

Control Variables of Remote Joint Analysis Realization on the M2M Case

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Abstract

New trend called ubiquitous leads the recent business by standardization and integration. It should be the main issue how to guarantee the integration and accountability on each business, especially in mission critical system which is mainly supported by M2M (Machine to Machine) control mechanism. This study is from the analysis of digital forensics case study that is from the M2M Sensing Control Mechanism problem of the "Imjin River" case in 2009, where a group of family is swept away to death by water due to M2M control error. The ubiquitous surroundings bring the changes in the field of criminal investigation to real time controls such as M2M systems. The needs of digital forensics on M2M control are increasing on every crime scene but we suffer from the lack of control metrics to get this done efficiently. The court asks for more accurately analyzed results accounting high quality product development design. Investigators in the crime scene need real-time analysis against the crime caused by poor quality of mission critical systems. It seems to be every need of Real-Time-Enterprise, so called ubiquitous society on the case. We try to find the efficiency and productivity in discovering non-functional design defects in M2M convergence products focusing on three metrics in study model with quick implementation. Digital forensics system in present status depends on know-how of each investigator and is hard to expect professional analysis on every field. This study set up a hypothesis "Co-working of professional investigators on each field will qualify Performance and Integrity" especially in mission critical system such as M2M and suggests "Online co-work analysis model" to efficiently detect and prevent mission critical errors in advance. At the conclusion, this study proved the statistical research that was surveyed by digital forensics specialists around M2M crime scene cases with quick implementation of dash board.

Keywords: Ubiquitous system, M2M control mechanism, mission critical system, information technology supervision & governance, control variables, remote forensic, Product development process, quality metrics.

1. Introduction

Modern business represented by ubiquitous is leading the trend change with its standardization and integration. The main issue in the modern society is found at the maintaining scheme for business integrity or accountability by finding the control variables for the system behavior.[1] And quality specification and metrication, result from a case-study in a mission-critical software domain using international quality standard(ISO 9126) and multi criteria decision making technique.[2] In accordance with the global trend, Korea established the foundation of information system control by initially announcing “the Act on the Efficient Establishment and Operation of Information Systems”, and got it merged with “the Act of the Electronic Government” and is under its enforcement.

The changes in the digital world have been also influenced on the area of criminal investigations. The demands for digital forensics are not limited at the computer crimes and are expanding to all areas of criminal investigations.[3] Based on the fact that only 640 out of 120,000 digital media, captured by the Gyeonggi Provincial Police Agency in South Korea, were requested for the digital proof analysis and that it only marks 0.5% of total, it is forecasted that there must be approximately 200 times of potential demands not even in the far future, in the present. Also, the quality level expectation of the forensics is being increased. The court is now requesting higher confidence level of the analysis results. The criminals are investing in the researches of new criminal tricks and evidence destruction methods, so the staffs of the authorities on the site are in need of real-time analysis results.[4] This phenomenon is in consistence with the issue of ‘Real-Time-Enterprise’.

However, it is hard to expect the expertise in every field since the digital forensics under the current organizational structure of police is mainly taking its stand-alone approach depending on the individual experiences and knowledge.[5] It is because even the most excellent profiler could not be expected to have both of the professional knowledge in every information technology area and the experiences in criminal suit code system or investigations. The lack of expertise leads to the errors in the analysis procedures and in turn, to the failure of revealing the truth by mistakes like catching innocent suspects or losing important proofs. Thus, there exist risks in the digital forensics field, such as the rapid increase in demands, the necessity of immediate analysis, the burden of strict legal confidence level, and the lack of shared professional knowledge.

To resolve these risks and issues in the digital forensics area, “Multilateral Remote Joint Analysis System(MJA)”, with the application of machine-to-machine (M2M) sensing case where all experts in every field participate in the improvement of remote forensics in the existing stand-alone approach, is suggested after the analysis of case study on M2M Sensing Control Mechanism of the “Imjin River” case in 2009, where a group of family is swept away to death by water due to M2M control error.[6]

In 2009, the Imjin River which was originated from North Korea got a heavy rain that made the dam of North Korea discharge the water, by which a group of South Korean family enjoying swim around the middle of the river had disappeared beneath the torrent. The South Korea already had operated Emergency Warning System before, with M2M sensing mechanism. But unfortunately when the river water had stood several meters above normal level after the discharge of North Korea Dam, M2M sensors around the river did not work. The investigation authority arrested the employee on duty of Emergency Warning System. Initially the judge passed sentence upon the worker by the evidence collected around the crime scene with suspicion, but dramatically after analysis of digital forensic team that there were some

defects in design of Emergency Warning System, the judge found guilty of the design of the M2M mechanism and not guilty for the worker. Because the sensors were weak in the exceed of capacity and outdoor conditions. Furthermore the digital forensics team found that the control mechanism of checking malfunctioning in sensor did not designed during initial definition and development of Emergency Warning Systems.[6]

This study confirmed that if the experts in each field share the professional knowledge and skilled experiences with each other considering design and development requirements when the suggested system is applied, it influences on the productivity improvement in three major factors; accuracy, speed and objectivity and through these, each opportunity to comply the standard procedure increases, and respectively integrity and chances to discover the proof improves.

2. Related Works

M2M (Machine to Machine) communication which refers to technologies those allow both wireless and wired systems to communicate with other devices of the same ability. M2M uses a device (such as a sensor or meter) to capture an event (such as temperature, inventory level, etc.), is a new and rapidly developing technology for large-scale networking of devices without dependence on human interaction. The recently studied metrics for M2M is cost down thus to achieve productivity. Edmund W. Schuster seeks the communication mechanism by using internet technology such as XML [7] and Neyre Tekbiyik tries to find shortest routing path for energy efficient system. [8]

Table 1. Machine-to-machine control variables comparison

Scope	Variables (Metrics)	M2M Subject Applied	Dependent Variable
Related Work	Cost	Cost down use by Applying XML among M2M Communications for case of Agricultural System[7]	Productivity
	Cost	Cost down use by Finding Shortest Routing Path for case of Energy Efficient M2M System[8]	
This Study	Accuracy	Performance controls in qualifying chain of custody to the court in Remote Forensics case of M2M Sensing Mechanism	Productivity
	Speed		
	Objectivity		

Table 1. illustrated the machine-to-machine control variables of previous works and suggestions of this study for each field. Automation for M2M Communications by using internet technology to get cost down is tried to get the performance metrics. Edward W. puts forth an internet-based architecture for machine-to-machine communication and computation that enhances bio-productivity in agriculture. That approach utilizes an auxiliary language to enable data interoperability in a synthetic computing environment and to make connections between data and mathematical models. In general, future agricultural systems will be internet-based thus reducing cost and increasing capability. Standards organizations are certain to play an important role in this development, which might continue for the next decade or longer. [7] [9] The XML (Extensible Markup Language) standard forms the basis of current internet technology such as web service, which utilizes XML to have the communications automated by software component between provider and customer. It allows the ability to use any word, regardless of its definition, for a tag. In the study of Edward W., XML is widely adopted to have the M2M communications done more efficiently thus reducing communication cost.

And energy efficiency is one of the important design objectives for machine-to-machine network architectures that often contain multi-hop wireless sub-networks. To find shortest-path based energy-efficient M2M routing alternatives to get cost down, constructing energy-efficient routes for sending data through such networks is important not only for the longevity of the nodes which typically depend on battery energy, but also for achieving an environmentally friendly system design overall, which will be imperative as M2M networks scale in number of nodes as projected. With comprehensive classification of shortest-path-based energy-efficient routing algorithms designed for wireless ad hoc and sensor networks, it ends by comparisons and discussions of the use of different cost metrics. [8] To verify M2M control variables, Min-Chun Pan tried to find qualifying remote online machine condition monitoring case of mission critical system. Various signal-processing computation schemes such as time-frequency analysis and order tracking for signal analysis and pattern recognition purposes are implemented. [10] But in this study, the cost factor, which was independent variables in previously related works, was considered as same with dependent variable like “productivity” for M2M investigation case. In IT (Information Technology) service and software design and development area, “cost alignment” stands for the resource and capability of IT service provider as the basis of “productivity”. [9]

The suggested model of this study is from the practices of the digital forensics. The investigators need to know the appliances of remote online machine condition monitoring systems, and the requirements for expertise sharing and synergy effect because it is constantly occurring with vulnerability. In a similar study, “Digital Investigation Ontology (DIALOG)”, a joint framework which is general and independent from the application system especially in mission critical system as in this study like M2M sensing mechanism, was suggested for the management, reuse, and analysis of Digital Investigation knowledge. The adaptation of joint framework to share the investigation knowledge through Information Ontology, which was a kind of dictionary that the software components use, was asserted; however, there were restrictions to conduct case studies for the connection with the actual productivity. Because there were no attempts in finding requirements and designs defects with control metrics like this study. [11]

And as for IT (Information Technology) convergence product appliances, because M2M product is in the scope of these appliances in the market, we need to see ITSM (Information Technology Service Management) standards and public control framework as referential guidelines to get the focus on control variables in M2M as a part of industrial appliances of IT.

ITSM has been spread and performed in the global context since its registration at ISO/IEC 20000 in 2005. And it has been studied in correlations with Control Objectives for Information and related Technology (COBIT) and IT governance. Also it is found that there is a need to review the detailed application cases by each industrial domain. [9][12][13]

3. Remote Forensic Proposals on M2M Control Variables

Multilateral Remote Joint Analysis (MJA) System Model of digital forensics, suggested in this study, is a forensics model which is applied to M2M case with the consideration of supervising on initial detection of design defects affecting the ESI(Electronically Stored Information) in the cases [14], to draw the best analysis result by remote-sharing experiences and knowledge among the each area's experts on the specific case, with the focus on getting M2M product design defects considered by understanding proactive control variables with utilizing the remote-control and remote-video-conference technology, and remote-operating the analysis system.

Compared to the existing remote forensics model, where M.I. Cohen has proposed recently "Distributed Forensics and Incident Response model" associated with incident management that is for accelerating initial investigation response in 2011 [3], since Philip Sealey suggested "Remote Forensics" model introduction that was mainly for on-line cooperation around specific incident cases with a level of partially sharing the on-site contexts through terminals in 2004 [15], the suggested Multilateral Remote Joint Analysis System is a model where the real-time management and response level are improved by analyzing and accepting the Imjin river case 2009, from which this study can draw the need of accountability as executive summary to stakeholders about requirements to implementations by dash board [6], to supply the suit case with possible understating of requirements or service design defects in actual M2M products.

Accounting the service improvement life cycle to trace sound designs for the market requirements and environment changes before and after the discovering or disclosure of ESI in suit case is needed. [14]

Design defects or changes are considered as the root cause of vulnerability, and can always give the motives for digital crimes for themselves by the nature or by the human, if we don't have any controls.

3.1 Remote Joint Analysis Procedure

Remote Joint Analysis proceeds as follow. It includes stages of decision-making on meeting, meeting preparation, case outline, briefing, joint analysis, and review and finalizing. This procedure is drawn from the case study in Imjin river suit case of South Korea 2009 by the thirst for improvement among the digital investigators in Korea, with a reference of procedure of previous studies as in Table 2. [6][15]

Table 2. Remote Joint Analysis Procedure in M2M case

Phase	Role	Procedure
Decision-making on meeting	Responsible for Digital Forensics Team	Define the priority of a case, then summarize how to analyze then whether call remote joint analysis or not
Meeting preparation	Responsible for Digital Forensics Team	Load the image copy of the case and application for analysis to Remote Joint Analysis System. Then create account for the attendee according to access control policy.[16] Prepare the image copy of the case, recovery of the deleted files, hash code for each file, information of the operation system, internet connection log, etc. to prevent lag time from occurring.
Case outline	Responsible for Digital Forensics Team	Call every specialist for operation system, DBMS, programming language, network analysis. Then invite the investigators who have experience in similar case, and digital forensics standard specialist to the case.
Briefing	Supportive, Consulted & Informed for Detective	Brief the attendee on the case summary, progress, requests for analysis, etc.
	Responsible for Digital Forensics Team	Brief the attendee on the basic collecting information and purpose.
Joint analysis	All attendee	Discuss the suggestions of each specialist, remote analysis application operation with the attendee.
Review and finalizing.	All attendee, Responsible for Digital Forensics Team	After collaborative work by remote analysis, the case can be finished with digital signature of each attendee if a successful executive summary can be figured. But if more resource is needed, next meeting will be scheduled for further analysis. The digital forensics investigator who is responsible in the case should clear every basic analysis in advance before the next meeting.

3.2 Control Variables of Remote Joint Analysis Realization

And also this procedure helps to identify the roles and responsibilities as in **Table 3** with the cross-functional communications analysis in the suggested MJA, resulting in

constructing models with value chain of digital investigation as in [Table 4](#) and implementation as in [Fig.1](#) and [Fig. 2](#)

The principles of value chain of digital investigation are generally referred to the “integrity of electronically stored information and initial response”. [\[3\]\[14\]\[15\]](#)

Table 3. Control Variables Proposal in M2M case

Phase	Control Variables (Metrics)		Role & Responsibility			
			Responsible for Digital Forensic Team	Supportive for Detective	Accountable for Supervisor	Consulted & Informed for Detective
Decision-making on meeting	Position of attendee	Objectivity	●			
	Specialty of attendee	Objectivity	●			
Meeting preparation	Original disk	Accuracy	●			
	Image copy of the original disk	Objectivity	●			
	Forensic tools(HW, SW)	Objectivity	●			
Case outline	One time password for authentication and authorization	Objectivity	●			
	Remote joint analysis connectivity	Speed Accuracy Objectivity	●	●	●	●
Briefing	Personal information of the accused, suspect and witness	Accuracy	●			●
	Case briefs and request for analysis	Accuracy	●	●	●	●
	Investigation summary before attendance	Objectivity	●	●	●	●
	Basic investigation history before attendance	Accuracy	●	●	●	●
	Conference call solution	Speed	●	●	●	●
Joint analysis	Original disk	Accuracy				
	Image copy of the original disk	Objectivity	●	●	●	●
	Joint analysis remote monitoring for joint analysis	Speed Accuracy Objectivity	●	●	●	
	Digital forensic tools	Objectivity	●	●	●	●
	File image extract during analysis	Accuracy	●	●	●	●
	Transaction log of other attendee	Objectivity	●	●	●	●
	Administrative command other than digital forensic	Objectivity	●			

	tools					
	Extra data gathered	Objectivity	●			
Review and finalizing.	Check list for standard analysis	Objectivity	●	●	●	●
	Executive summary for final joint analysis	Accuracy Objectivity	●	●	●	●

3.3 Restrictions in Process

As Remote Joint Analysis Model suggested in this study is subject to the transfer of data through the open network called IP, with consideration of easiness of accessibility, convenience of the task and cost aspects, to efficiently measure the drawn result of task productivity, the general security threats (TCP-hijacking, man-in-the-middle-attack, authority-excess, cheating, etc.) generated due to the network service characteristics can be accompanied. Therefore, corresponding securing measures need to be prepared by utilizing international/domestic information security management as measurement to adopt the method into the actual tasks.

4. Evaluations of Remote Forensic Proposals on M2M Sensing Mechanism

4.1 Hypothesis on Application of Multilateral Remote Joint Analysis Model

As control metrics, this study initially set three factors from [Table 1](#). like “accuracy, speed, objectivity” as independent variables, but “cost”, which was independent in previously related works, was considered as dependent variable in this study with “productivity” for M2M investigation case. Because generally in software or service oriented convergent product design and development process like this study, the “cost alignment” as the “ability of shaping resources” forms the basis of “productivity”. [\[12\]](#)

And to evaluate the case, this study also has several mappings done with three variables as “policy, standard, architecture” in [Table 4](#). which were already proven to be feasible in other studies in different cases, considering the value chain and roles and responsibilities across the stages of digital investigations procedure previously suggested in [Table 2](#). and in [Table 3](#). to validate the initial factors, then suggests differences in productivity by quick implementation and statistical analysis between existing analysis by the three factors and MJA Model by three factors also in recent suit case study with M2M sensor error. Generally mission critical systems which are also supported by M2M sensors are in scope of this study but other factors are not exactly mentioned. [\[17\]](#)

4.2 Preparation & Quick Implementation

The purpose of this study is to explain the influences of control metrics of Remote Joint Analysis Model onto productivity in M2M suit case. For this case, the properties of MJA dash board, which are suggested to related profilers working with digital forensics in police offices in Korea, were equipped and the questionnaires asking the usage results were sent via intranet emails. About 85.7 percent of questionnaires were responded before analysis, and it was confirmed that at least one person from each organization like each of regional councils and police headquarters responded, so the results seemed to be qualified as a material for this case study.

The variables which are suggested in this study are from the thirst for improvement of M2M case digital investigations in each local police head-quarter of Korea. Thus, to get this verified as reference, we carry out mapping between the suggested variables and already verified policy or study, such as “Policy” as in EA of Korea [18], “Standard” as in ISO20000, and ITIL[9], and “Architecture” as in Control metrics [19][20] during evaluation like [Table4]. Then based on this mapping we can suggest dash board design and quick implementation with explanation of each properties of suggested variables to the digital profilers working with digital forensics in police offices in Korea.

Table 4. Key Factors on Questionnaire

Measurements (Variables)		Questionnaire	MJA Dash Board
Existing Analysis System	Accuracy	Self-satisfaction in accuracy	Policy A
		Defendant-satisfaction on accuracy	Standard A
		Whether having experiences in accuracy complaints	Architecture A
	Speed	Satisfaction on knowledge collection time	Architecture B
		Satisfaction on research experiment time	Architecture C
		Satisfaction on no-experience-case analysis time	Standard B
	Objectivity	Unscrupulous result draw	Standard C
		Theoretical misjudge	Standard D
		Subjective substantiation	Policy B
Joint Analysis Model for M2M case	Accuracy	Expected satisfaction on accuracy at joint analysis	Policy C
	Speed	Expected satisfaction on speed at joint analysis	Architecture D
	Objectivity	Expected satisfaction on objectivity at joint analysis	Standard E

Nowadays, dash board is widely adopted as a tool to evaluate performance of organization. [21] It is also for an executive summary that simplify communicating metrics to members of boards. [22] We try to find the efficiency and productivity in discovering non-functional design defects in M2M convergence products focusing on three metrics in MJA model quick implementation. As in ISO9126 quality metrics, non-functional requirements are fivefold of functional requirement. Generally architecture design focuses on non-functional requirements considering total influences to requirements. [9][12]

Control Metrics

Recent Policy

- Attendee Check Policy
- Attendee Specialty Policy
- Accountability Policy

Standard & Guidance

- E-Discovery Guidance Policy done

Architecture

- Case briefs and regs Std done
- Original disk logs Std done
- Transaction logs Std done
- Check list for std Std done
- Executive summary Std done

Case Summary

SEARCH

Classification	Case Number	Case Status	Created Time	Owner
Intellectual Property	2011-10-934	Completed	09 Oct 2011	Dr. Lee
Fraud	2011-10-935	Completed	10 Oct 2011	Lt. Choi
Murder or Killed	2011-10-936	Progressing	12 Oct 2011	Dr. Kim
Cyber Terror	2011-10-937	Progressing	13 Oct 2011	Dr. Lim
Bribe	2011-10-938	Progressing	15 Oct 2011	Lt. Kim
Sexual Violence	2011-10-939	Stand-by	15 Oct 2011	Lt. Choi
Gambling	2011-10-940	Stand-by	16 Oct 2011	Dr. Lim
Defamation	2011-10-941	Stand-by	17 Oct 2011	Dr. Lee

My Case

SEARCH

Go To Examine Recent Policy Standard & Guidance Architecture

Case Number: 2011-10-937 Attendee List: Dr. Lee, Expert of System Eng. Ltd, Choi, Expert of Investigation

My Role: E-Discovery Expert Investigator

Case Description

Case Summary
: 6 Casualties including infants, swept to death by imjin river M2M error

Request for Analysis

- Warning system M2M sensor error
- Symptoms of Cyber terror
- Misconduct of Due Diligence

Status Details

Case Summary
: 6 Casualties including infants, swept to death by imjin river M2M error

Request for Analysis

- Warning system M2M sensor error
- Symptoms of Cyber terror
- Misconduct of Due Diligence

Fig. 1. MJA Dash Board Prototype - Main Page

- ① This outline includes investigator's act of duty like objection to illegal evidence gathering, privacy policy statement etc. See **Table 3, Table 4**
- ② This outline includes standard guidance & procedure etc. see **Table 3, Table 4**
- ③ This outline includes accountability & analysis for non-functional requirements etc. See **Table 3, Table 4**
- ④ Click to see policy done to each standard or guidance
- ⑤ Click to see standard done to each architecture metrics
- ⑥ Click here to see "profiles, login status" and to enable "report writing, view reporting and digital signature" of the participants of the case under review. The related sub-page is **Fig. 2** as below

- ⑦ Click to see policy done to this case
- ⑧ Click to see standard done to this case
- ⑨ Click to see architecture done to this case

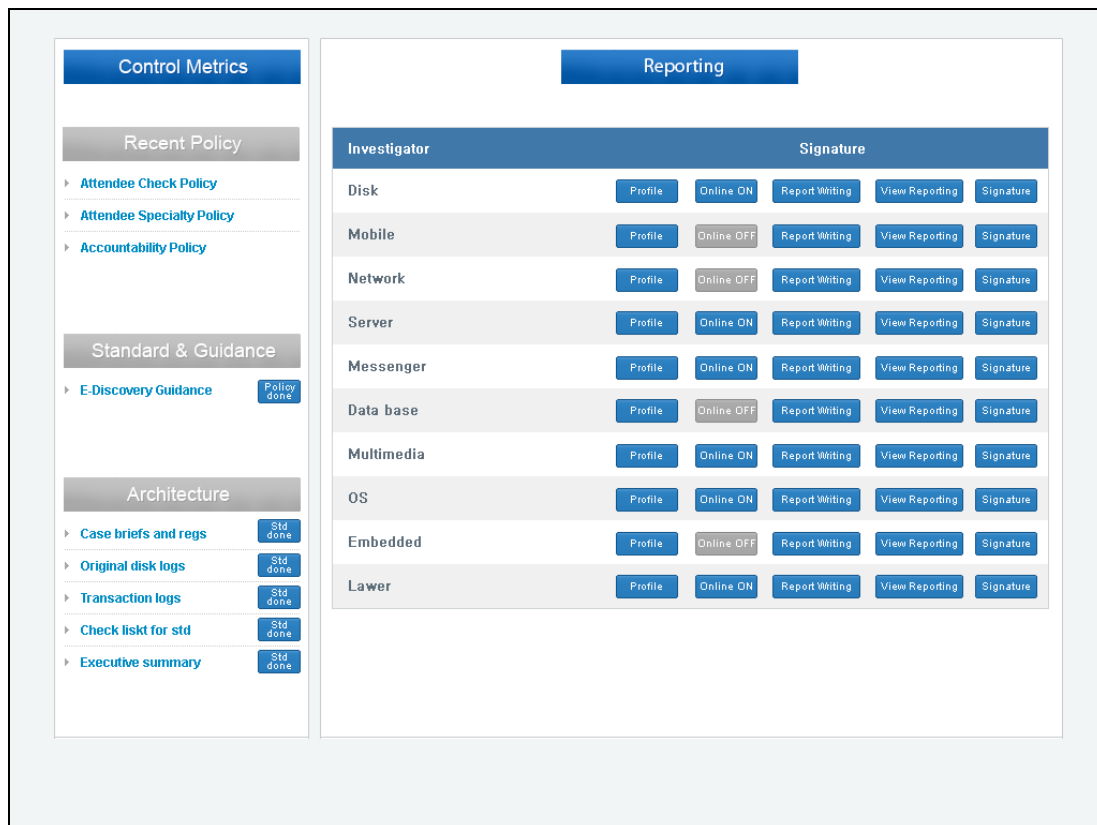


Fig. 2. MJA Dash Board Prototype - Reporting Page

4.3 Evaluation

The target of evaluation for this study, is to find the casual relationships between suggested control metrics initially as “Accuracy, Speed, Objectivity” and finally as mapping done by “Policy, Standard, Architecture” in existing analysis and also in “MJA Metrics Model” in the view of productivity for identifying non-functional design defect of mission critical system like M2M case, more efficiently. Three control metrics and quick implementaion of dash board properties were suggested to the digital forensics investigators with self-diagonosis check list which is rolled up in [Table 3](#).

The digital investigators or profilers identify their assigned roles for each MJA phase then check each questionnaire by likert-type scale.

Table 5. Survey Results Summary

Classification	Mean	Standard Deviation	Investigator
Architecture_A	3.23	0.89	60
Architecture_B	3.1	1.311	60
Architecture_C	3.2	1.338	60
Architecture_D	3.9	0.706	60
Policy_A	2.07	1.071	60
Policy_B	3.23	0.767	60
Policy_C	4.03	0.61	60
Standard_A	3.53	0.769	60
Standard_B	3.27	1.539	60
Standard_C	3.07	0.733	60
Standard_D	2.9	0.477	60
Standard_E	3.87	0.676	60
MJA Control Metrics	3.55	.746	60
Classification	1.50	.504	60

In **Table 5** MJA Control Metrics and Classification are considered to make questionnaires simple to identify “before and after MJA model”. As a result of reliability analysis with eliminating redundancy, it was proven to be acceptable by Cronbach’s Alpha value “0.686”

Table 6. Reliability Analysis on Variables

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Item Total
0.686	0.707	14

Then by the result of factor analysis, we can find that main factors by the priority order “MJA Model which is rolled up by Speed, Accuracy, Objectivity” and “Existing Analysis Model with Speed and Accuracy only” respectively have the meaningful influences to this study model as suggested in **Table 7**, **Fig. 3**, **Fig. 4**.

Table 7. Factor Analysis on Variables

Classification	MJA Control Metrics	MJA Dash Board	Ingredient		
			1	2	3
Existing Analysis System	Objectivity	Standard_C	.603	.043	.413
		Standard_D	.359	-.229	.071

		Policy_B	.739	-.141	.200
	Speed	Architecture_B	-.183	.961	-.006
		Architecture_C	-.027	.993	-.023
		Standard_B	.097	.971	-.064
	Accuracy	Policy_A	.442	-.023	.651
		Standard_A	-.159	-.175	.772
		Architecture_A	-.047	.077	.843
Joint Analysis Model for M2M case	Accuracy	Policy_C	.802	-.200	-.252
	Speed	Architecture_D	.865	.042	-.149
	Objectivity	Standard_E	.868	-.209	-.117
Parameter	Total Average	MJA_Control_Metrics	.651	.311	.127
	Before and After	Classification	.105	.021	.007

To find out concrete differences between “before MJA metrics application” and “after MJA metrics done”, we try t-test which is a tool to verify any significant difference between two groups.

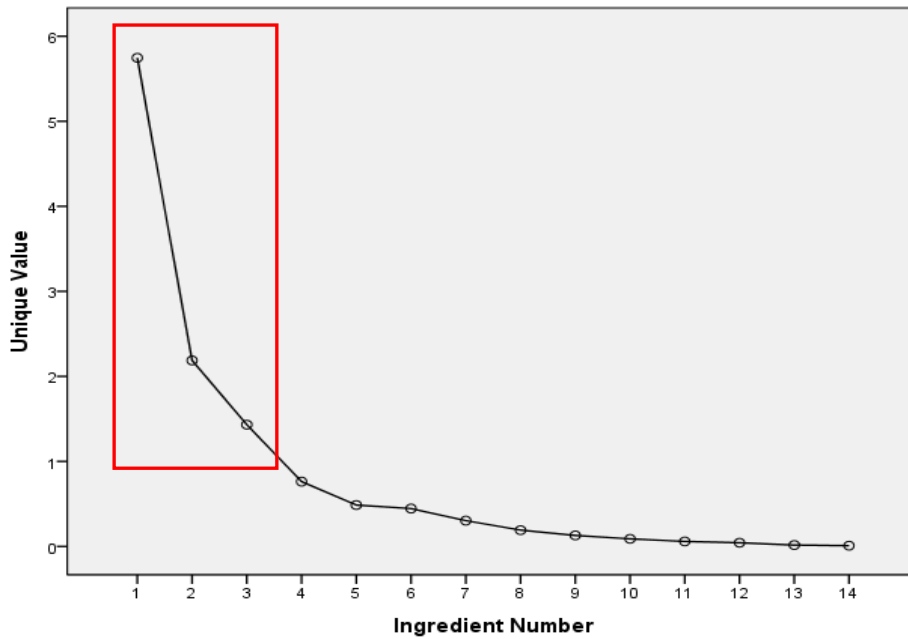


Fig. 3. Factor Analysis by Scree Diagram

The highlighted group of ingredient numbers of Fig. 3 shows the level of impacts and distinctive differences of Table 7.

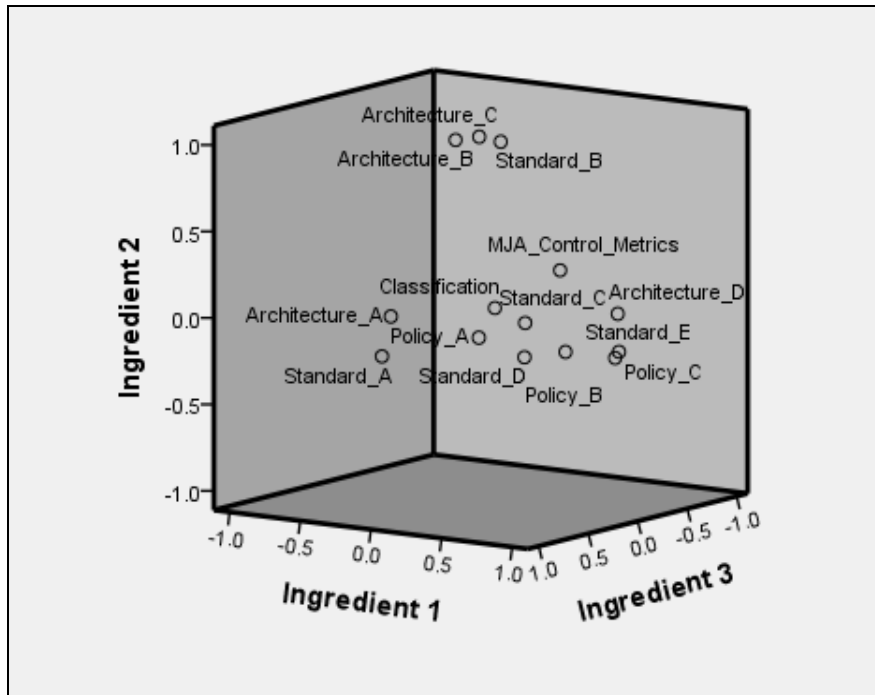


Fig. 4. Component Diagram in Tuning Space

The component diagram like Fig. 4 shows the distributions of each sub-metrics across each axis of ingredient of impacts from Table 7.

Table 8. Group Statistics

Classification		N	Mean	Std. Deviation	Std. Error Mean
MJA Control Metrics	Before Application	30	3.17	.648	.118
	After Metrics done	30	3.93	.640	.117
t = -4.613 df = 58 p = .000					

As a result of t-test, for two groups of classes as “before MJA metrics application” and “after MJA metrics done”, F value which means equality for variances is 0.333 and significance value is 0.566 > 0.05, so we use equal variances assumed. Then t value is -4.613 and significance value is 0.000 < 0.05, and consequently we have meaningful differences between “before and after MJA metrics done”. By summing up, we can find that MJA control metrics awareness was average level by “before MJA metrics application”, and satisfaction

level by “after MJA metrics done”.

Additionally, we also try to draw simple structural equation model, based on **Table7**, but suggested model of this study is not suitable for identifying general purpose of remote digital forensics identification, because exogenous as independent and endogenous as dependant variables with relevant constraints in general purpose of digital forensics themselves are not exactly match with this case study purpose. Because this model is designed maily to detect non-functional defects across product development in mission critical systems and following chain of custody to the court in Korea. [23]

In a future, if we may expand this study to the global remote forensics with suggested control metrics of this study, we need to backup more metrics properties relatively considering cross-functional process influenced by each nation’s constraints, not to lose focus.

5. Conclusion

This study suggested control metrics of Multilateral Joint Analysis model to response to the M2M sensor defects more efficiently. This set of metrics can be used in the cases with increasing requests on analysis quality and exploding demands of digital forensics around mission critical systems which are mainly supported by M2M control, considering the social trend of ubiquitous.

The research started from a hypothesis that there must be limitations that the profilers cannot possibly follow up all the skills in numerous information technology areas including product requirement and design defects that are ever-changing in real-time, and by the lack of expertise in this reason, eventually the accuracy, speed and objectivity in digital forensics could be limited to this case study.

Furthermore, it was found that the case, which is required to response with real time control variables such as M2M suit case, “the environment sharing the professional knowledge and skillful experiences” influences on accuracy and speed of digital forensics. There can be found that no direct relationship is in “objectivity” metrics. However, through the suggested model, the most of forensic workers who experienced mission critical system suit cases, showed strong expectations on the facts that three of “Speed, Accuracy and Objectivity” may improve the productivity around this case. [24] Also, other integrity check items necessary for actual application of the suggested model were replied by questionnaire, and the necessity was confirmed by digital forensic experts in Korea. If developing Multilateral Remote Joint Analysis, the following effects can be expected.

First, the analysts can remote-invite the corresponding field experts and proceed with the joint analysis when they need specific skills or product knowledge in certain area they are not familiar while they comply with the standard procedure and flow it. This can reduce unnecessary overlaps of learning, experiment, research time on the new knowledge, and allow the faster digital forensic results with high quality by relatively less resources.

Secondly, investigators on the sites who are not the forensics experts can be supported on the spot without visiting the forensic department, and comply with the standard procedure of proof collecting from the on-site investigation stage.

Thirdly, the process can be presented to the case investigators occasionally even in the middle of analysis process, so it is easy to add or modify the requests.

Forth, many experts including product design specialist participate in the procedure at the same time, so the possible unscrupulous analysis result due to private requests or personal relations can be prevented.

Fifth, Remote Joint Analysis method is applicable to the general scientific investigation field discerning DNA, fingerprint, bloodstain, fire, etc. according to the domain of business industry.

Sixth, in a long term, it can be a good method to overcome the geographical restrictions for the international cooperation investigations of the globalized crimes.

Seventh, after the reception of results, the contexts can be explained to the demanders of analysis result report (investigators, the related parties, etc.) by directly showing the analysis system, and this will enhance the understanding on the analysis result report.

The purpose of this case study was to review the hypotheses; how three control variables influences on productivity of Multilateral Remote Joint Analysis Model in M2M suit case by reliability analysis and factor analysis with dash board design and quick implementations. Additionally, we draw quick structural equation model through variable cleanup, variable calculation by reliability and factor analysis, using professional statistical analysis tool (SPSS and AMOS), but we do not adopt it as an evaluation because some restrictions in identification of exogenous and endogenous constraints do not fit in the scope of this study. 85.7 percent of responses in the sample group may not be enough to run the statistic analysis; however, it was disappointing that the Korea has not enough number of digital forensic investigators. Thus speed and accuracy with productivity are essential factors of field work especially in mission critical system with M2M mechanism.

Again, it was confirmed that the sharing environment of professional knowledge influences accuracy and speed enhancement, but for the expected improvement in “objectivity”, it was only confirmed as a type of expectation that “the suggested model will enhance the objectivity more” without enough substantiation, possibly due to sample group characteristics that they usually have high conscience and sense of responsibility.

Besides, various parameters, which were possibly influential to the hypothesis, could be examined during the research; however, it was necessary to concentrate only on the items related to the suggested model of this study, so the broad analysis reflecting all other factors was abstained.

Further suggestions need to be checked by setting a future test department, and actually constructing the remote joint analysis system in commercial versions, and test-operating it, and reviewing through the experiments to discover the advantages and disadvantages drawn in the procedure and the analysis of user responses.

This study suggested the possibility to improve the productivity of digital forensics by sharing the professional knowledge including IT convergent product design and analysis and the skillful experiences around M2M suit case, and the meaning of research was found where the findings could help the decision-making procedure for system development to find non-functional requirements of the case analyzed as sample operations.

This could be done by using the quality metrics of IT supervision models as in ITSM in Remote Forensics practices. Since the constant quality control and improvement on the IT system is required to realize the real-time multilateral remote joint analysis, the focus has been on the validation of task productivity, if the cooperation and support are applicable, by field expert's remote control assistance in the stage of proof collection and analysis, through consideration on procedure of ITSM CSI(Continual Service Improvement) based on ISO20000 standards and realization of suggesting models considering the examples of cyber investigation procedure in Korea. [12][25]

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