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Title	ICARE : Real time chemical detection for safety and security : Real time chemical detection
Sub Title	
Author	アトナープ株式会社(Atonarp Inc) 春山, 真一郎(Haruyama, Shinichiro)
Publisher	慶應義塾大学大学院システムデザイン・マネジメント研究科
Publication year	2010
Jtitle	Active learning project sequence report Vol.2010, (2010.) ,p.423- 451
JaLC DOI	
Abstract	Health is a topic of great interest and many people take care of themselves by performing various exercises or by eating healthy foods. However, despite such efforts, they still have chances of getting diseases, which is because of a lack of precise understanding about their own health condition or as to how to deal with it due to the limitations of existing devices in reliability, availability and simplicity. When considering the daily care of individuals' health, an accurate, affordable and easy way of monitoring health should be offered to individuals. Therefore, we propose a new health monitoring system for smartphones based on the technique of chemical analysis of the breath, which is highly reliable, inexpensive and small enough to be portable. Chemical analysis of the breath has attracted much attention as an effective approach to investigating the health condition and a number of promising results have indicated its promising potential of detecting diseases. This is based on the fact that people with cancer, asthma and many other diseases carry trace amounts of distinctive biomarkers in their breath. Precise detection of these markers thus allows you to know your health condition or diagnose such diseases in their early stages noninvasively and before symptoms arise. To realize the concept, we employed Real Time Chemical Detection (RTCD) technology, which is a real-time detection and analysis of chemical substances using a highly sensitive, inexpensive and small olfaction processor, and developed a health monitoring system for smartphones named ICARE. We have selected a smartphone as a part of the system because talking on the phone is a part of our daily life, where you are breathing out, and the market of smartphones is growing rapidly, which will eventually expand market share of the system. This system can be used almost anytime, anywhere for anyone as long as it can detect chemical substances in the breath and helps you maintain your health or notice diseases in their early stages readily, which will lead to an increase in your quality of life (QOL) and a decrease in the cost of treatment because you may not need to take as much medicine as the patients with late-stage diseases.
Notes	Student final reports Group 11
Genre	Research Paper
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=KO40002003-00002010-0423

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Group 11

Group 11's Theme Proposed by Atonarp Inc.

Theme 1:

ALPS "safety and security" theme title: Real Time Chemical Detection

Proposer Organization's Name: Atonarp Inc.
Supporter Name and contact info: Tomoyoshi SATO / tomosat@atonarp.com
Prakash Murthy / prakash.murhty@atonarp.com

Abstract of your project theme :
<Back Ground>
In the past years Free Economics shows us rapidly growing like Google or YouTube. We're seeking the next Google model and new business model to bring much more impact.
Over today's Internet high speed searching engine is working pretty well but it expects text base input. When you bring unknown material to there, it cannot bring us any information at all without some text base inputs. Some missing link is existing over today's Internet. We're providing new method of Real Time Chemical Detection (RTCD) into new society at much compact and very low cost that can be implemented on iPhone or smartphone. It will be common for lots of apps and devices.

1) How can Real Time Chemical Detection (RTCD) change the current world into much more secure world?
2) By using RTCD new business over Internet can be possible like breath monitoring that can identify deceases or health condition, location awareness security system or new advertisement system to introduce wine, perfume or the other products. How about the next killer apps to overcome Google?
3) Once RTCD becomes common, what will be the next issues to realize much more secure world? What kind of apps can be more important or possible as the next killer apps on iPhone or smart-phone solve and what are still remaining issues as the next problems to realize rapidly growing?
4) The best case scenario: The RTCD are accepted for the future society. Most important point and strategy?
5) The worst case scenario: The RTCD are rejected for the future society. What kind of reason can be fatal or difficulty to make big success?
6) What is the most cost effective solution for secure world and why the next technology is needed to make it?

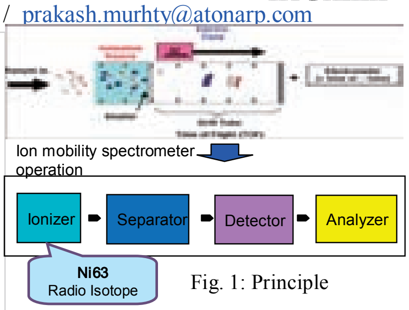

Fig. 1: Principle

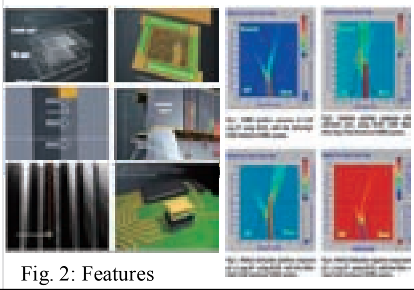

Fig. 2: Features

ALPS Final Report 2010

Group 11

PROJECT TITLE:
"ICARE - REAL TIME CHEMICAL DETECTION FOR SAFETY AND SECURITY -"

Theme:
"Real Time Chemical Detection"

Proposer Organization: Atonarp Inc

Proposer Organization's Supporter: Tomoyoshi Sato

Keio Mentor: Shinichiro Haruyama

Members:
MORIMOTO, SHUSUKE
ISHIGURO, AKI
NAITO, YUKA
SATO, MAKOTO
NAGASHIMA, SO

Graduate School of System Design and Management
Keio University

ALPS Group 11

ICARE - REAL TIME CHEMICAL DETECTION FOR SAFETY AND SECURITY -

Shusuke Morimoto
Graduate School of System Design and Management, Keio University

So Nagashima
Global COE Research Assistant; Graduate School of Science and Technology, Keio University

Aki Ishiguro
Graduate School of System Design and Management, Keio University

Makoto Sato
Graduate School of System Design and Management, Keio University

Yuka Naito
Graduate School of System Design and Management, Keio University

1. EXECUTIVE SUMMARY

Health is a topic of great interest and many people take care of themselves by performing various exercises or by eating healthy foods. However, despite such efforts, they still have chances of getting diseases, which is because of a lack of precise understanding about their own health condition or as to how to deal with it due to the limitations of existing devices in reliability, availability and simplicity. When considering the daily care of individuals' health, an accurate, affordable and easy way of monitoring health should be offered to individuals. Therefore, we propose a new health monitoring system for smartphones based on the technique of chemical analysis of the breath, which is highly reliable, inexpensive and small enough to be portable.

Chemical analysis of the breath has attracted much attention as an effective approach to investigating the health condition and a number of promising results have indicated its promising potential of detecting diseases. This is based on the fact that people with cancer, asthma and many other diseases carry trace amounts of distinctive biomarkers in their breath. Precise detection of these markers thus allows you to know your health condition or diagnose such diseases in their early stages noninvasively and before symptoms arise.

To realize the concept, we employed Real Time Chemical Detection (RTCD) technology, which is a real-time detection and analysis of chemical substances using a highly sensitive, inexpensive and small olfaction processor, and developed a health monitoring system for smartphones named ICARE. We have selected a smartphone as a part of the system because talking on the phone is a part of our daily life, where you are breathing out, and the market of smartphones is growing rapidly, which will eventually expand market share of the system.

This system can be used almost anytime, anywhere for anyone as long as it can detect chemical substances in the breath and helps you maintain your health or notice diseases in their early stages readily, which will lead to an increase in your quality of life (QOL) and a decrease in the cost of treatment because you may not need to take as much medicine as the patients with late-stage diseases.

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3. PROBLEM STATEMENT

Nowadays people are health-conscious and they take good care of themselves by performing many different exercises or by eating healthy foods. However, in spite of such efforts, they still have chances of getting diseases. This is because of a lack of precise understanding about their own health condition or as to how to deal with it, which is probably due to the limitations of existing technologies or products. For example, a thermometer has been widely used because of its simplicity and availability and thanks to this easy-to use device, you can measure the temperature easily; however, it cannot help you understand what your health condition actually is or what kind of diseases you are suffering from because it cannot distinguish among the possible causes.

To get precise information on your health condition, chemical analysis of your breath has attracted much attention and a number of promising results have been reported on its effectiveness [1] [2] [3] [4] [5]. This is because people with cancer, asthma, and many other diseases carry trace amounts of distinctive biomarkers in their breath. Therefore, detecting these markers could allow you to diagnose such diseases in their early stages noninvasively and before symptoms arise.

One of the good instruments for such chemical analysis is Gas Chromatograph Mass Spectrometer (GC/MS). GC/MS combines the techniques of gas chromatography (GC) and mass spectroscopy (MS). GC separates the components of a mixture and MS characterizes each of the components. The advantage of this instrument is its high sensitivity. It analyzes chemical substances at ppb level. By using this instrument, we can identify and quantify the amount of target chemicals in the mixture precisely, which will greatly contribute to an accurate diagnosis. However, this precise instrument is not appropriate for individual use like a thermometer because of the time for detection, price and size. Therefore, new technologies or products are highly desired that can combine the advantages of the existing technologies or products described, that is to say, high reliability, time-saving, reasonable price and portability.

In this project, we thus propose a new health monitoring system named ICARE, which meets the aforementioned needs. ICARE is designed for your own smartphones, which detects and analyzes the chemical substances in your breath in real time. To operate this system, basically you need four items: smartphone, detecting device attached to the phone, application and your breath. This system is based on Real Time Chemical Detection (RTCD) technology, which is our proposer's key technology. RTCD is a real-time detection and analysis of chemical substances using a highly sensitive and small olfaction processor and by applying this RTCD technology to chemical analysis of the breath, we can develop a highly reliable, time-saving, inexpensive and portable health monitoring system. Since talking on the phone is a part of our everyday life, where you're breathing out, and the market of smartphones is growing rapidly, we have selected a smartphone as a part of the ICARE system. What is good about ICARE is that it can be used almost anytime, anywhere for anyone as long as it can detect chemical substances in the breath. Therefore, this system helps you maintain your health or notice diseases in their early stages readily.

4. ANALYSIS AND DISCUSSION OF ALPS METHODS

We have used many tools and methods we learned from ALPS. We had a meeting at least every week, and discuss the methods or direction that we will take. The important thing is that we basically worked on all the assignments or presentations by all members in the team since if only one of us addressed the task or problem, we never get the best answer and it may kill all the precious ideas. Sometimes it takes more time, but we believe that we came up with a better solution which none of us could not have generated. Therefore, as it is shown by our Road Map, we changed our concept several times throughout this project.

Although all tools and methods were new and useful to us, we agreed there are tools which had strong impact on our project. The top-value tool for us was Brainstorming. This tool is a most simple but has a very important role which may affect the entire output of our project. By doing Brainstorming, we always have some kinds of Aha, Oops, or Eurika at the discussion. This tool can bring out all the possibilities of the project.

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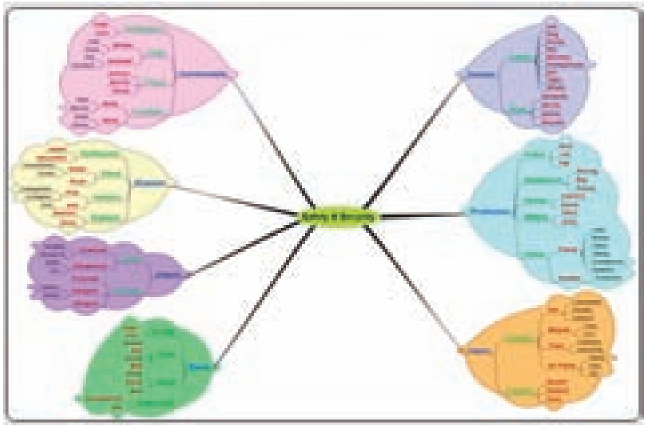
Another top-ranked tool was Prototyping. We tried to create some prototypes at each ALPS lectures because by creating something tangible, we are able to see or touch our concept physically, try it out to someone who is outside of our team, or evaluate our achievement as from a third party. We have done a short skit, paper prototyping, video prototyping, prototype of hardware and software, and three minutes commercial video, and so forth. We revised our prototype as our concept changed. The details of our result for each tool will follow. Now, we will demonstrate the details of what we have done for analysis and discussion of ALPS methods.

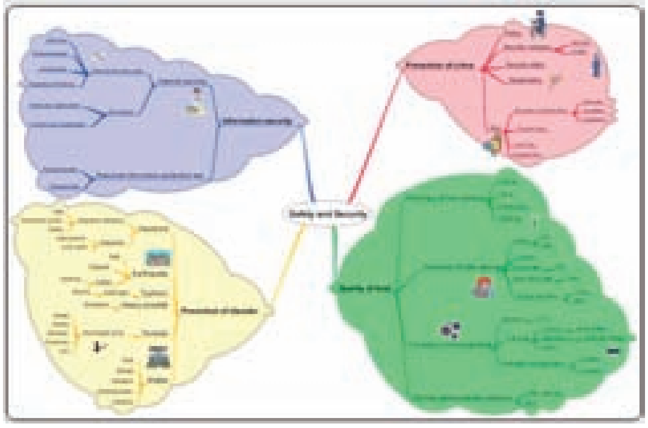
Mind Map

We used this tool as our first tool in ALPS to consider and see what we have in mind. The central theme of the Mind Map was Safety and Security which is the theme of ALPS in this year. We are not sure about if it was useful or not for our system since we did not have specified theme from sponsors yet at this stage. However, in a sense of the understanding for the theme of ALPS, it was fairly useful and we may also use this tool in the future outside of ALPS to think about some new theme or problem at the first time.



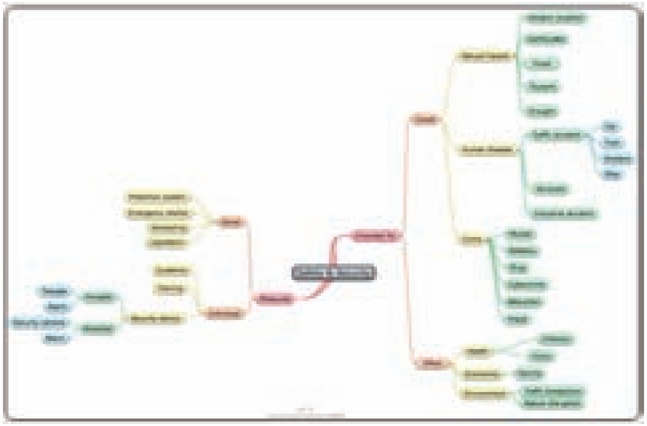
(a) Mind Map from Shusuke Morimoto.

(b) Mind Map from Aki Ishiguro.



(c) Mind Map from Yuka Naito.

(d) Mind Map from Makoto Sato.



(e) Mind Map from So Nagashima.

Figure 1: Mind Map from each member

Project Priority Matrix

We did not use this tool in the project because the priority of each project task could be established thanks to the lectures and assignments, which we have worked on in chronological order.

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Scenario Graph

We have made Scenario Graph three times.

- The first time: We used Brainstorming as our input for Scenario Graph.
- The second time: We had interview with ATONARP and made some changes in our scenario.
- The third time: We used information from feedback from our presentations and the result of Pugh Concept Selection.

We chose key scenarios as follows;

- The first time: We chose Hospital for "Where", Treating for "What", Doctors for "Who", Daytime for "When", and Painful for "User State".
- The second time: "Where" was School, "What" was Talking, "Who" was Students, "When" was Free Time, and "User State" was Sad.
- The third time: We finally reached certain point for our scenario. House for "Where", Talking for "What", Couples for "Who", Free Time for "When", and Tired for "User State".

Figure 2 shows the result of our Scenario graph with selection of key scenario. We decided our key scenario by reflecting the feedbacks and reached the conclusion that the advantage of our system is that it can be used almost anytime, anywhere for anyone.

The problem was the feasibility of our system. First we considered the system which can detect or analyze the mental condition of people. However as our research progresses, we found that it might be difficult to know our mind state with chemical detection. There are some relations between chemical substances and feelings of people, but it will be unreliable since peoples' mind is too complicated to detect and hard to express sometimes. Also, considering the theme of ALPS "Safety and Security", we finally reached the system which is for detection of health condition.

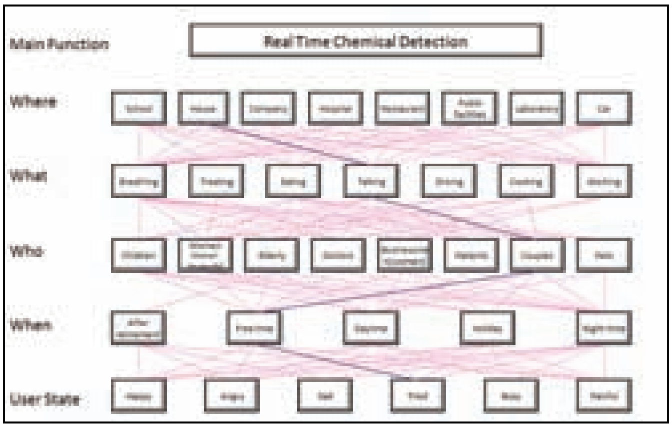

Figure 2: Selection of key scenario from Scenario Graph.

Customer Value Chain Analysis

Before interviewing CEO of ATONARP Inc., we made a CVCA based on the hypothesis that we came up with from brainstorming. After the interview, however, it turned out that the CVCA was different from what CEO had in mind and expected us. Therefore, we had to revise it based on the information obtained from the interview and our brainstorming after the interview.

Figure 3 shows the final CVCA, in which we listed seven stakeholders i.e. User, ATONARP, Distributer, Adviser, Device Supplier, Database Developer and Application Constructor. Thanks to Scenario Graph, we came to the conclusion that the unique technology of ATONARP Inc. could not work by itself and required other supporting systems such as database, device and application. In addition, we thought that distributor was necessary to spread the use of the technology.

We utilized OPM (Object Process Modeling) as the next tool for analyzing the relationship among the objects in more detail.

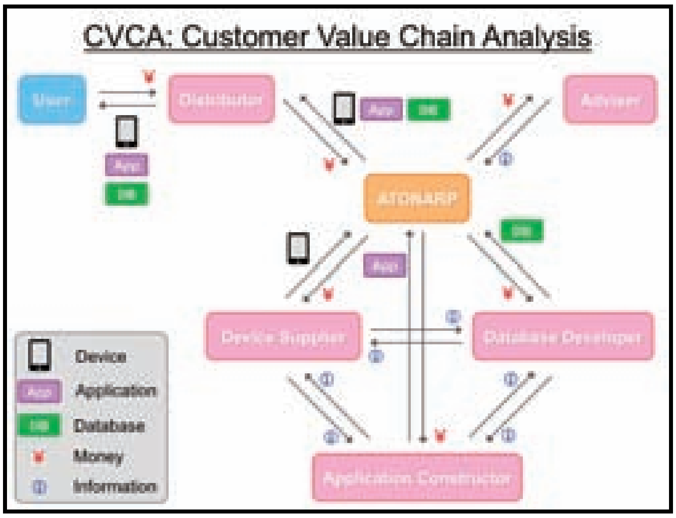

Figure 3: Customer Value Chain Analysis.

Interview, Observation

We established a list of yes-no and open-ended questions for the interview using Scenario Graph, CVCA and Brainstorming.

Based on the CVCA, we interviewed five stakeholders: ATONARP Inc., Application Constructor, Database Developer, Adviser and User. Since all the stakeholders except User are expert in their fields, we got a lot of meaningful information. As for User, thanks to the open-ended questions, they gave us interesting suggestions or opinions as to how to make our system popular.

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We utilized the valuable information obtained from the interview with the stakeholders for the revision of CVCA and OPM. Through the interview, we realized that to ask open-ended questions was useful for getting valuable information, which we had not had on our mind.

Following is a part of the results and feedbacks from the ALPS workshop. We continued observation and interviews throughout a year. The list below is profiles of the person who answered the interview (Sex, Age, and Job). Figure 4 shows the result.

- No1. Male, 62, Office worker
- No2. Male, 42, Office worker (Management)
- No3. Male, 32, Office worker
- No4. Male, 29, Office worker
- No5. Female, 26, Office worker
- No6. Female, 27, Office worker
- No7. Female, 28, Office worker
- No8. Female, 29, Office worker

We used this result to consider the best solution, and figure out what is really needed by customers.

Many people found our system useful, but the problem was a cost of “RTCD”. If cost of “RTCD” is not reasonable, the number of users who wish to use will increase.

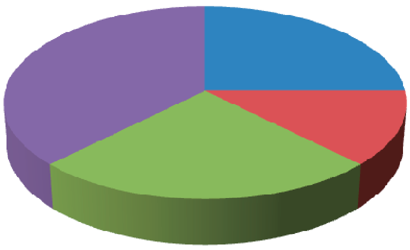

Figure 4: Tolerance level of cost.

Scenario Prototyping Rapidly

We did a short skit, made a video and a simple application as Prototyping Rapidly. Also, for concept displaying, we created a paper prototype and the final prototype as well as three minutes commercial and the poster for our system.

Feedbacks from these prototypes were very useful for creating our system. With Scenario Prototyping Rapidly, we are able to see or confirm the acceptance level of our concept and scenario from audiences or other people from a point of view of the usability and operability. Figure 5 shows the short skit at the second workshop, and Figure 6 is simple application prototype. The results of other prototyping are shown in Appendix.

Figure 5: Short skit at the second ALPS workshop.

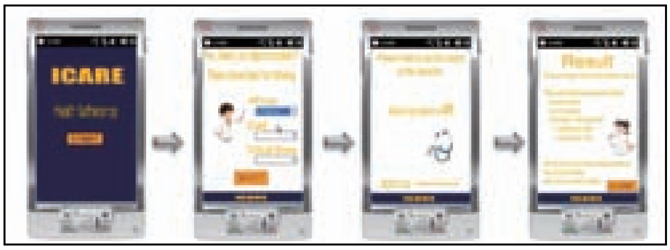

Figure 6: Prototype of simple application.

Value Graph

Figure 7 shows the Expanded Value Graph. From this analysis, we found that OLP (Olfaction Processor) played a great role in improving the characteristics of our product. OLP was the key technology of our proposer and was a kind of ready-made integrated device consisting of various components. In order to meet the demand of customers, understanding of the relationship between Voice of Customer and each component of the OLP might be of help.

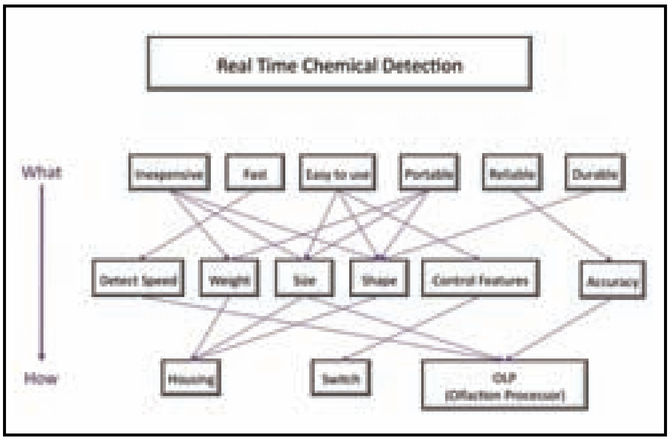

Figure 7: Expanded Value Graph.

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Quality Function Deployment I & II

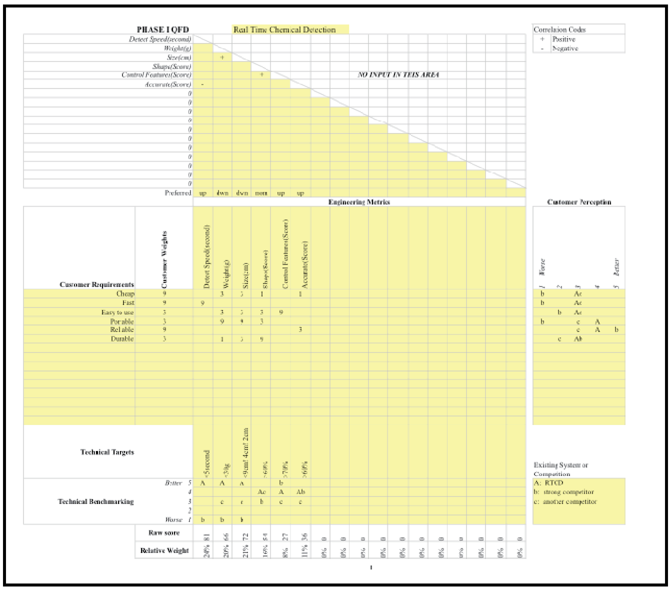
To perform Quality Function Deployment (QFD), we used the items listed below.

- Customer Requirements (CR)
- Engineering Metrics (EM)
- Physical Structures (Component)
- Customer Weights

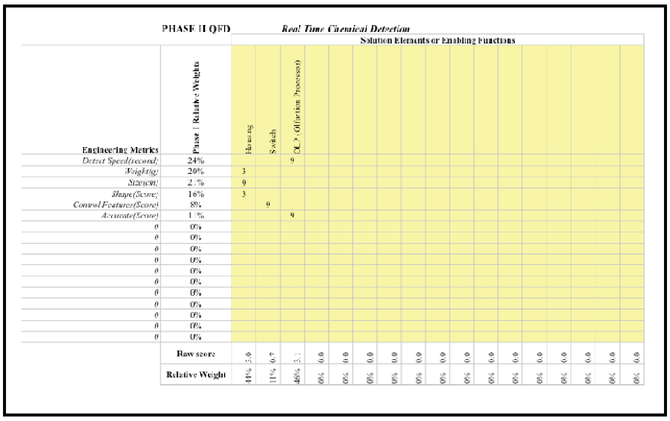
Here it should be noted that CR and EM were identified and defined from Voice of Customers (VOC), respectively. The Customer Weights were estimated based on CR.

Figure 8 shows the QFD I and II. From the result that Detect Speed had the highest relative weights of 24% among EM, it can safely be said that the customer value is most attributed to Detect Speed. From QFD II, it was found that the customer value would reside in Housing and OLP (Olfaction Processor).

After QFD analysis, we utilized Cost-Worth Analysis as the next tool for investigating which component should be invested to enhance the customer value.



(a) Quality Function Deployment I.



(b) Quality Function Deployment II.

Figure 8: Quality Function Deployment I & II

Complexity / Cost Worth Analysis

To perform Cost-Worth Analysis, we used the items listed below.

- QFDI
- QFDII
- Cost estimation

Figure 9 shows the result of Cost-Worth Analysis. Since Housing was located in the area of "low cost" and "high worth", this component should be invested and enhanced to satisfy the customer requirements. OLP (Olfaction Processor) was the key technology of our proposer and was a kind of ready-made integrated device consisting of various components. It might have been better to conduct QFD I, II and Cost-Worth Analysis even for the OLP for more detailed analysis.

We utilized this result for designing and manufacturing products that fulfill customers' desires.

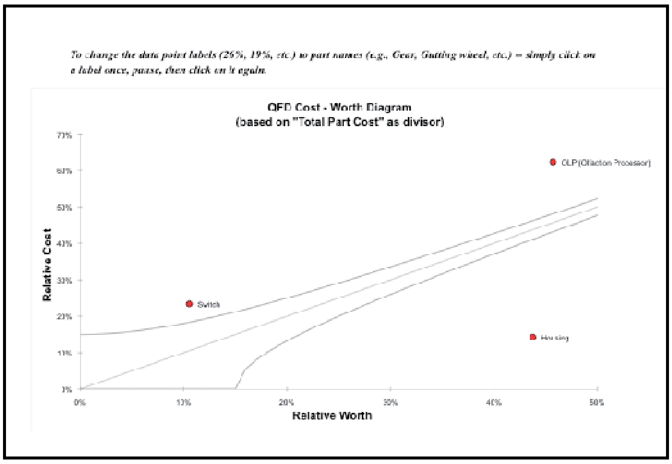


Figure 9: Cost-Worth Analysis.

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Function-Structure Map, Failure Modes & Effects Analysis

Figure 10 shows the results of Function-Structure Map and Figure 11 shows that of Failure Modes and Effects Analysis (FMEA). By using Function-Structure Map, we can break down the structure of our system and understand the connection between the function and structure. FMEA is a technique used to identify potential failure modes in a system. Our system consists of three components and requires six processes for the operation. We considered power source, display, access to database, on-off switch, and “RTCD” device itself.

From FMEA, we found that as the system became complicated, the frequency of failure modes gets higher. We also found that although FMEA has a bottom-up approach and analyzes possible failures, it may sometimes miss fundamental failures. In order to carry out more precise analysis, it is better to combine the FMEA with "FTA", which has a top-down approach.

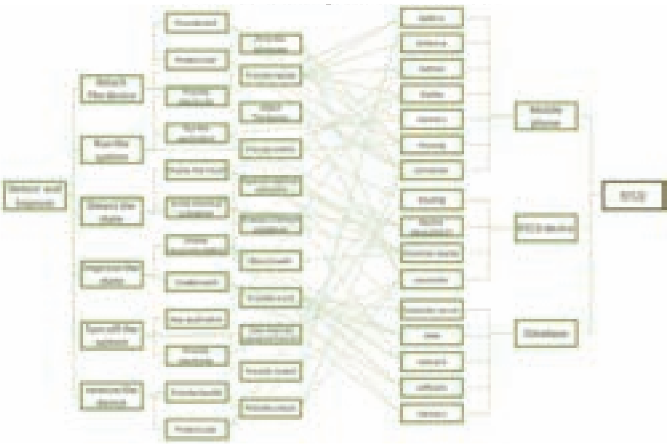
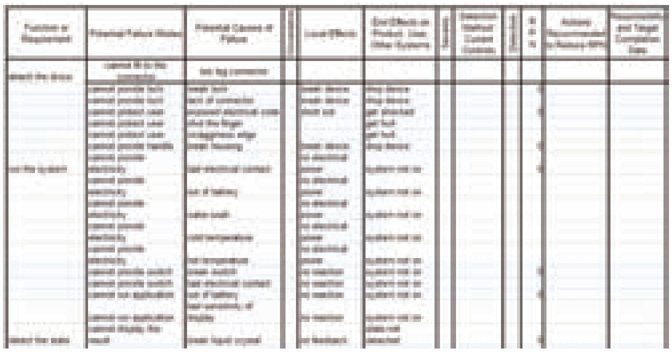


Figure 10: Function-Structure Map.



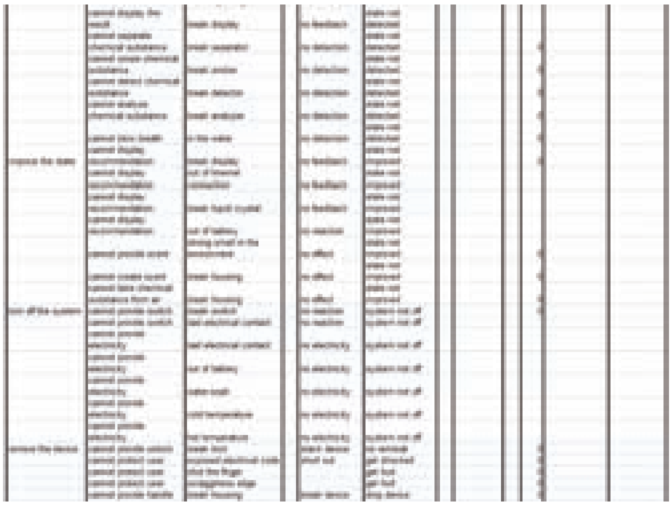


Figure 11: Failure Modes and Effects Analysis.

Design for Variety

We did not use Design for Variety (DFV). We thought DFV seeks a tool that enables product managers to estimate the cost of introducing variety into their product line. This will help them to maximize market coverage while maintaining required profit margins. Variety incurs many indirect costs that are not always well understood or are difficult to capture. These costs are often not considered by people making the decision about introducing variety. DFV model attempts to capture these indirect costs through the measurement of three indices: commonality, differentiation point, and set-up cost. We used Cost Worth Analysis, Cost breakdown, and our unique format. This is the reason why we chose not to use this tool.

Environmental Complexity/Recyclability

A life cycle is designed from a viewpoint of recycling. First, the product design from a viewpoint of recycling will be carried out. Then, specifically, the examination which improves the recycling performance seen from the decomposition performance will be carried out. It supports that a designer decreases a product retirement cost and a chip through suitable selection of design modularity, material selection, and a decomposition strategy. This method incorporates change of the process technical capability to reuse paying attention to the dismantling process relevant to many product groups and generations.

Serviceability

We did not use the specific tool called “Serviceability”. We thought Serviceability expresses easiness of fault recovery and maintenance. It tends to express MTTR (Mean Time To Repair) from fault recovery to restoration. The reason why we did not need this concept is that OLP4SI (OLP4SI is a chip to detect and analyze the chemical substances.) was not available yet.

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Quality Scorecarding

The objective of Quality Scorecarding is to measure the performance of our system or service that we provide. The basic elements are Project Objective, Objective Measures, Control Factors, Noise Factors, and Transfer Function. We considered following elements according to our discussion and analysis from cost and revenue.

・Project Objective (Biggest Y)
Our project objective is to come up with new business model and spread the real time chemical detection to the world in a short term (two to three years).

・Objective Measures (Big Ys to Small y's)
We set our objective measures as Market Share, Publicity or Name recognition, Profit (The number of unit sales, Sales profit).

・Control Factors (X's)
1. Controllable factors:
The things that we can control are Price, Production volume per year, Accuracy or quality, Design of the shape, Object to detect, and Detection method (such as using olfaction processor or beagle).

2. Things we can level:
We can level Technology of competitive companies, New virus of disease, Unusual weather, and Disaster.

・Noise Factors (V's)
The noise factors for our system are: Change in market trend, Technology change, Condition of the operation.

・Transfer Function (Biggest Y = f(x))
Our transfer function follows: Making ICARE (the portable real time health monitoring system which uses RTCD technology) compatible not only to mobile device but also to other kinds of devices.

Net Present Value Analysis

We did not use Net Present Value. It is difficult for us to consider Net Present Value since our scenario was not stable at that time. We have changed our scenario three times. Instead of Net Present Value Analysis, we considered Cost Analysis using our unique format.

Design Structure Matrix

Figure 12 shows the task-based DSM. To create it, we listed what we had learned through ALPS workshops and arranged the items in chronological order before filling in the worksheet.

After careful consideration, we found that the order of the items could not be rearranged and the task sequence was thus the same as what we created at the beginning. This was probably because each item was ordered chronologically at the beginning.

Although we could not find DSM useful then, we believe that DSM is a useful tool for analyzing and improving design process. Therefore, we will use it next time we are assigned to a new project or we will create another type of DSM such as object-based DSM.

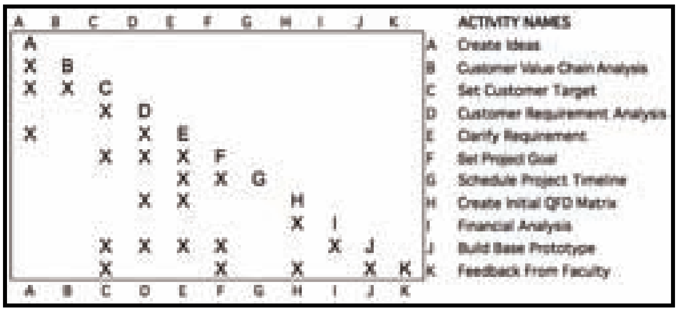

Figure 12: Design Structure Matrix.

Design of Experiment

We conducted experiments with our prototypes by both simulation and physical experiment. We showed the video and short skits so that we can simulate the actual simulation and get feedback from audiences to see if it will work or not. Also, shown as Figure 13, we created actual sample prototype of the ICARE which can be actually attached to several kinds of smartphones so that we can see physically how it will work or not.

Figure 13: Physical experiment with application.

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KJ Method

We used KJ Method (Affinitizing) to categorize themes which we generated by using Voice of X (VoX), and Figure 14 shows the result. We came up with five candidate project themes: Smart, Public, Environment, Communication, and Health. Next step is to select the best theme among them.

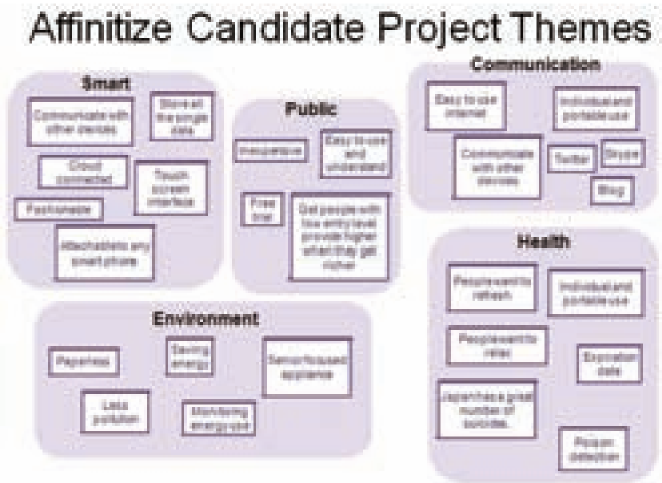

Figure 14: KJ Method.

Pugh Concept Selection

We used Pugh Concept Selection to measure advantages and disadvantages of each theme. Our criteria for selection are Growth potential, Core Competence, Market Size, Need, Management, and Competition.

Figure 15 shows the result of Pugh Concept Selection. We found that Pugh Concept Selection highly depends on the criteria since it is based on those criteria to calculate weight and select one theme from them. We chose those six criteria according to the requirement from our sponsor, ATONARP. The initial requirement or objective was to spread RTCD throughout the world and make it popular in a short term so that they will get a rapid growth. Therefore, we set our first and the most important criteria as Growth potential. Core competence and Market size are also fairly important since it will affect the rapid growth in a point of view of market share. Other criteria are user needs, management aspect, and the competition with other different existing technologies.

Criteria	Weight	Smart	Public	Communi cation	Health	Environ ment
Growth potential	30	+	S	+	S	D
Core Competence	20	—	—	—	S	A
Market Size	20	+	+	S	+	T
Need	15	+	S	+	+	U
Management	10	+	+	+	S	M
Competition	5	—	—	—	S	

Figure 15: Pugh Concept Selection.

Once we chose one theme for DATUM, we can now compare other themes. S means the same, + means it has advantage, and - means it has disadvantage comparing to the DATUM theme.

The result shows that the health concept is most suitable for our objective compared to environment and other criteria. Therefore, we repeated our brainstorming in the case of health use of RTCD afterwards.

Object-Process Methodology

After creating Scenario Graph and CVCA, we had a meeting among CEO of ATONARP INC., mentor of our team, and team members. We got a lot of feedbacks, discussed the concept of operations for our system, and shared all the information we had. Based on what we got through our meetings and the interview, we created OPM to study and develop our system both in general and in particular.

Figure 16 shows the Level 0 OPM of our system, which indicates how our product system will relate to other outside system, object, people, or environment. We set RTCD (Real Time Chemical Detection) Adapter as a product system, and considered related object and processes, such as Detecting, Sending, Cell Phone, Chemical Substance, Application, Database, Accessing, Operating, User, and so forth. Also, we specified operator, operand, super system, consumee, and resultee. Finally, we have natural language shown as Figure 4, based on Level 0 OPM.

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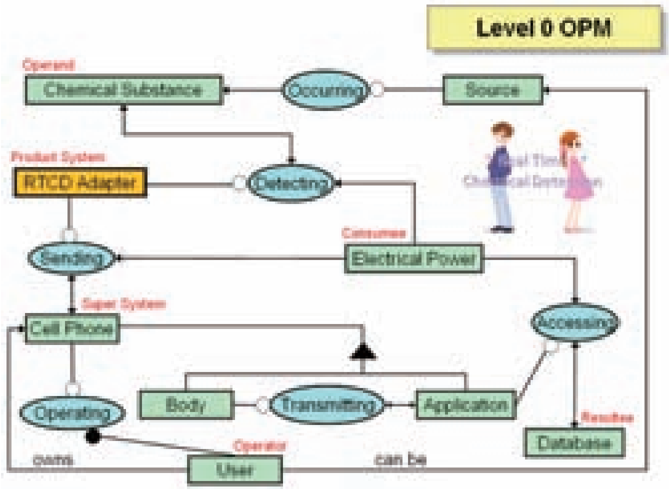


(a) OPM diagram of our system.

Cell Phone consists of Body and Application.
User owns Cell Phone.
User can be Source.
User handles Operating.
Occuring requires Source.
Occuring yields Chemical Substance.
Detecting requires RTCD Device.
Detecting affects Chemical Substance.
Detecting consumes Electrical Power.
Sending requires RTCD Device.
Sending affects Cell Phone.
Sending consumes Electrical Power.
Accessing requires Application.
Accessing affects Database.
Accessing consumes Electrical Power.
Operating requires Cell Phone.
Transmitting requires Body.
Transmitting affects Application.

(b) Statements generated from Opcat.

Figure 16: Object-Process Methodology (Level 0).

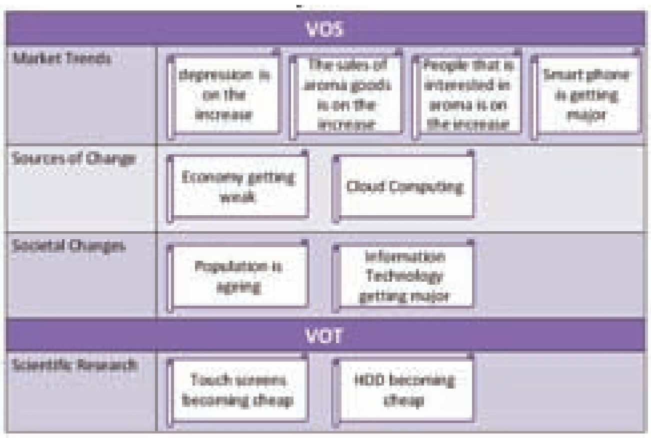
It took time to make Level 0 OPM since we had different opinion about which kind of links we use between objects and processes. Also, we discussed the boundary of each object and confused about how much we should breakdown objects as making Level 0 OPM. Another problem was choosing the word for each process that we had different ideas of words.

Voice of X

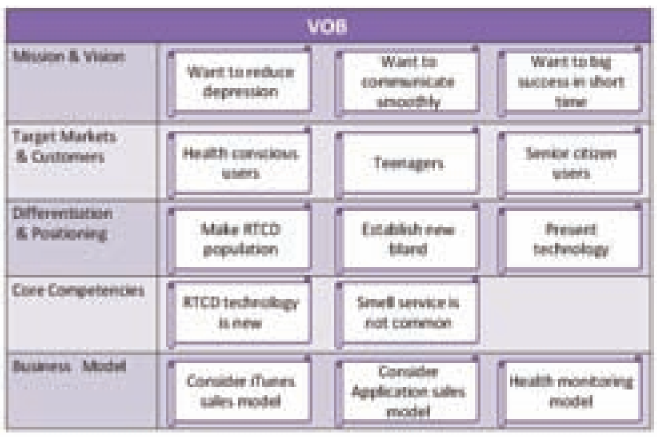
VOX stands for "Voice of X". VOX consists of three major subjects: "Voice of Society (VOS)", "Voice of Technology (VOT)" and "Voice of Business (VOB)". VOS verifies the scenario which someone developed from the aspect of society. VOT verifies the scenario from the technological aspect. VOB verifies the scenario from the business perspective. The validity of a scenario is checked through these three verifications.

- From VOS: Although the technical level is progressing steadily, the social uneasiness or distress is becoming large.
- From VOT: Information technology will continue to be an increasingly key component in our lives. It is going to be more highly efficient and widely affordable.
- From VOB: Physical or mental issues were found to be potential targets. Our group has thus decided to utilize "RTCD" as a means to prevent and prescript increasing social unrest.

We had to do some researches for the current trend and changes to understand VOS, VOT, and VOB. It was a good opportunity to find out the real needs from social, technological, and business point of view. Figure 17 shows the result of Voice of Society, Technology, and Business.



(a) Voice of Society and Technology.



(b) Voice of Business.

Figure 17: Voice of X.

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Brainstorming

Brainstorming help us to consider the situation that the RTCD system who should be a customer, when this system useful for customer, what kind of situation that RTCD most helpful for customers, etc. This process has a big impact and is an important role in our project as the first step since we will consider our direction and goal from this result.

Figure 18 shows the first result of our brainstorming. There were six categories at that time: place, user, appearance, state, time, and object. We repeated brainstorming and kept investigating new ideas or solutions. We used tiny cards for brainstorming since it is cheap and easy to move around or categorize. Writing out is very important because it makes our hazy idea into a real world and we can see and share our ideas in mind. Also, to write out our ideas, first we need to organize them in mind. It makes our concept clear and let us reach to the better solution.

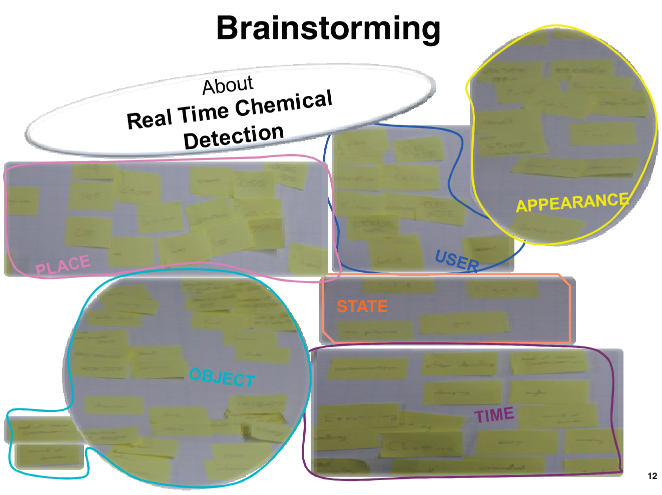
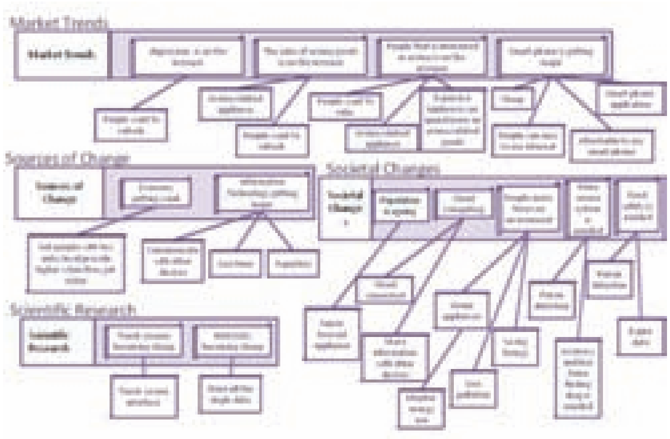


Figure 18: The first result of Brainstorming.

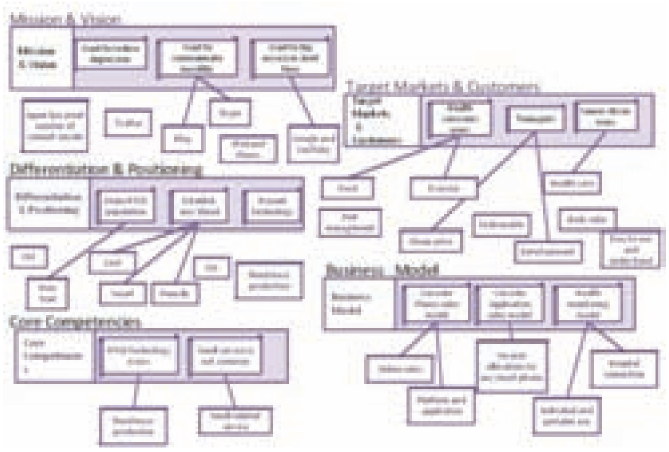
Morphological Concept Generation

After we analyzed VOX, we used morphological concept generation to expand our ideas in many fields. Through this tool, we came up with a lot of new ideas which we had not considered before. It gave us a great chance to reconsider what kind of system we should create.

Figure 19 shows the result of Morphological Concept Generation using the output from VOX. We considered concepts related to each element from market trends, sources of change, societal changes, scientific research, mission & vision, differentiation & positioning, core competencies, target markets & customers, and business model. We wrote a lot of new ideas and point of views by using this tool. Also, we found that our core competencies are RTCD technology, usability, and operability for health condition management.



(a) Morphological Concept Generation.



(b) Continued Morphological Concept Generation.

Figure 19: Morphological Concept Generation.

While we were considering Morphological Concept Generation, we realized the mistake that we did not have enough VOX. Therefore, we went back to VOX to make it exhaustive. From this point of view, we felt VOX plays an important role in finding needs and ideas.

Analysis of Cost / Revenue

We considered "Fixed cost" is uncontrollable cost, while "Variable cost" is controllable cost shown as Figure 20. "Fixed costs" are Indirect labor cost, Depressing cost, Office, Facility cost, Tax, Tooling (mold and die), Advertising cost, and Sales cost. "Variable costs" are Raw material cost, Purchased parts cost, Direct labor cost, Energy cost, and Delivery cost.

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Fixed Cost	Variable Cost
Indirect labor cost: Uncontrollable	Raw material cost: Controllable
Depressing cost: Uncontrollable	Purchased parts cost: Controllable
Office: Uncontrollable	Direct labor cost: Controllable
Facility cost: Uncontrollable	Energy cost: Controllable
Tax: Uncontrollable	Delivery cost: Controllable
Tooling (mold and die) : Uncontrollable	
Advertising cost: Uncontrollable	
Sales cost: Uncontrollable	

Figure 20: Fixed Cost and Variable Cost.

As Figure 21 shows, we divided ICARE into three parts, Application, Device, Access of Database, and we considered price, size, share and growth of market.

	Market price	Market size	Market share	Market growth
Application	500 JPY	700 billion JPY	3%	+2.6%
Device	1,000 JPY	500 billion JPY	2%	+10%
Access of Database	50 JPY/Data	25 million JPY	1%	+1%

Figure 21: Our system and the market.

Use Case

Figure 22 shows the Use Case. To develop it, we used the key scenario selected out of candidate scenarios. As you can see, there are two major use cases: individual use and mutual use. The former case is to understand your own health condition precisely using ICARE. The latter case is to know the health condition of someone who you are talking with on the phone. For example, when you are talking with your family living far away from you, you can understand whether they are in good health or not by using ICARE, by which you will probably feel relieved or know how to help them improve the condition.

Health monitoring system to help you maintain your health or notice diseases in their early stages

■ Individual Use

1. Does not feel well
2. Run ICARE attached to the smartphone
3. Blow on the sensor embedded in ICARE attachment
4. ICARE identifies the present health condition
5. ICARE gives feedback as to how to cope with the disease in seconds

■ Mutual Use

1. Talking with someone (e.g. friends, family) on the smartphone
2. ICARE attached to each smartphone automatically detects chemical molecules in each user's breath
1. ICARE identifies the present health condition of the users
2. ICARE gives feedback as to how to cope with the disease in seconds
3. The feedback is displayed on the screen of the other's smartphone

Figure 22: Use Case.

Project Charter & Milestone Chart

Project Charter is a start point that we clarify the list of team members, key stakeholders, project purpose (business needs), high-level requirements, and success criteria. Also, WBS (Work Breakdown Structure) was used to perform Milestone Chart.

- List of team members: Shusuke Morimoto, Aki Ishiguro, Yuka Naito, Makoto Sato, and So Nagashima. Our mentor is professor Haruyama, and proposer is Atonarp.

- Key stakeholders: Atonarp, User, Team Member, Mentor, Application, and Database.

- Project purpose: To create health monitoring system which detects humans' health condition anywhere and anytime to realize safe and secure world. By using RTCD technology, we are able to understand the health condition of people. In Japan, the number of elderly is increasing rapidly, so we think the business needs of our system are high especially in the future.

- High-level requirements: The required ability is to detect conditions of people. Also, this system shall be easily used by anyone with simple operation and interface. This system shall support network infrastructure to deliver the information from each smartphone.

- Success criteria: To propose new idea for safety and security using RTCD technology. Our goal is to make a health monitoring system named ICARE and spread the system to all around the world.

We created Work Breakdown Structure (WBS) shown as Figure 23 at early stage of ALPS so that the task to complete our mission will be clear and understandable.

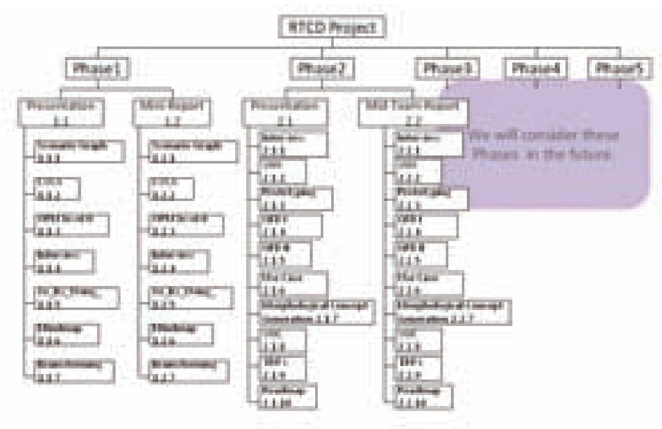

Figure 23: Work Breakdown Structure.

Figure 24 shows the result of Milestone Chart. We made this chart at the same point as WBS. To achieve the goal, we

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needed to make the work and schedule for our project. If we are not sure about detailed task at that point, it is still useful and important to consider the tasks and our schedule or plan for whole project to avoid or find unknown risks in the future.

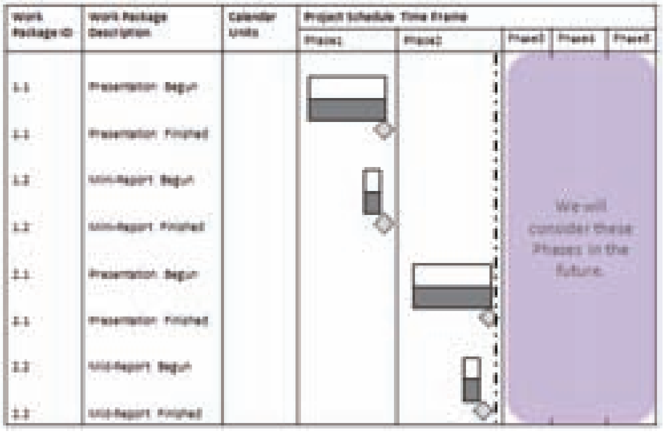

Figure 24: Milestone Chart.

To_By_Using

ICARE can be used almost anytime, anywhere, for anyone as long as it can detect chemical substances in the breath. And helps you maintain your health or notice diseases in their early stages. Figure 25 shows our To_By_Using statement.

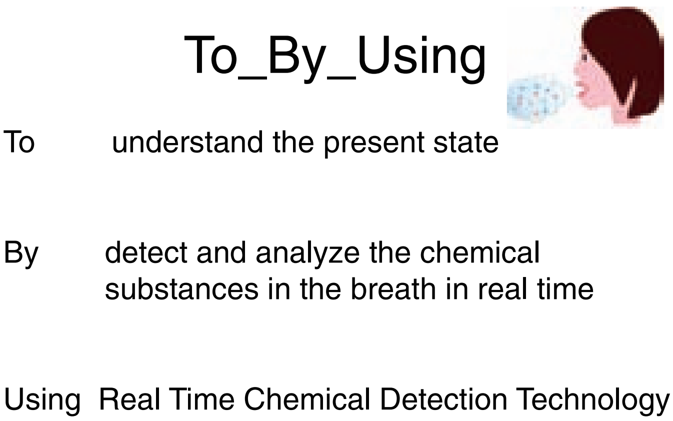

Figure 25: To_By_Using.

Robust Conceptual Design

The purpose of Robust Conceptual Design is to list possible changes and variations of the system as many as possible, and consider how to deal with all of them so that the system will be robust. Before attacking Robust Conceptual Design, we discussed the concept and direction of our team, and worked on Failure Modes and Effects Analysis (FMEA), Design Structure Matrix (DSM), and Prototyping.

Figure 26 shows the result of Robust Conceptual Design. We used brainstorming for listing sources of variation. The matrix below shows the variations, how system will address, dimensions of variation, and potential architectural impact of our system.

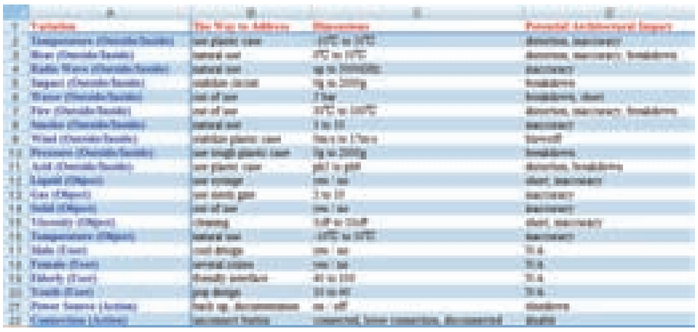

Figure 26: Robust Conceptual Design.

We figured out that the interface of our system is important because of the variation in age and sex of our potential users. Also, the documentation, backup plan for data, and connector to smartphones is necessary to create our prototype.

5. DESIGN RECOMMENDATION

Detailed explanation of our final solution

The name of our final system is ICARE. ICARE is a new health monitoring system for smartphone (users' mobile device). It detects and analyzes the chemical substances in your breath in real time and helps you maintain your health or notice diseases in their early stages. Also, user can send the result of analysis to someone who user wants to inform.

Product specification or process specification

Product specification:

Our product is real time chemical detector and application.

・Real time chemical detector
  Weight: Less than 20g
  Size: Less than 90mm×40mm×20mm
・Material
  Punched Metal
  Compound Metal
・Application
  Response time: Less than 4seconds
・Material
  No material for application because it is unsubstantial.

Process specification:

1. Real time chemical detector detects the chemical substances in users' breath.
2. The application collates the chemical substances with data of the database.
3. The application analyzes the chemical substances and displays the result.

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4. (The application sends the result to someone who you want to inform it.)

Implementation Plan

ICARE is consists of RTCD that is the ATONARP's technology, database, mobile device and application. And, we assumed seven stakeholders i.e. User, ATONARP, Distributer, Adviser, Device Supplier, Database Developer and Application Developer.

User buys the real time chemical detector from Device Supplier and installs application into users' mobile device through the mobile network. (We assume that user already have a mobile device such as smartphone.)

ATONARP has the RTCD technology and manages Database developer and Application Developer. Device Supplier makes real time chemical detector containing the sensor of ATONARP's technology and sells the detector. Database developer makes chemical database. Application developer makes ICARE application.

Life-Cycle Plan

Life-cycle plan of our system is classified into 2 types as follows;

- running in cycles
- maintaining the abilities of disposal, reuse, recycle

Database and Application are running in cycles because they are unsubstantial. The real time chemical detector is maintaining the abilities of disposal reuse and recycle because it consists of some materials that become too old for use.

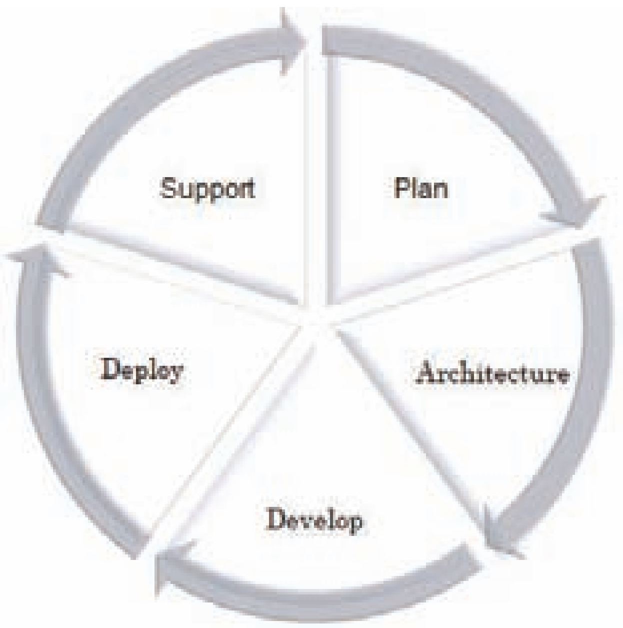

Figure 27: Life-Cycle Plan (Database and Application).

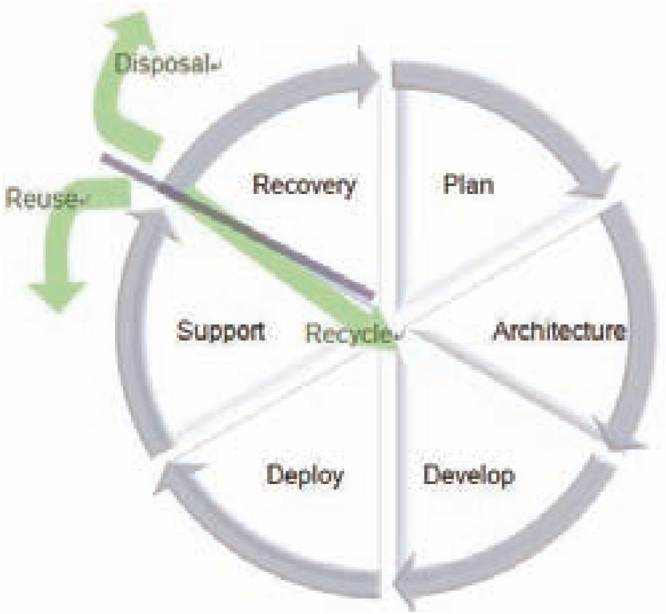

Figure 28: Life-Cycle Plan (Real Time Chemical Detector).

Detailed descriptions of the functions, structure and operation of our system

Functions:

- Detecting and analyzing the chemical substances in users' breath
- Displaying the result of the users' condition
- Sending the result to someone

User necessaries:

- Mobile device (Smartphone)
  Mobile device is equipped application, and attached real time chemical detector.
- Application
  Application is important part of this system. Application displays the result of the real time chemical detector's analysis. In addition it sends the result to someone while talking on the videophone.
- Real time chemical detector
  Real time chemical detector is detecting device attached to user's phone. It detects and analyzes the chemical substances in your breath in real time.

User Operation:

1. User Start the application on the mobile device.
2. User blows out her breath on Real time chemical detector.
3. User confirms the result of her condition.
4. If user wants, user sends the result to someone using mail or phone.

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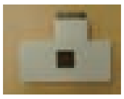
6. COMPETITIVE ANALYSIS

Competitive analysis, as the name implies, is an exploration of the project in a given industry sector or market niche that are competing with your project's products or services for market share. The analysis may be an in-depth exploration of the top five competitors, or a larger number of competitors could be examined (typically with less depth in the analysis). In most cases, the client will have identified the target competitors for you.

The primary benefits of any competitive analysis are a better understanding of what your competitors are doing, what they are offering to customers, and how to maintain your competitive advantage. The findings from this analysis are likely to factor strongly into your own company's strategic planning. However, this is definitely not the only take-away from the process of analyzing competitors.

We created device break down matrix plan of the product into following parts: Housing Case, PCB, IC, Resister, Condenser, Detector (LSI), Connector, Switch, Assemble PCB, Cover Intake, Sensor Capture, and Assemble cost. Figure 29 shows the result with different case of units per year.

ICARE Device Cost Break Down



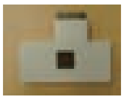
This estimate differs from actual part data. It estimated by carrying out the benchmark of the remote control key for cars.

Pland Volume 10,000 **pcs/year**

										Investment			
		Quantity	Material	Weight	Raw Material Cost	Purchsed Parts Cost (per price)	Processing Cost (JPY)	Sub Total (JPY)	Profit & Sales Cost (JPY)	Tooling Cost (JPY)	Supplier R&D Cost (JPY)	Amotization (2years)	Total Cost (JPY)
1	Housing Case	1	PP	0.006	2.1		11.33	13.43	2.69	1,000,000	0	50	66.12
2-1	PCB	1				16		16.00	3.20	0	100,000	5	24.20
2-2	IC	2				22		44.00	8.80	0	0	0	52.80
2-3	Resister	8				0.9		7.20	1.44	0	0	0	8.64
2-4	Capacita	6				15		90.00	18.00	0	0	0	108.00
2-5	Detector (LSI)	1				240		240.00	48.00	0	1,000,000,000	50000	50,288.00
2-6	Memory	1				120		120.00				0	120.00
2-7	Connector	1				150		150.00	30.00	0	0	0	180.00
2-8	Switch	1				18		18.00	3.60	0	0	0	21.60
2-9	Assemble PCB	1			0.5		5.42	5.92	1.18			0	7.10
3	Cover Intake	1	Punched Metal			1.3		1.30	0.26			0	1.56
4	Sensor Capture	1	Compound Metal			80		80.00	16.00			0	96.00
5	Assemble Cost	1					141.25	141.25	28.25	300000		15	184.50
	Total				**2.6**	**663.2**	**158.00**	**927.10**	**161.42**	**300,000**	**1,000,100,000**	**50,070.00**	**51,158.52**
	Our sales cost & Profit												**10,231.70**
	Our seling price												**61,390.22**

(a) The case of production of 10,000 units / year.

ICARE Device Cost Break Down

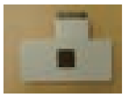


Pland Volume 100,000 **pcs/year**

										Investment			
		Quantity	Material	Weight	Raw Material Cost	Purchsed Parts Cost (per price)	Processing Cost (JPY)	Sub Total (JPY)	Profit & Sales Cost (JPY)	Tooling Cost (JPY)	Supplier R&D Cost (JPY)	Amotization (2years)	Total Cost (JPY)
1	Housing Case	1	PP	0.006	2.1		11.33	13.43	2.69	1,000,000	0	5	21.12
2-1	PCB	1				16		16.00	3.20	0	100,000	0.5	19.70
2-2	IC	2				22		44.00	8.80	0	0	0	52.80
2-3	Resister	8				0.9		7.20	1.44	0	0	0	8.64
2-4	Capacita	6				15		90.00	18.00	0	0	0	108.00
2-5	Detector (LSI)	1				240		240.00	48.00	0	1,000,000,000	5000	5,288.00
2-6	Memory	1				120		120.00				0	120.00
2-7	Connector	1				150		150.00	30.00	0	0	0	180.00
2-8	Switch	1				18		18.00	3.60	0	0	0	21.60
2-9	Assemble PCB	1			0.5		5.42	5.92	1.18			0	7.10
3	Cover Intake	1	Punched Metal			1.3		1.30	0.26			0	1.56
4	Sensor Capture	1	Compound Metal			80		80.00	16.00			0	96.00
5	Assemble Cost	1					141.25	141.25	28.25	300000		1.5	171.00
	Total				**2.6**	**663.2**	**158.00**	**927.10**	**161.42**	**300,000**	**1,000,100,000**	**5,007.00**	**6,095.52**
	Our sales cost & Profit												**1,219.10**
	Our seling price												**7,314.62**

(b) The case of production of 100,000 units / year.

ICARE Device Cost Break Down



Pland Volume 1,000,000 **pcs/year**

										Investment			
		Quantity	Material	Weight	Raw Material Cost	Purchsed Parts Cost (per price)	Processing Cost (JPY)	Sub Total (JPY)	Profit & Sales Cost (JPY)	Tooling Cost (JPY)	Supplier R&D Cost (JPY)	Amotization (2years)	Total Cost (JPY)
1	Housing Case	1	PP	0.006	2.1		11.33	13.43	2.69	1,000,000	0	0.5	16.62
2-1	PCB	1				16		16.00	3.20	0	100,000	0.05	19.25
2-2	IC	2				22		44.00	8.80	0	0	0	52.80
2-3	Resister	8				0.9		7.20	1.44	0	0	0	8.64
2-4	Capacita	6				15		90.00	18.00	0	0	0	108.00
2-5	Detector (LSI)	1				240		240.00	48.00	0	1,000,000,000	500	788.00
2-6	Memory	1				120		120.00				0	120.00
2-7	Connector	1				150		150.00	30.00	0	0	0	180.00
2-8	Switch	1				18		18.00	3.60	0	0	0	21.60
2-9	Assemble PCB	1			0.5		5.42	5.92	1.18			0	7.10
3	Cover Intake	1	Punched Metal			1.3		1.30	0.26			0	1.56
4	Sensor Capture	1	Compound Metal			80		80.00	16.00			0	96.00
5	Assemble Cost	1					141.25	141.25	28.25	300000		0.15	169.65
	Total				**2.6**	**663.2**	**158.00**	**927.10**	**161.42**	**300,000**	**1,000,100,000**	**500.70**	**1,589.22**
	Our sales cost & Profit												**317.84**
	Our seling price												**1,907.06**

(c) The case of production of 1,000,000 units / year.

Figure 29: Break Down Matrix Plan.

The tables shown as Figure 21 are made by excel sheet with some functions so that we can change the number of products volume and find our sales cost, sales price, and selling price. Currently we are thinking one million products as volume and it will be about 1,907 JPY per one product from our estimation.

Figure 30 shows the impact of investment amortization rising cost. However, in this calculation, we did not care about volume discount in case of producing large amount volume. Therefore, we think it is possible to realize more cost reduction from purchased parts price. Also, this calculation set the production country as Japan. If we can change the situation of production to low cost country, we can reduce the cost of our system successfully.

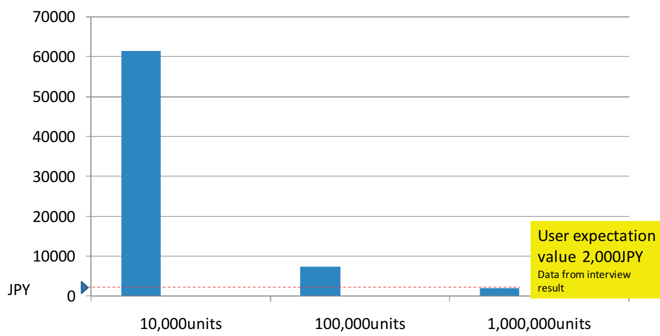


Figure 30: Examination of the cost in production quantity.

7. ALPS ROADMAP AND REFLECTIONS

Roadmap is a set of clear streams. By adding words such as "Aha", "Oops", and "Eurika", we can understand convergence and divergence. Thanks to this tool, when we find something is wrong, we will understand where to go back and what to reconsider. Figure 31 shows the footsteps that we took.

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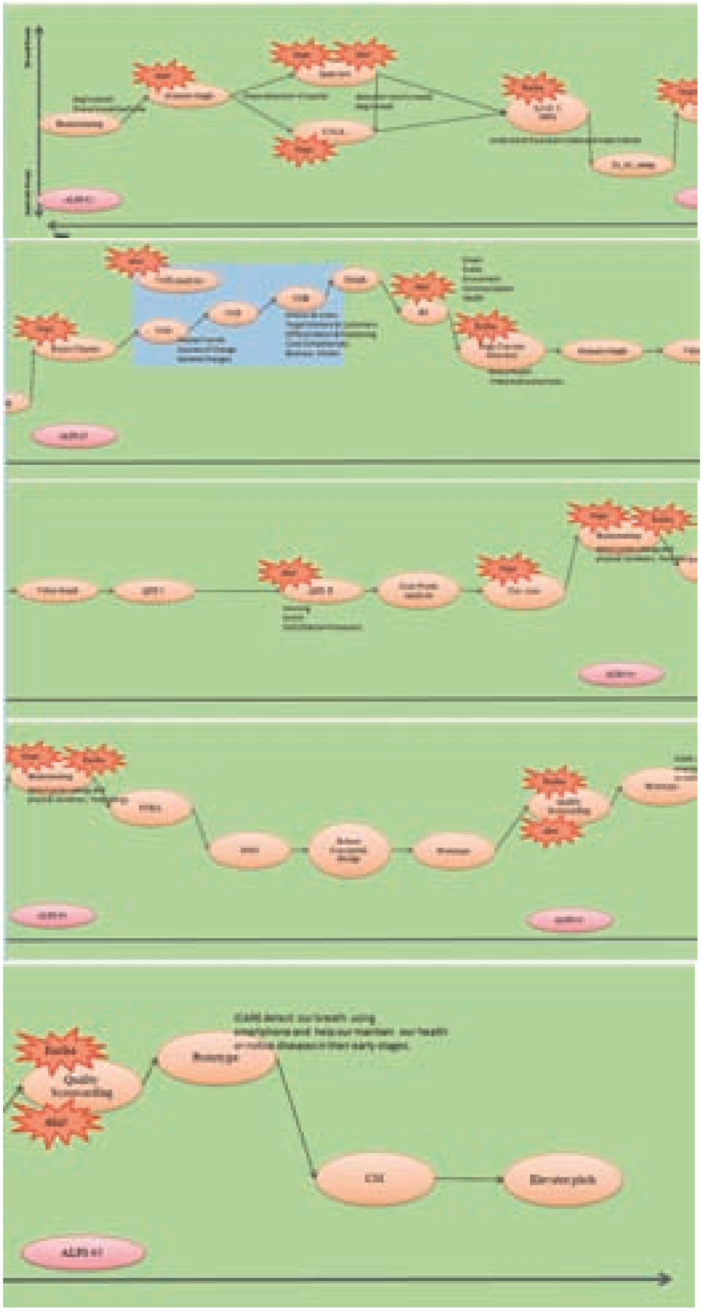

Figure 31: Roadmap.

Aha is a key discovery that is new to our team. Scenario Graph, Interview for ATONAP Inc, VOX analysis, KJ method, QFDN II and Quality Scorecarding have Aha! Oops is team tests ideas and changes direction. Interview for ATONAP, CVCA, Project charter, use-case and second Brainstorming have Oops! Eureka is flair. Level 0 OPM, Pugh concept selection and second Brainstorming have Eureka.

The first "Aha" was the first Scenario Graph. Many ideas come out of Brainstorming and we came up with various Scenario Graphs. However, what we made were different from what our sponsor had in mind and expected us. Therefore, the first "Oops" was CVCA and "Eurika" was level 0 OPM. ALPS#2, after getting feedback from the faculty members, we had to revise our approach and "Oops" was thus at Project Charter. We got divergent ideas by using Morphological Concept Generation and our ideas converged at KJ method. After using Pugh Concept Selection, we decide the direction of our ideas. ALPS#3, after getting feedback from the faculty members, we thought that we had to revise our approach. Therefore, we brainstormed again and decided a new approach. ALPS#4, after getting feedback from the faculty members, we thought our approach does not need to change. Therefore, we strengthen our approach.

We have made Scenario Graph three times. The first time was Interview for ATONARP Inc. Therefore, it is a big discovery that we understood user requirement. The second and third times were after getting feedback from the faculty members. On this occasion, it was VOX analysis, second Brainstorming and prototype to discover tool.

If we could do the project again from the beginning, there are five tools that we would like to put heavy weight. First tool is Interview for a partner company because we understood user requirement. Second one is VOX analysis. Third tool is Pugh Concept Selection because we were objective about our approach. Fourth is Prototype because we had real time image building. Last one is to make a CM because we understood point of our approach by creating these kinds of video or prototypes. Therefore, we think the teaching staff put emphasis on these five tools.

8. CONCLUSION AND FUTURE WORK

In conclusion, we would like to emphasize that the technology such as RTCD or a system such as our proposal ICARE will be strongly needed in the future. [6] Especially, Japan is the world's fastest aging society. The researchers stated that the percentage of elderly will be 25% in 2013, 34% in 2035, and 40% in 2055. [7] It is clear that our existing society, system, or service need to be changed in the near future in order to accommodate totally different population structure.

Considering elder people, we think that there will be strong needs for health system. We will need a system that can monitor our health, notice our condition, and connect to the doctors so that we can get an appropriate treatment before our condition gets worth. ICARE and RTCD enable those needs in the future. However, before that moment arrives, there are future works need to be solved.

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The privacy problem is not covered in this ALPS sequence, so we need to consider about privacy to make ICARE system in the real world. Also, the interface is another future work. How do we display the information about their health? In case of interface, there is nothing to do with the functionality of the system, but this is more about philosophy or psychology. We need to analyze and maybe interview many times to figure out how people feel about the display of their health information.

To complete our project, the device or prototype which has actual function of RTCD is needed. Then, we need to test it out to other people, have interviews, and get feedbacks from them. Since the RTCD chip is not yet available, we need to wait for that to make our project successful. Also, it may be necessary for us to revise our system regarding to the feedbacks.

We expect that the olfaction processor and RTCD chip will be available within 2011 to 2012 so that we will be able to create real prototype. Until then, we will work on the privacy and interface problem first.

While looking back the work we have done so far, we found that ALPS taught us a lot of things. We believe that our proposal is not a dream, and there will be strong needs in the future. Therefore, we will keep the things we have done in mind, and are looking forward to the future with knowledge and confidence that we got from ALPS.

9. ACKNOWLEDGMENTS

This project is an achievement of ALPS (Active Learning Project Sequence) 2010 of Graduate School of System Design and Management. The authors would like to thank Prof. Shinichiro Haruyama, Prof. Sun Kim, and all the students and lecturers who contributed to support ALPS for their kind assistance throughout the year. We also thank to Prof. Olivier de Weck, Prof. Kurt Beiter, Prof. Gerard Dijkema, Prof. Whit Fowler, and Prof. Tak Ishimatsu for helpful lectures and feedbacks to make our project successful from start to finish. Most work described in this paper would not be realized without their great efforts. Thanks also to Mr. Tomo Sato from ATONARP, Inc. who brought us an opportunity to work on a great topic of RTCD.

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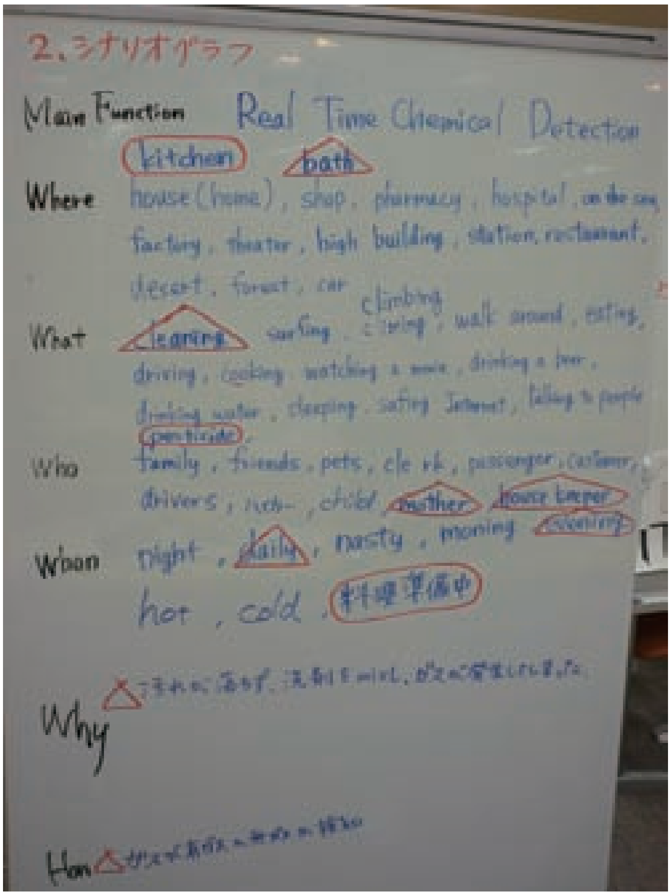
APPENDIX A

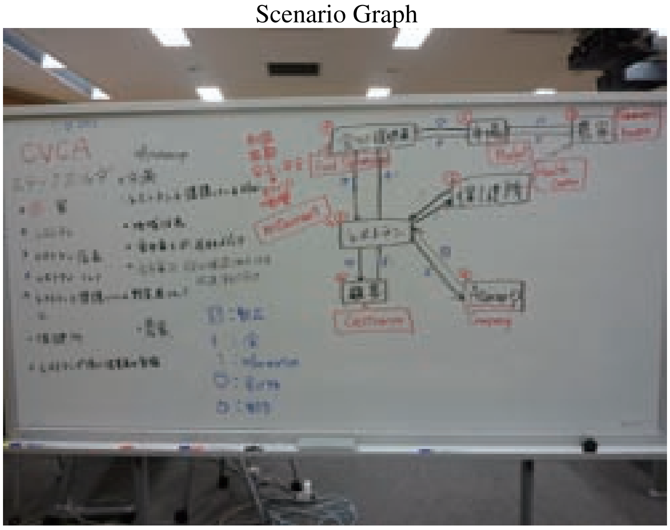
DETAILED OUTCOME OF OUR GROUP WORK

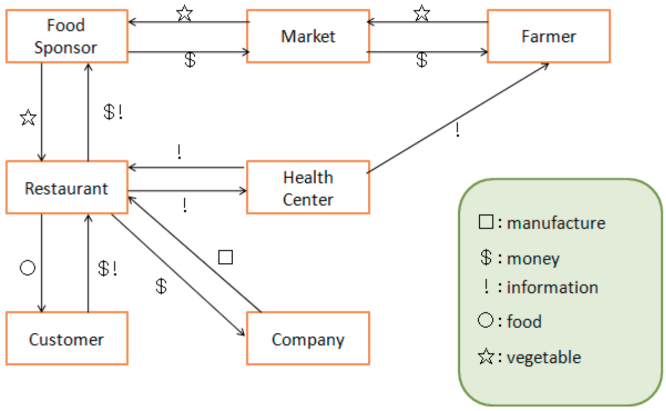
Here we show our outcome of our group work throughout the year.

The two pictures below are the first Scenario Graph and CVCA at the first overnight assignment. We noticed that we had totally different point of view and ideas compared to the final solution since we did not know about the technology in detail and did not have done researches at that moment. However, it is good to see our great changes through lectures and discussions.



Scenario Graph





CVCA

In this CVCA, we considered to use RTCD technology for food, and the stakeholders shown here are totally different from that of our final solution.

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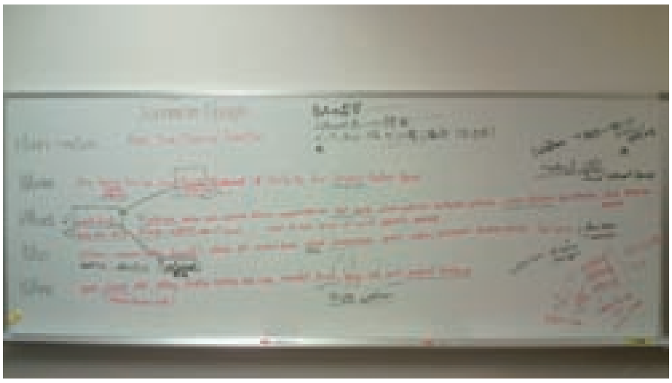
This is the interview at a cafeteria in Hiyoshi campus. At that moment, we were trying to find the effective usage of the key technology, RTCD.

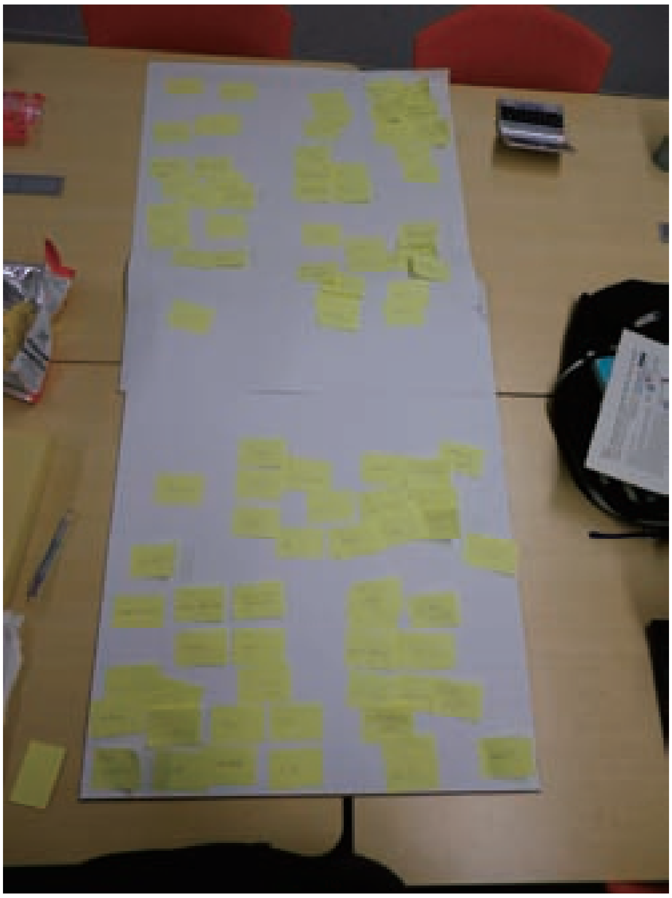
Following is a revised version of Scenario Graph and CVCA. We continued revisiting Scenario Graph and CVCA by using Brainstorming, Interview, and Observation.



Scenario Graph

CVCA

This is a one of our Brainstorming. It was quite impressive that there are numbers of ideas came up when all of us get together and had discussion. This is a one of the amazing thing of group work that there is something which only one person could never achieve or think of.



Brainstorming

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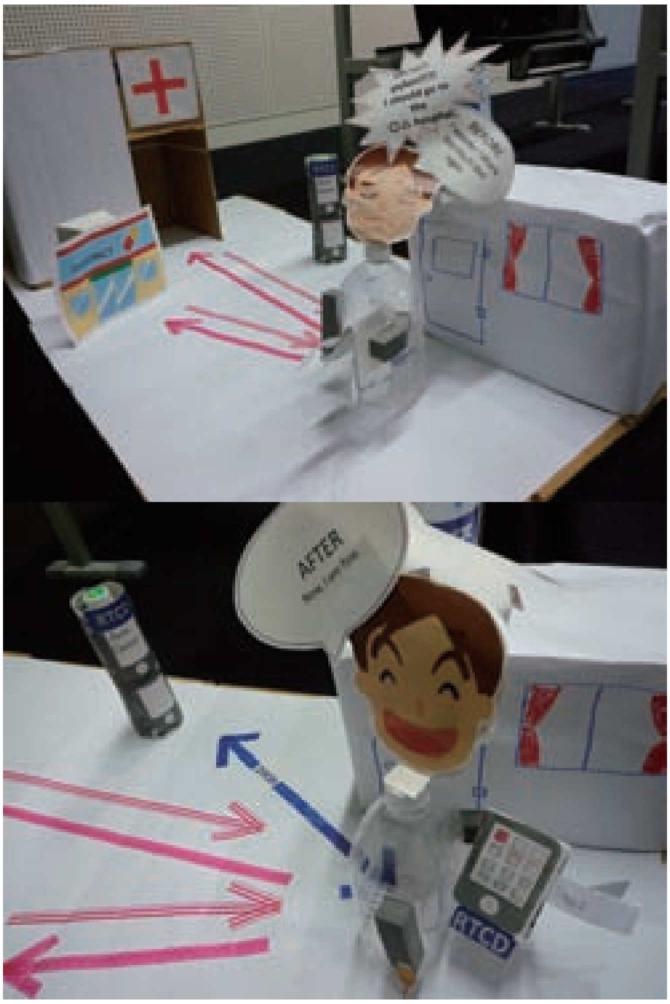
This is our first paper prototype for overnight assignment. It is quite tough work to make a prototype with paper only, but we could exchange opinions to other group by displaying and explaining this paper prototype.



Paper Prototype

The next photo is the final prototype of introduction of concept other than video and poster. We focused on visually understandable prototype which people can get the idea at the first sight. This one shows our systems' usability and operability that users can use the system anywhere and anytime and communicate each other.


The final prototype for concept introduction

The picture below is a physical prototype which can be actually attached to several kinds of smartphones. We repeated these kinds of rapid prototyping because we believe that the prototype is a useful method to communicate with outside of our group. The feedback from other people is very valuable since we may have done too much research or got knowledge about our concept and have a narrow view of things.


Physical prototype for smartphones

We also used the physical prototype at the Elevator Pitch at the final ALPS workshop, and we believe that actually handing in something tangible means a lot of things and it has a big impact on other people.

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One minute elevator pitch competition

We have created video several times to show our concept. They are available on a website of following address: http://www.ht.sfc.keio.ac.jp/~morishu/ALPS2010ICARE/ (this URL might be changed in the future.)


Five members wearing ICARE uniform

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Group 11's Final Presentation Slides

ALPS 2010

November 20, 2010

ICARE

Health Monitoring System for Smartphones

• Member: S. Morimoto, A. Ishiguro, Y. Naito, M. Sato, S. Nagashima
• Mentor: Prof. Haruyama
• Sponsor: ATONARP Inc.

Background

■ Health-conscious consumers

■ Limitation of existing technology/products

	Reliability	Convenience		
		Time	Price	Portability
A	⇦	×	×	×
B	×	⇦	⇦	⇦

New technology/products to overcome the trade-off are highly desired.

1

Our Solution

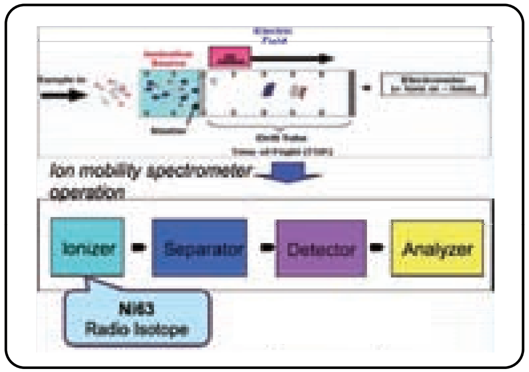
ICARE

Health monitoring system for your own smartphones using “Real Time Chemical Detection” technology

2

Real Time Chemical Detection

Real-time detection and analysis of chemical substances released into the environment



3

What is ICARE?

ICARE examines your health condition in real time
by detecting and analyzing chemical substances in your breath.

Detectable chemical substances	NO (asthma), CH_5N (liver, kidney), C_3H_6O (diabetes), etc.
Detectable level	ppm (1/1000000) ~ ppt (1/1000000000000)
Time for detection	msec (1/1000 sec) ~ min
Price	2,000 JPY
Size	20 mm × 60 mm × 8 mm

4

MOVIE

5

Conclusions

ICARE is a new health monitoring system for your own smartphones, which is:

- highly reliable
- time-saving
- inexpensive
- portable

ICARE

- helps you to maintain your health.
- allows you to notice diseases in their early stages.

6