnerability on web server(Y) is calculated by the following formula.

- Y = Vt/ Sn = (Af*10 + Bf*5 + Cf*2 + Rf) / Sn = (15*10+45*5+300*2+7) / 50 = 19.64

This number shows us the quality of Web security management. Weight number came from Table 2. However, the average number of vulnerability missing (Ym) index is more meaningful for measuring SVR team's quality performance instead of "Y" index, which indicates customer's security management level. In order to get "Ym", "Vm" should be calculated in advance. The data can be taken from prior 5-2 working process. Weight number came from Table 2 also.

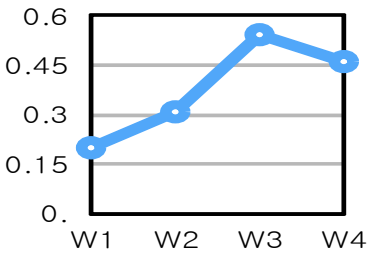
- Vm = Am*10 + Bm*5 + Cm*2 + Rm = 1*10+2*5+ 0*2+3 = 23
- Ym =Vm / Sn = 23 / 50 = 0.46

Legend 3: Average Vulnerability Number (Y)
• Y: Average number of vulnerability per web server(quality index) • Ym: Average number of vulnerability missing per web server (quality index). • Vt: Weighed number of vulnerability. • Vf:Number of Vulnerability founded. Not used. • Vm: Number of Vulnerability missing. • Af: High risk founded number(ex, 15) • Bf: Medium risk founded number(ex, 45) • Cf: Low risk founded number(ex, 300) • Rf: Reference number founded(ex, 7) • Am: High risk missing number(ex, 1) • Bm: Medium risk missing number(ex, 2) • Cm: Low risk missing number(ex, 0) • Rm: Reference number missing(ex, 3) • Sn: Number of web server (ex, 50)

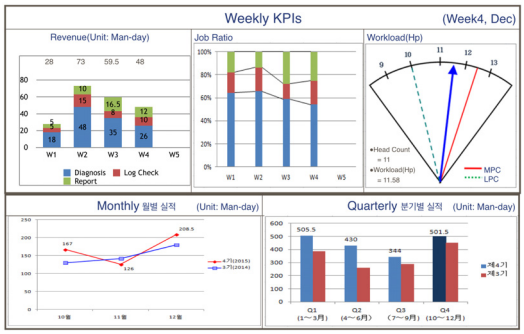
The meaning of (Ym = 0.46) is that WDT team missed only below 1.0 vulnerability on each web server, which is regarded as a good performance. Company A sets up upper control limit of "Ym" as 0.5. So, the above exercise said that SVR job was within allowance range. If this number is above 0.5, SVR TL should decide to repeat SVR job again.

5.4 Visualization

Ym is one of the KPI that we proposed for measuring



(Fig. 3) Ym index



(Figure 4) Dashboard Layout

WDT performance. TL of WDT utilizes Fig. 3 like line chart for manager's weekly performance measure. Even though this KPI estimates SVR service quality for each customer, upper management wanted more abstracted management tools for resource planning.

So, we designed a one page dashboard prototype such as Fig. 4. For resource management, the best measurement index is the headcount requirement (Hp). Dashboard prototype has five sections, namely as the following.

- Job achievement (stacked bar, weekly view) by three work category: They categorized job into diagnosis, analysis, reporting.
- Normalized job ratio trend (100% stacked bar, weekly view): This is for comparing the above three job fluctuations. This chart gives a perceptional insight for management by exception.
- Monthly job achievement (line, prior year comparison, monthly view): For year to year monthly comparison.
- Quarterly job achievement (paired bar, prior year, quarterly view): For year to year quarterly comparison.
- Headcount requirement (Hp): To check whether the current resource is going over or below than the MPC limit. Continuous overflow of resources above the MPC limit signals to management that additional recruitment is required.

5.5 Keyword Definition

While we proceed with this dashboard modeling process, we need to define some terminology and share general knowledge with task team members. These documentations were regarded as a valuable intellectual property for future employee education and business process re-engineering. Over Chapter 5, we defined measurement key words and verified those values with KPI policy. Also, we need to share some general terminology such as MECE (mutually exclusive, collectively exhaustive), Normalization, Learning curve, "AnKun" and etc. This communication by defining general terminology with team members was a very important process in this study. Without proper terminology definition, KPI conceptual modeling does not go further.

6. Conclusion and Future Study

Parry & Turner (2006) believed that any manager who could not draw their process on a single A4 piece of paper is unlikely to be able to manage it [11]. The main contribution of this empirical research is a proposed process diagram of dashboard design implementation and a sample calculation for measuring KPI of internet web security service team members. Referenced dashboard is useful for upper management to easily evaluate, compare the progress of SVR jobs and immediately respond with resource contingency.

To save money, no one would request a vehicle without a dashboard, it sounds crazy [12]. Company A's management were satisfied with the proposed KPI and dashboard for their weekly staff meeting, because it provides graphical representation for management to keep up with contingency situations like a car's dashboard. For other implementers, this paper presents KPI definition processes for dashboard design, especially useful for measurement works in internet/web security service industry.

In the future, we plan to solidify a broad and relevant

model for KPI and dashboard design process by applying this model to other companies. Also, we are going to search for optimal numbers for weight, distribution and correction factors which are used in "Vm" and "Hp" calculation.

In a data oriented society, the skill of presenting excellent charts and graphic is more important than writing skills [13]. If manager groups motivate their professional employees to make one page dashboards which explain their KPI, it will enhance their company's maturity level one step further.

* Acknowledgment to Ms. M.S. Kim in CSLAC Korea for her active support during this project.

References

[1] S. Ortiz Jr., "Taking Business Intelligence to the Masses," Computer, Vol. 43, No. 7, pp. 12-15, July 2010. http://dx.doi.org/10.1109/MC.2010.208

[2] D. A. Price, "The Dawn of a New ERA," DM Review, pp. 18-22, Feb. 2006.

[3] N. E. Cagiltay, G. Tokdemir, O. Kilic, D. Topalli, "Performing and analyzing non-formal inspections of entity relationship diagram(ERD)," The Journal of Systems and Software, Vol. 86,No. 8, pp. 2184-2915, 2013. http://dx.doi.org/10.1016/j.jss.2013.03.106

[4] J. Lee and S. Jeong, "A Practical 1 Page Contextual Diagram for Monitoring Multiple Projects: An Empirical Study of an IT Organization," Journal of Internet Computing and Service, Vol. 17, No. 5, pp. 121-129, Oct. 2016. http://dx.doi.org/10.7472/jksii.2016.17.5.121

[5] W. van der Aalst, "Process Mining," Springer, 2nd edition, 2016. http://dx.doi.org/10.1007/978-3-662-49851-4

[6] K. Bauer, "The CPM Dashboard - The Graphs, Designing an Effective Dashboard is like creating a Steven Spielberg Film," DM Review, pp. 68-71, June 2004.

[7] D. M. Raab, "Selecting Customer Value Dashboard Contents, Part 2," DM Review, Vol. 16, pp. 12, March 2006.

[8] J. Wickboldt, L. Bianchin, R. Lunardi, et al., "A framework for risk assessment based on analysis of historical information of workflow execution in IT systems," Computer Networks, Vol. 55, No. 13, pp. 2954-2975, Sept. 2011. http://dx.doi.org/10.1016/j.comnet.2011.05.025

[9] S.A. Lesany, A. Koochakzadeh, S.M.T. Fatemi Ghomi, "Recognition and classification of single and concurrent unnatural patterns in control charts via neural networks and fitted line of samples," International Journal of Production Research, Vol. 52, No. 6, pp. 1771-1786, 2014. http://dx.doi.org/10.1080/00207543.2013.848483

[10] G. Tsiotras, "Quality improvement for group work management process," Total Quality Management, Vol. 4, No. 3, pp. 257-260, 1993. http://dx.doi.org/10.1080/0954412930000040

[11] G. Parry and C. Turner, "Application of lean visual process management tools,"Production Planning & Control, Vol. 17, No. 1, pp.77-86, Jan. 2006. http://dx.doi.org/10.1080/09537280500414991

[12] H. Mckew, "Dashboard without an Operator," Engineered Systems, Vol. 27, No. 11, pp. 66, Nov. 2010.

[13] D. M. Wong, "Guide to Information Graphics," The Wall Street Journal, 2010.

◐ 저 자 소 개 ◑

Jung-Gyu Lee

1986 B.S. in Mechanical Engineering, SungKyunKwan Univ., Seoul, Korea
1996 MBA in Sogang Univ., Seoul, Korea
2011~2013 Adj. Prof., Graduate School of KAIST Innovation & Tech. Management, Seoul, Korea
2015~Present: Graduate School of Business IT, Kookmin Univ., Korea
Research Interests: Process Innovation, Project Management, Startup Development & IT Process
E-mail; dominic.jg.lee@gmail.com

Seung-Ryul Jeong

1985 B.A. in Economics, Sogang Univ., Seoul, Korea
1989 M.S. in MIS, Univ. of Wisconsin, WI, U.S.A.
1995 Ph.D. in MIS, Univ. of South Carolina, SC, U.S.A.
1997~Present: Professor, Graduate School of Business IT, Kookmin Univ., Korea
Research Interests: System Implementation, Process Innovation, Project Management, Information Resource Management etc.
E-mail; srjeong@kookmin.ac.kr