Development and Applications of a Multiple Risk Communicator with its Future Direction

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Various Risks in Corporate Management

Original Risk

Primary Risk
The risk taken positively in order to obtain profits

Secondary Risk

Information Security Risk

Personal Information Leakage Risk

Compliance Risk, Tax Risk etc.

The risk at which reputation gets worse
Trend

Among them, **Information security risk** and **privacy risk** which contains personal information leakage risk become very serious in Japan.

According to the JNSA survey in 2008, personal information of more than seven million people leaked in Japan.

JNSA: Japan Network Security Association
Security and Privacy

Concepts

Security
(Confidentiality, Integrity, Availability etc.)

Privacy
Protection of personal information

Measures

Security countermeasures
- Intrusion prevention
- Data secrecy etc.

Privacy countermeasure
- Personal information leakage prevention
- Anonymity maintenance

Technologies

Security technology
- Cryptography
- Digital signature
- Access control etc.

Privacy Technology
- Anonymous channel
- P3P
- Ring Signature etc.
Multiple Risks (Risk vs. Risk)

• Public key certificate system is main measure to reduce security risk. However it often causes privacy risk, because the user name, address, etc become open.

• Thus, how to deal with one risk versus another risk, or tradeoff of multiple risks, is a major problem.
The Image to Solve the Conflict

Preference of Decision Maker

Solution with Technology

<Example>

Public Key Certificate System
(Name, Address, Birth Day )

Attribute Certificate System
(Only Attribute)

Many Participants for decision making have many preferences.
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Background and Requirements to Develop MRC

**Requirement 1** Existence of many risks (security risk, privacy risk and so on) → Necessity of measure for avoiding conflict of risks

**Requirement 2** Difficulty to achieve the objective with only one measure → Necessity of searching for optimal combination of measures

**Requirement 3** Existence of many participants (executive officer, customers, employees and so on) → Necessity of risk communication to obtain consensus from many participants

**Development of Multiple Risk Communicator (MRC)**
Requirements and Main Measures in MRC (1)

Requirement 1 Existence of many risks (security risk, privacy risk and so on) => Necessity of measure for avoiding conflict of risks

Requirement 2 Difficulty to achieve the objective with only one measure => Necessity of searching for optimal combination of measures

Requirement 3 Existence of many participants (executive officer, customers, employees and so on) => Necessity of risk communication to obtain consensus from many participants

Formulated as Combinatorial Optimization Problem
Requirements and Main Measures in MRC (2)

Requirement 1  Existence of many risks (security risk, privacy risk and so on)  $\Rightarrow$  Necessity of measure for avoiding conflict of risks

Requirement 2  Difficulty to achieve the objective with only one measure  $\Rightarrow$  Necessity of searching for optimal combination of measures

Requirement 3  Existence of many participants (executive officer, customers, employees and so on)  $\Rightarrow$  Necessity of risk communication to obtain consensus from many participants

<MRC>
The display easy to understand the optimal solution for participants, and easy to obtain the consensus
Overview of MRC

Multiple Risk Communicator (MRC)

(1) Assistant Tool for Specialists
   Assistance for analysis (FTA etc.)
   Assistance for formulation
   Assistance for parameter setting

(2) Total Controller

(3) Optimization Engine
   Assistance for consensus construction

(4) Assistant Tool for Participants
   Display the results of analysis

(5) Database

(6) Negotiation Infrastructure

The Internet

Participants for decision making (Manager, Customer, Employee, etc.)

Facilitator

Specialists
Development of MRC Program

(1) The MRC program was implemented using Java and PHP in a Windows XP environment.

(2) The total number of coding steps was about 10,000.

(3) Apache 2.24 was used for the Web server, MySQL 5.0 for the Database server, and Xoops 2.0.16 for the communication server.

(4) In addition, Mathematica 5.2 was used to deal with the numerical formula in the PC for the specialist.

Ryoichi Sasaki, et al.” Development and applications of a multiple risk communicator ” Sixth International Conference on RISK ANALYSIS 2008 (in Greece)
1. In order to formulate as combinatorial optimization problem, specialists decide
(a) objective function, (b) constraint functions, (c) proposed measures, (d) coefficient values, (e) constraint values.

How to Use MRC (1)

(1) Assistant Tool for Specialists
- Assistance for analysis (FTA etc.)
- Assistance for formulation
- Assistance for parameter setting

(2) Total Controller
Display the results of analysis
Assistance for consensus construction

(3) Optimization Engine
Assistance for consensus construction

(6) Negotiation Infrastructure

The Internet

Participants for decision making (Manager, Customer, Employee, etc.)

Facilitator

Specialists
Decide the objective function and constraint functions

**Objective function:**
Min (Total risk of information leakage $+$ Total cost of measures)

**Constraint functions** is used to represent the risks for each Stakeholder:
(a) Probability of leakage (for the year) for Customers
(b) Cost of measures for Manager
(c) Degree of worker’s privacy burden for Employees
(d) Degree of worker’s convenience burden for Employees
Result of the total formulation

Minimization:  
$$Min \{ \text{Amount of damage } * \ (P_{\alpha_1} + P_{\alpha_2} + P_{\beta}) + \sum_{i=1}^{8} C_i * X_i \}$$

Subject to  
$$\sum_{i=1}^{8} C_i X_i \leq Ct \quad \text{(Total cost of measures)}$$

$$\sum_{i=1}^{8} D_{1i} X_i \leq D_1 \quad \text{(Degree of privacy burden)}$$

$$\sum_{i=1}^{8} D_{2i} X_i \leq D_2 \quad \text{(Degree of convenience burden)}$$

$$P_{\alpha_1} + P_{\alpha_2} + P_{\beta} \leq Pt \quad (X_i = 0,1) \quad \text{(Probability of Information Leakage)}$$
Result of the total formulation

Minimization:

\[ Min \{ \text{Amount of damage} \times (P_{\alpha_1} + P_{\alpha_2} + P_{\beta}) + \sum_{i=1}^{8} C_i \times X_i \} \]

Subject to

\[ \sum_{i=1}^{8} C_i X_i \leq C_t \] (Total cost of measures)

\[ \sum_{i=1}^{8} D_{1i} X_i \leq D_1 \] (Degree of privacy burden)

\[ \sum_{i=1}^{8} D_{2i} X_i \leq D_2 \] (Degree of convenience burden)

\[ P_{\alpha_1} + P_{\alpha_2} + P_{\beta} \leq P_t \quad (X_i = 0, 1) \] (Probability of Information Leakage)

If Xi=1, then i-th alternative measure is adopted
If Xi=0, the i-th alternative measure is not adopted

Ci: cost of i-th measure.
Result of the total formulation

Minimization:

\[ \text{Min} \{ \text{Amount of damage } \ast (P_{\alpha_1} + P_{\alpha_2} + P_{\beta}) + \sum_{i=1}^{8} C_i \ast X_i \} \]

\[ P_{\alpha_1} : \text{Probability of leakage by the employee permitted to enter the isolated area. This equation is obtained automatically from Fault Tree with MRC.} \]

\[ P_{\alpha_1} = P \left\{ \left[ P_b \left( 1 - \Delta P_{\alpha_1} X \right) \left( 1 - P_{\alpha_6} X \right) + P_c \left( 1 - \Delta P_{\alpha_1} X \right) \left( 1 - \Delta P_{\alpha_2} X \right) + P_{\alpha_1} \left( 1 - \Delta P_{\alpha_3} X \right) \right] \right\} \]

\[ P_{\alpha_1} + P_{\alpha_2} + P_{\beta} \leq P_t \quad (X_i = 0, 1) \]

(Probability of Information Leakage)
Result of the total formulation

Minimization:

\[
\text{Min} \{ \text{Amount of damage} \ast (P_{\alpha_1} + P_{\alpha_2} + P_\beta) + \sum_{i=1}^{8} C_i \ast X_i \} 
\]

Subject to

\[
\sum_{i=1}^{8} C_i X_i \leq Ct \quad \text{(Total cost of measures)}
\]

\[
\sum_{i=1}^{8} D_{1i} X_i \leq D_1 \quad \text{(Degree of privacy burden)}
\]

\[
\sum_{i=1}^{8} D_{2i} X_i \leq D_2 \quad \text{(Degree of convenience burden)}
\]

\[
P_{\alpha_1} + P_{\alpha_2} + P_\beta \leq Pt \quad (X_i = 0,1)
\]

(Probability of Information Leakage)

These constraint values are given by specialists or participants.
Display Image of MRC for Specialists

Flow of Operation

Initiation Display

Graph for FTA

Optimization Results
2. To obtain optimal combination of proposed measures, “optimization engine” is used.

For example, the combination of measure 1, 3, and 6 is adopted as the 1st optimal solution.

Function to obtain 1st to 100th optimal solutions with
1. Brute force Method
2. Lexicographic Enumeration Method
How to Use MRC (3)

Multiple Risk Communicator (MRC)

(1) Assistant Tool for Specialists
(2) Total Controller
(3) Optimization Engine
(4) Assistant Tool for Participants
(5) Database
(6) Negotiation Infrastructure

3. This result is displayed intelligibly to participants for risk communication.

The Internet

Participants for decision making (Manager, Customer, Employee, etc.)

Facilitator

Specialists
Display Image of MRC for Decision Participants

A two-dimensional distribution map from 1st optimal solution to 100-th optimal solution

First Optimal Solution

Optimal combination of alternative measures

Constraints and the values

Optimal value
Display Image of MRC for Decision Participants

1. Using these displays, participants can understand the status of the proposed optimal solution.
2. In addition, MRC has the function for the participants to search for the background from which such solution was lead.
How to Use MRC (4)

4. Each participant says the opinion such as “Add the measure we proposed”, “We propose to change the value of the constraint” etc.

5. Formulation is changed by specialists and recalculated with MRC.

(1) Assistant Tool for Specialists
   Assistance for analysis (FTA etc.)
   Assistance for formulation
   Assistance for parameter setting

(4) Assistant Tool for Participants
   Display the results of analysis
   Assistance for consensus construction

(6) Negotiation Infrastructure

The Internet

Participants for decision making (Manager, Customer, Employee, etc.)

Specialists

Facilitator
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MRC Application Process

**<Preparation Process>**

1. Decide the object
2. Analyze the object
3. Decide the participants for decision making
4. Decide the objective function and constraint functions
5. Propose the alternative measures

**<MRC Usage Process>**

6. Formulate as optimization problem
7. Obtain optimal combination of proposed measures using optimization engine
8. Display the result to participants for risk communication.

Satisfy?  
Yes  END  
No

Participants for decision making

Specialists
MRC Application Process

<Preparation Process>

① Decide the object
② Analyze the object
③ Decide the participants for decision making
④ Decide the objective function and constraint functions
⑤ Propose the alternative measures

Personal information leakage problems at junior high schools in Setagaya-ku, Tokyo

Participants for decision making

Specialists

Satisfy?

no

yes

END
MRC Application Process

<Preparation Process>

① Decide the object

② Analyze the object

③ Decide the participants for decision making

④ Decide the objective function and constraint functions

⑤ Propose the alternative measures

Participants for decision making

Analysis to obtain the probability of personal information leakage.

1. Attack from outside
2. Attack from inside
3. Mistake of insider

Using Fault Tree Analysis (FTA)

Satisfy? yes END
MRC Application Process

**<Preparation Process>**

1. Decide the object
2. Analyze the object
3. Decide the participants for decision making
4. Decide the objective function and constraint functions
5. Propose the alternative measures

**<MRC Usage Process>**

6. Real manager in the Setagaya-ku government office,
Information system engineer of the Board of Education,
Representative of the teachers in the junior high school

Participants for decision making

Specialists

Participants for decision making

Satisfy?

yes

no
Decide the objective function and constraint functions

Objective function:
Min (Total risk of information leakage + Total cost of measures)

Constraint functions:
(a) Probability of leakage (for the year) for Students
(b) Cost of measures for Manager
(c) Degree of worker’s privacy burden for Teachers
(d) Degree of worker’s convenience burden for Teachers
Decide the objective function and constraint functions

Objective function:
Min (Total risk of information leakage + Total cost of measures)

Constraint functions:
(a) Probability of leakage (for the year) for Students
(b) Cost of measures for Manager
(c) Degree of worker’s privacy burden for Teachers
(d) Degree of worker’s convenience burden for Teachers

Privacy risk not only for students but for teachers is considered in this formulation.
Result of Actual Application (1)

(1) In this case, the number of alternative measures was 13.

(2) Every optimal solution was obtained within one minute.

(3) Consensus of the participants for decision-making was obtained after three times meetings.

(4) The number of total times that the optimal solution was shown to participants for decision making was 12 times.
(5) The adopted optimal solution consists of three measures such as encryption of the data in USB memory.

(6) The Setagaya-ku government office is preparing to implement the measures included in the adopted optimal solution for all junior high schools in Setagaya-ku.
Application Results of MRC

The MRC

① Personal information leakage problems,
② Internal control problems
③ Illegal copying problems

Best paper award was given to the paper related with MRC from Japan Security Management Society in 2009.
Results and Future Direction

In cases in which the number of people necessary for consensus formation is low, such as forming a consensus within an organization, the MRC offers a possible solution to this problem.

However, the MRC cannot be applied to problems of social consensus formation among several thousand or more stakeholders, and an innovative solution is necessary.
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Objective to Develop Social - MRC

For applying to problems of social consensus formation among several thousand or more stakeholders, we developed the concept of Social - MRC in 2009.

Problems to be solved with Social - MRC are
- Information filtering to protect children,
- introduction of a citizen identification system,
- installation of surveillance cameras
Overview of Social-MRC

Social-MRC

< Level One >

MRC-Studio
(1) Support for consensus formation among opinion leaders
(2) Support for reflecting the opinions of ordinary stakeholders
(Expansion of the MRC)

Support server

< Level Two >

MRC-Plaza
(1) Live broadcast of meeting and MRC-Studio output display
(2) Provision of information to the facilitator through automatic analysis of ordinary stakeholder opinions
   (Newly developed)

Use scenes

Web-based public hearings, consensus meetings, government program reviews, television discussion programs

Internet

Ordinary stakeholders

Live broadcast of meeting

Opinion leaders

Facilitator

MRC specialist
Overview of Social-MRC

Use scenes
- Web-based public hearings, consensus meetings, government program reviews, television discussion programs

Level One
- MRC-Studio
  1. Support for consensus formation among opinion leaders
  2. Support for reflecting the opinions of ordinary stakeholders
  (Expansion of the MRC)

Level Two
- MRC-Plaza
  1. Live broadcast of meeting and MRC-Studio output display
  2. Provision of information to the facilitator through automatic analysis of ordinary stakeholder opinions
  (Newly developed)
Overview of Social-MRC

<table>
<thead>
<tr>
<th>Use scenes</th>
<th>Web-based public hearings, consensus meetings, government program reviews, television discussion programs</th>
</tr>
</thead>
</table>

- **Social-MRC**
  - **< Level One >**
    - **MRC-Studio**
      1. Support for consensus formation among opinion leaders
      2. Support for reflecting the opinions of ordinary stakeholders
      (Expansion of the MRC)
  - **< Level Two >**
    - **MRC-Plaza**
      1. Live broadcast of meeting and MRC-Studio output display
      2. Provision of information to the facilitator through automatic analysis of ordinary stakeholder opinions
      (Newly developed)

- **Support server**
  - **Ordinary stakeholders**
  - **Internet**

- **Live broadcast of meeting**
  - **Opinion leaders**
  - **Facilitator**
  - **MRC specialist**
Social-MRC system configuration

**<MRC-Studio>**
Overall display screen image (for example, Conference feed, MRC output, Stakeholder response)

- MRC specialist
- Chairperson
- Camera
- Conference room
- MRC Studio server
- <MRC output, Conference feed>

**<Social-MRC>**

- Router
- Internet
- Twitter server
- Ordinary stakeholders
- Writing down of opinions
- Systematic route
- Director in charge of MRC-Plaza
- Conference room
- MRC-Plaza server
- <Selection>
- <Opinions>
- Syste
- matic
- route
- Heuri
- stic
- route
- Supporter selection
- MRC specialist
- Chairperson
- Camera
- Opinion leaders
- Conference room
- MRC Studio server
- <MRC output, Conference feed>
To support participation by many ordinary stakeholders, this development makes use of existing Internet-based systems such as Ustream and Twitter.

Twitter: Micro blog
UStream: Video sharing service
Example of Broadcast with USTREAM

Ustream: video sharing service for the live broadcast of conferences
According to the dual-process theory of risk psychology, two types of people exist:

① rational judges who can properly express their own opinions on the basis of the systematic route
② people who can only indicate the people whose opinions they agree with on the basis of the heuristic route.

Both types of opinions are treated.
Application Phases of Social-MRC

① Arrangements Phase before the Start of Broadcasting

② Phase of Selecting Preferable Opinion Leader

③ Phase of Forming Consensus among Opinion Leaders

④ Phase of Voting to Provisional Agreement Alternatives by Stakeholders

⑤ Arrangements Phase after Broadcasting
Application Phases of Social-MRC

1. **Arrangements Phase before the Start of Broadcasting**
2. **Phase of Selecting Preferable Opinion Leader**
3. **Phase of Forming Consensus among Opinion Leaders**
4. **Phase of Voting to Provisional Agreement Alternatives by Stakeholders**
5. **Arrangements Phase after Broadcasting**
① Arrangements Phase before the Start of Broadcasting

(1) The sponsor decides in advance the problem to be solved and the opinion leaders.

(2) The specialist formulates the problem to be solved as a combined optimization problem, inputs the parameter and constraint values into MRC-Studio, and seeks an optimal combination of measures as an initial solution.

(3) The specialist shows the results to the opinion leaders, and make them add proposed measures, change parameter values, changes constraint values, and uses MRC-Studio to calculate the optimal combination of the proposed measures for each opinion leader.
Example of optimization results for each opinion leader

Bob’s optimal solution

Alice’s optimal solution

Combination of measures 3–5, 8, 10, and 14

Constraint values and other values

Optimal value
Application Phases of Social-MRC

① Arrangements Phase before the Start of Broadcasting

② Phase of Selecting Preferable Opinion Leader

③ Phase of Forming Consensus among Opinion Leaders

④ Phase of Voting to Provisional Agreement Alternatives by Stakeholders

⑤ Arrangements Phase after Broadcasting
② Phase of Selecting Preferable Opinion Leader

(1) Each opinion leader expresses his or her preferred combination of proposed measures obtained by using MRC-Studio in an advance deliberation along with basic stance, evaluation indexes that should be emphasized etc.

(2) This process is shown to the ordinary stakeholders through MRC-Plaza using images captured by video cameras and the MRC-Studio output screen. The ordinary stakeholders select their preferred opinions.
Display of MRC-Plaza

Phase of Selecting Preferable Opinion Leader

For selecting preferable opinion leader

Output of MRC-Studio

Opinions of stakeholders with Twitter
Application Phases of Social-MRC

① Arrangements Phase before the Start of Broadcasting

② Phase of Selecting Preferable Opinion Leader

③ Phase of Forming Consensus among Opinion Leaders

④ Phase of Voting to Provisional Agreement Alternatives by Stakeholders

⑤ Arrangements Phase after Broadcasting
Phase of Forming Consensus among Opinion Leaders (1)

(1) Since the results are made known to the facilitator via MRC-Plaza, subsequent discussion progresses on the basis of optimal solution of the selected opinion leaders.
(2) Each opinion leader points out problems with the combinations of proposed measures in question or makes observations, such as differences in the values of coefficients and constraints.
③ Phase of Forming Consensus among Opinion Leaders (3)

(3) In response to these opinions, the MRC specialist uses the MRC-Studio to calculate the optimal combination of proposed measures and displays the results on the display screen.
③ Phase of Forming Consensus among Opinion Leaders (4)

(4) This process is made known to the ordinary stakeholders using Ustream. The ordinary stakeholders input their own opinions using Twitter.

(5) MRC-Plaza (semi-)automatically analyzes the important opinions, and conveys the results to the facilitator and opinion leaders.
Application Phases of Social-MRC

① Arrangements Phase before the Start of Broadcasting

② Phase of Selecting Preferable Opinion Leader

③ Phase of Forming Consensus among Opinion Leaders

④ Phase of Voting to Provisional Agreement Alternatives by Stakeholders

⑤ Arrangements Phase after Broadcasting
④ Phase of Voting to Provisional Agreement Alternatives

Do you agree to provisional agreement alternatives?
Application Phases of Social-MRC

① Arrangements Phase before the Start of Broadcasting

② Phase of Selecting Preferable Opinion Leader

③ Phase of Forming Consensus among Opinion Leaders

④ Phase of Voting to Provisional Agreement Alternatives by Stakeholders

⑤ Arrangements Phase after Broadcasting
(1) The results of the consensus formation are linked to specific measures.

(2) The specialist or facilitator analyzes the Social-MRC application process and organizes the expertise for use in a future application.

(3) In cases in which a deadline is reached without a consensus having been formed, the sponsor plans the next conference.
Small Scale Trial Application

Prototype program of Social-MRC was applied to small scale trial issue.

(1) Applied Social-MRC
   MRC-Studio: Conventional MRC
   MRC-Plaza: Developed Prototype Program

(2) Applied Issue
   Information Filtering to Protect Children
   In Japan, the law for Information Filtering to Protect Children was established in 2008, and it is to be made a review three years later.
"The regulation is an infringement of the freedom of expression and of the children right to know. It should be weakened."

"The regulation is useful to protect children. It should be strengthened."
Players in Trial Application(1)

Two Opinion Leaders:
First Person
   Role Player of a Chair of PTA from Regulation agreeable group (Student of Master Course)

Second Person
   Role Player of Free Journalist from Regulation opposition group (Professor)
Players in Trial Application(2)

Ordinary Stakeholders (7 persons):

Professors and Students engaged in the research of Security

(Watching Discussion of Opinion Leaders with Ustream, Writing opinions with Twitter, Selecting preferable opinion leaders)
Staff for Trial Application

Facilitator (1 person): Student of Master Course
(Support of consensus formation)

Director (1 person): Student of Master Course
(Operation of MRC-Plaza)

Video Cameraman (1 person): Student of Bachelor Course
(Photography of the meeting)

Specialist of MRC (1 person): Student of Bachelor Course
(Operation of MRC-Studio)
Objective function

Min \{ \text{Risk for children} (\text{Yen}) + \text{Total cost for implement measures} (\text{Yen}) \}

Risk for children =
The probability that the damage occurs to a child by harmful information of the Internet \(X\)
Size of the damage at the time of the occurrence
Stakeholders and Constraints

(1) (For Children and Parents) The expected number of children to be damaged

(2) The convenience burden degree
   (For Parents) Trouble of the judgment whether or not they hang filtering to the mobile telephone of the child

(For WEB site operator) Trouble to take the young people cannot watch harmful information measures
Result of Small Trial Application (1)

It was not results against our expectation.

(a) The ordinary stakeholders were able to watch the discussion of opinion Leaders and the output of MRC-Studio.

(b) They were able to send their opinions to facilitator with Twitter and to select the answer of questions.

(c) It was possible to obtain the consensus among two opinion leaders and many stakeholders.

However,
However, the number of stakeholders was very limited. We will perform the experiments under more than several thousands stakeholders after improving the Social MRC program.

Ryoichi Sasaki, et al.,” Proposal for a Social-MRC Social Consensus Formation Support System Concerning IT Risk Countermeasures” IMS2010 (to be held in Korea in Nov. 2010)
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Conclusion (1)

(1) We developed Multiple Risk Communicator MRC, and applied it to personal information leakage problems, illegal copying problems etc.

(2) Judging from these application results, we can say that MRC is useful for obtaining consensus in cases in which the number of people necessary for consensus formation is low, such as forming a consensus within an organization.

(3) However, it was impossible to apply to the problem of which number of stakeholders is more than several thousands such as social consensus formation.
(4) We proposed the Social MRC for supporting the social consensus formation.

(5) The primitive prototype program of Social MRC was developed and applied the information filtering issue to protect children.

(6) We will perform the experiments under more than several thousands stakeholders after improving the Social MRC program.
Thank you for your attention

Any questions?