Agri-Food Business Models Based on NFC

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Abstract In recent times, NFC technology adaptations for smartphones have been increasing. This study proposes the adaptation of agri-food business models based on NFC technology and presents the basic technological characteristics of NFC. An NFC tag can store more information than prior tagging technology methods, such as QR codes, and provides a better user experience. Based on the unique features of NFC, this study suggests an NFC business model application for the agri-food business.

Keywords NFC, Smartphones, Mobile, Tags, QR Code, Business Model, Traceability, Agri-food

1 Introduction

The number of wireless subscriptions is continuously increasing, not only in Korea, but overseas as well, exceeding 50,000 as of March 2011. The number of Korean wireless Internet subscribers across three telecommunication providers in Korea rose to 48 million for WAP, 100,000 for ISMS, 1,800 for CDMA 1x, and 490,000 for WiBro. As a result, access to the wireless Internet has become much more user-friendly (Issue Quest, 2011).

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One of the factors that has contributed to the increasing number of wireless Internet subscriptions was the availability of smartphones. In 2007, users were introduced to smartphones with the Apple iOS, which was a new mobile OS, and with the Android OS that improved user-friendly operations (Byeong-Jick Jegal, 2010).

Many developers participated in the production of high-quality applications for mobile smartphones, while a continuous supply of applications and phone units created an increase in smartphone users to more than 20 million as of October 2011 (KOCSC, 2011).

In addition to this, user experience (UX) is also improving. The wireless Internet fees that consumers pay have been decreasing, while the quality of wireless connections have improved in terms of speed and stability. Even modules such as Near Field Communication (NFC) are clustered in order to provide easy information input to a smartphone (Issue Quest 2011). Accordingly, users now have the ability to obtain a variety of information (that is not the result of direct input), with a simple touch.

In response to this shift, public and business entities now develop and provide applications for smartphones which may be either for fee or for free (Byeong-Jick Jegal, 2010). Users can look up information (which may be around them or at a remote location), in real time through wireless internet, which is accessible from anywhere in the country. Using a smartpad can increase even further the number of process functions available. With respect to business applicability, many information-related queries can be answered through the intelligent use of smartphone technologies and wireless communication networks. In consideration of such future trends and potential, it is necessary to develop an agri-business utilizing NFC, which is a newly-adopted function for smartphones. In the sophisticated process of agri-food that stretches from production to consumption, the smartphone can help to find a facilitator that improves the marketing and efficiency of information exchange.

This study is purposed to suggest an NFC-based busi-

ness model for agricultural food products by analyzing the overall features of NFC technology due to the recent trend where smartphones are supplied with NFC modules attached.

2 Smartphones and NFC

A smartphone device is composed of various types of software and hardware. The main feature is that various technologies are combined to build a completely new application. In the past, mobile phones had a limited number of functions, which were easily understood by the user. For such limited functions, high-performance computation devices were not required. However, the current smartphone functions are very demanding (Junich, 2010) and can only be realized through minimization of the many parts which need to be clustered (Park Se-Hoon et al.).

The recent diversification of smartphone functions has facilitated the minimization of various modules to allow them to fit into a smartphone. In other words, various modules (such as the NFC module) are clustered into one smartphone. Adding several modules allows a smartphone to receive nearby NFC tag information and to request or transfer relevant information through a wireless network.

NFC technology is a type of non-contact wireless technology that enables communication between electronic devices within the low-power frequency of 13.56MHz when the distance is less than 10 cm. Unlike Bluetooth, it can start communication instantly (about 0.1 second in magnetic induction) without pairing procedures. NFC is a method of transplanting non-contact communication technology into mobile devices. The non-contact communication technology is applied to an IC card, as it can assist the fast and intuitive exchange of information without physical contact, and is currently spreading into other mobile devices. (Issue Quest, 2011).

Table 1 NFC Modes (Source : Issue Quest 2011)

Mode	Content
Read/Write Mode	Open or save information from NFC-activated tags, posters, or kiosks, etc.
P2P Mode	Exchange information between NFC-activated devices (image, contact list, etc.)
Card Emulation Mode	Replace a previous IC card with the NFC unit itself

Table 1 summarizes three functions of the NFC module. Like the Read/Write module of an RFIC card, the Read/Write mode of NFC enables a device to read and write information that is recorded in a tag that the NFC module can read (Issue Quest, 2011).

The NFC module gains a practical advantage by interacting with previous RFID tags as well. Because of this, NFC is programmed to read 4 different types of international standard tags.

Table 2 NFC-compatible RFID Size (Kim, Gyung-Sik and Shin, Jun-Ho 2011)

	Type 1	Type 2	Type 3	Type 4
RF Interface	ISO-14443 A	ISO-14443 A	ISO-18092	ISO-14443
Speed	160 kbps		212 kbps	106-424 kbps
Memory	Less than 1kb	Less than 2kb	Less than 1MB	Less than 64kb
Application	Low capacity tag for single application service		High capacity tag for multiple application services	
Relevant Product	BroadCom Topaz	Sony Felica	NXP MAFARE	ISO/IEC Compatible

Table 2 provides a summary of previous RFID specifications which are compatible with the NFC module. Data contained in each tag is saved in NDEF format when it is under 4GB. However, it cannot exceed the physical limit supported by a tag (Kim, Kyung-Sik & Shin Jun-Ho, 2011).

NFC can completely replace QR code technology with its Read/Write mode. A tag function for the saving of in-

formation is one of the most basic functions of NFC. Nevertheless, in its simplest form, NFC can still provide an advantage in the most common usages. Likewise, using NFC as a tag to physically save agri-food information can replace the QR code for the transfer of that information. When NFC is used as a physical tag, there is no difference in the two storage capacities in terms of technical specifications.

Table 3 Storage Capacity Comparison of NFC Tag and QR code

Technology	Storage Capability
QR Code	2953 bytes
NFC Tag (ISO 14443)	Maximum 2048 bytes

Table 3 compares the tag memory of both the QR code and NFC as a physical tag for the storage of information. There are many types of RFID tags which are compatible with NFC. The NFC tag used in the table is as small as a sticker and can be cheaply mass-produced. In terms of memory capacity, the QR code can contain more information than a mass-produced tag among the ISO 14443 methods that are able to replace the QR code. However, the QR code itself can cause more problems in terms of user experience compared to NFC because the QR code saves information in a method somewhat similar to printing it on paper.

Table 4 Problems with QR Code as an Information Tag

Symptoms	Description	User Experience
Manual program execution by user	□ A user needs to manually execute a program that operates the camera sensor of a smartphone in order to read QR code. • Because of power management limitations, a camera sensor cannot be left on all the time.	□ Increase in reading time. • Decrease in user experience.
QR code targeting by user	• To interpret QR code, a tag must be located in a fixed spot in the camera image of a smartphone reader in order to be read.	□ Increase in reading time. □ Decrease in user experience. • Indirect method of use.
Difficult QR code interpretation	• As QR code contains more and more information, when printed, the dots that indicate information decrease in size. The automatic focus system of a camera needs to be capable of reading them, requiring more time.	□ Increase in reading time. • Decrease in user experience. • Camera must be able to focus automatically.

Table 4 displays various problems that can occur when a user must read information where the QR code is being used as the information tag. The QR code requires a camera which can focus automatically and in high definition in order to interpret large-memory information because it records information in a way that is similar to writing on paper, rather than in a digital medium.

Reading QR code takes a relatively longer time than NFC because the user must aim the camera sensor toward the applicable QR code, while the camera sensor focuses automatically and then interprets the QR code.

NFC is capable of replacing the QR code as a future agri-food information tag for several reasons: 1) it can read the information within 0.1 second, 2) it is intuitively easy for a user to read the information by placing a smartphone in front of the tag, a procedure the user is already familiar with, and 3) it can read much larger amounts of information than QR code.

From the perspective of tags related to agri-food, the information-storage capability of a large memory tag (2kb) can be advantageous in promoting the growth of wireless Internet. Although wireless Internet usage increases as costs decrease, there is still no guarantee that everybody will use wireless internet.

The Read/Write code of NFC can replace QR code as it allows greater accessibility for people to use universal services such as agri-food information tags. Although the number of smartphone users has increased, it is not assumed that all smartphone users use wireless Internet. This means that agri-food consumers can get information about a particular agri-food without an Internet connection if the information is available in the tag.

Table 1 demonstrates that P2P allows the sharing of information between two devices with NFC chip sets embedded. Similar to Bluetooth communication, it enables the transfer of information through short-distance communication between devices. However, the P2P mode of NFC provides intuitive usage as a simple single contact between

devices can take place in under 1/10 second without a separate pairing process.

In Table 1, the card emulation mode plays a role in making an NFC device recognizable by other NFC devices as the NFC-activated device itself acts as a card with RFID signals. As this function can be applied to financial transactions, it could even replace the credit card payment system. In addition to this, it can be used in unrelated areas such as ID recognition for entry and exit control.

3 Necessity of NFC Tag Information Standardization

Recently QR information has been displayed in agri-food environments for providing additional information. NFC is a more intuitive method than a QR code, so that even large data-base information can be researched by users. As a result, such NFC technologies increase the possibility of the adoption of additional information tags for agricultural products in the future.

NFC has the ability to add intuitive features to tag searches from the perspective of a user in that a smartphone with NFC allows an NFC tag function to always work as a permanent service in a particular operating system and thus enables the user to transfer the NFC tag information through the basic previously-assigned NFC application when the user reads an NFC tag. For this reason, the user can eliminate execution of a separate program for the purpose of operating the NFC-related program in order to read NFC tags.

This could be a way of encouraging users to scan agri-food tags more readily once they are provided with an exclusive application for agri-food NFC tags. Nevertheless, users would be able to decide for themselves which NFC tag-reading program they will use. It would be even more desirable to establish standardized data-saving structures and develop the requirements for saving agri-food information in an NFC tag, rather than producing an NFC tag-reading program for agri-food, with respect to helping each NFC tag-reading program to better display the information.

Standardizing agri-food NFC tag information should be implemented for the benefit of agri-food producers and consumers both. From the perspective of producers, they may use basic NFC functions such as QR codes or develop their own application because at present there is no standardization of tag information. If the industrial segments related to agri-food (i.e. agricultural farms, agri-food processing businesses, etc.) each tag in their own unique way, it will result in an overlapping of investment within the same-purpose tag system.

The suggested tagging method can help each segment in the sharing of appropriate tagging of agri-food information, including general agri-food information, and its verification. Therefore, each interested segment could build a consumer-friendly tag system without an overlapping of investment in the tag system. On the other hand, users would be able to access and research agri-food information using any NFC tag-reading program that supported standardized agri-food information.

In the process of standardizing tagging, it is possible to build a mutual information system where both consumers and producers can communicate with each other. This could be different from the traditional uni-directional approach where consumers have access only to a producer's saved information, if both information of a platform, where tagging information of tags can be collected, and information that will be linked to the platform are available. Such an information-tracing platform would allow consumers to obtain more information at the same time as it allowed producers to collect additional data for a better understanding of those consumers who tagged the respective agri-food.

Good quality data about consumers could be accumulated, beyond connecting websites related to agri-food, if a tag information-tracking platform enabled NFC tag programs to accumulate information that users voluntarily agree to provide (i.e., user number, location information, tagging time, etc.), and if it were standardized to analyze which type of information consumers are most likely to agree to provide within a particular platform server.

Implementation of tag standardization would open a position for a platform administrator in government or in self-governing entities. Agri-food producers would have the ability to track consumer trends and other pertinent information by indicating platforms that are used for tags following the platform of a helpful administrator. On a more macro-level, a platform administrator would be able to find meaningful information pertaining to the entire market. If development continued in this way, agri-food tags could be advanced into a CRM system for agri-food rather than an actual tag itself.

4 NFC-based Agri-food Business Model

Rokzio et al. (2005) introduced the three factors of a user's mobile device, when interacting with the physical world, in examples where they suggested a framework that explained the interaction between them.

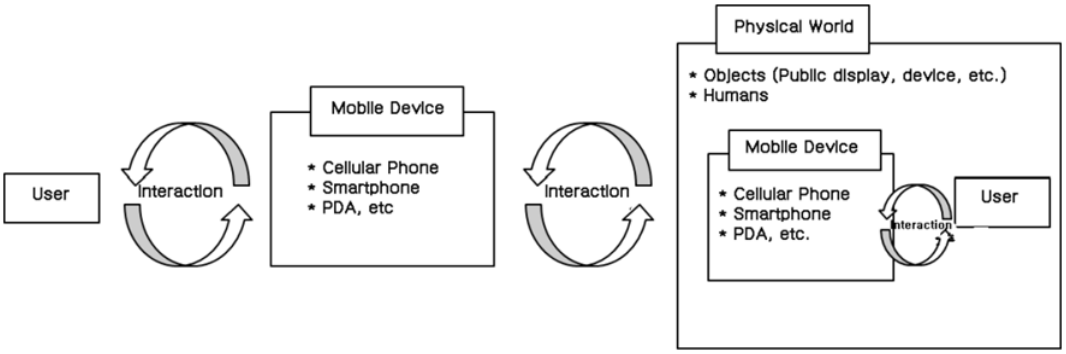

Fig. 1 Example : Interaction between Physical World and Mobile Devices (Rukzio et al., 2005)

Fig. 1 shows the diagram that Rokzio et al. (2005) used to explain the three factors of interaction between the physical world and a mobile device. The diagram implies that a mobile device interacts with people and that a user interacts with the physical world, (objects, people and places), through interaction with the mobile device. Chapter 2 and 3 of this study emphasized that NFC can help a mobile device obtain significantly more information (that is also more user-friendly) in a stable manner, replacing the QR code that originally allowed interaction between the physical factors of the world and digital devices. Based on this framework and the features of NFC, we introduced an agri-food business model in terms of interaction with the physical world.

4.1 Business Model based on Interaction with Objects

NFC is more advantageous in the tagging of objects than QR code. The type of NFC tag varies according to the particular application. Unlike QR code, where a relatively non-intuitive system is implemented to interpret tags by taking a picture when interacting with objects, NFC allows interaction with the information stored in a tag just by placing a mobile device close to the object or actually making contacting with it. This suggests a huge benefit for users because user experience in obtaining object tag information becomes more important as more and more objects are tagged. Technically, the information can be exchanged when a mobile device gets close to or contacts an object through NFC Read/Write modes.

This chapter suggests a business model example that can be deduced from the interaction between NFC and various objects.

4.1.1 NFC Business Model as a Platform to Verify the Impossibility of Agri-food Copying

We previously mentioned the necessity of both tagging and the standardization of agri-food information. The QR code system has several technical limitations when it comes to delivery and verification of multiple certifications from either producers or governments. Because of this, the QR code has difficulty providing either strong protection against damage or an electronic verification system.

Fig. 2 Damaged QR Code

Fig. 2 shows examples of when a QR code is partially damaged or covered by something else in an effort to prevent damage by dirt or dust. QR code manufacturers argue that about 30% of any data damaged by contamination can be recovered. However, in fact, it is often impossible to recover such damaged information (Wave, 2012).

In regards to such a problem, an experiment was done where a 2D bar code which was directly marked on poultry revealed the limitation of such a bar code. In the case of animal-related agri-food, which may have higher demands for tracking, codes should be durable and resistant to the types of data contamination that can occur through the behavior of animals. Because of this, a unique code should be used from the beginning stages in order to be able to track and verify any one individual object.

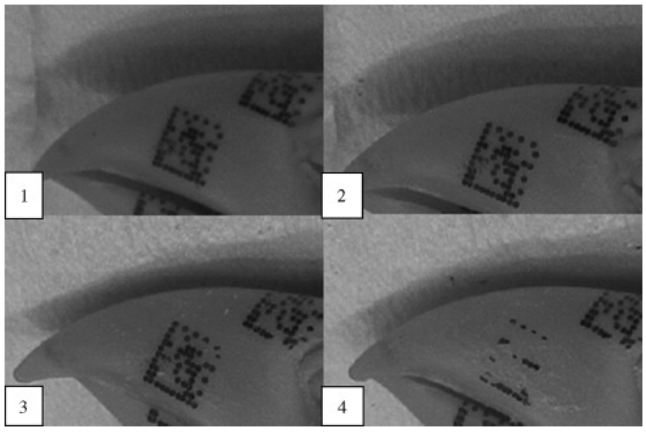

Fig. 3 An example of deterioration of a 2D Bar Code on Poultry

Fig. 3 shows the 2D bar code used in the experiment and the process of its deterioration. In this study, data matrix 2D bar codes were used to keep the miniature form of 10 × 10 (called 'dot size' - 40 ㎜) gs1, which conforms to ISO / IEC 16022, by marking a 2D bar code directly onto poultry. At the time of marking, a high definition bar code reader could achieve 96% readability when the code was located in an appropriate place considering the physical condition of the poultry. However, as it was moved or damaged, the readability factor did not reach the expected levels despite the recovery of 20% of the damaged data. Although ink variability was considered, utilization of different types of inks did not affect the result (Mc Inerney et al., 2010).

Unlike a bar code, NFC is compatible with some RFID standards, which have been emerging as a tag designed to be attached or inserted into an animal.

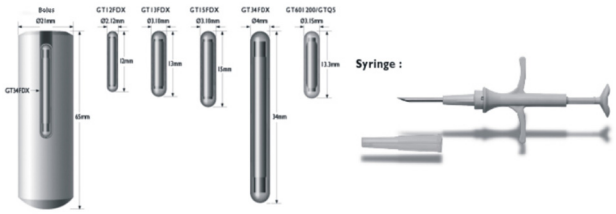

Fig. 4 Example : Animal-Insertible RFID (Synometrics, 2012)

The possibility of such damage to 2D bar codes makes it difficult for them to be used as a platform for agri-food certification information because they can be damaged. One problem with using QR code as a certification platform is its susceptibility to duplication and forgery or falsification. The QR code makes for easy direct duplication through a standard photocopier as it allows for printing on paper. In addition, the contents of the QR code can be read through any program capable of interpreting it, while the QR code algorithm itself can be created by anyone with the appropriate knowledge. Because anyone can read the contents of the code with a program, or easily create it, anyone with sufficient knowledge would easily be able to modify the code, either in part, or the entire contents.

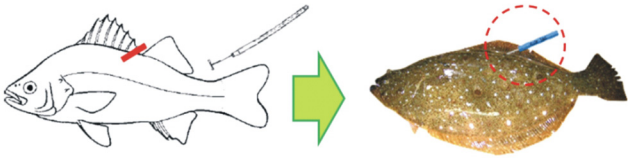

Fig. 5 Example : RFID Insertion in Halibut Farming

NFC, on the other hand, is relatively difficult to forge or falsify. Even though the unit price is higher, IC-linked tags are very effective against efforts to duplicate or falsify the information (Kim 2008). If NFC tags serve as information-certification tags for the purpose of preventing forgery and falsification, NFC could be applied to the agri-food area. For example, the system could be applied to halibut farming, for which many consumers are sensitive in terms of the country of production. In Korea, the "Clean Sea High Quality u-aquaculture Supporting Business (2008)", designed to support Jeju Island, is managing the individual fish population of the aquaculture through the insertion of RFID tags in the early stages. Using the features of an NFC tag helps aquaculture systems such as this, as it is able to provide reliable produce certification information to consumers who can easily check the information with a smartphone.

4.2 Business Model Based on Interaction with Places

NFC-based tags not only target an individual object but can also establish NFC tag infrastructure to allow insertion of location. If it is impossible to tag all objects, or if the cost is prohibitive, this NFC business model is very advantageous.

This chapter provides examples of a business model that can supply better agri-food information to consumers as well as solving problems for retail stores by establishing simple stations for NFC in retail stores (such as large-scale supermarkets), that are important points-of-purchase for consumers.

4.2.1 Real-time Pricing Tag System for Agri-food

Due to its very nature, agri-food is subject to time-sensitive price changes and thus has a short price-management period when compared to general industrial products. Because of this, price itself operates as a management factor. Large-scale retailers, including large discount supermarkets, customers of which are more sensitive to pricing, try to manage price by operating agri-food and fruit corners. However, these trials result in costs which are subject to frequent fluctuation. If management costs could be reduced, agri-food distributors and suppliers could provide better price competition for consumers.

There are factors which increase price fluctuation, including costs of mobilizing human resources, printing new tags for every price change (which badly impacts the environment), confusion for both customers and distributors through prices that frequently change, and costs for supervising the illegal opportunistic behaviors of intermediate managers in an attempt to gain benefit at consumer expense. It is therefore necessary to resolve such problems through design of an appropriate information system.

Large retailers can adopt NFC tags simply by attaching wireless beacons and electronic price tags on the shelves. A tag can become an NFC-tag simply through relatively easy installation of an NFC infrastructure facility.

Fig. 6 Example: Reading an NFC tag embedded in an electronic price marker with a smartphone

In the operation of this system, the updating of prices and other relevant information on the electronic price tags would be done automatically by the database center. In order to display additional information (i.e., history/certification, etc.) about a particular agri-food in the central database more effectively, an NFC tag could be inserted into the electronic price tags.

Fig. 6 shows an example of a smartphone reading an NFC-compatible RFID tag inserted into an electronic price tag. The central database acknowledges the NFC information inserted in the device and the specific identity of each electronic price tag. Therefore, when a consumer places a smartphone with an NFC chip in it close to the electronic price tag, the relevant information will be displayed as the NFC tag information read by the smartphone is delivered to the server.

If the suggested agri-food tagging method is standardized, NFC electronic price tags in a retail store could upload additional tracking information provided by agri-food producers without additional effort.

4.3 Business Model based on Interaction with people

NFC enhances communication between people. This communication can play an important role not only face-to-face, but also in remote virtual terms. This chapter suggests examples of this business model in two perspectives: communication between NFC devices and communication between objects with NFC embedded in them.

4.3.1 Agri-food Referral Network Business Model

In terms of effectiveness, networking increases in value with more users. Through modern module clustering by smartphone devices, many smartphones have adopted NFC as a basic pre-loaded program. Because of this, it is now possible for us to observe the introduction of a referral network that communicates agri-food information through NFC.

Fig. 7 How to Use NFC P2P Mode

One of the characteristics of NFC is that a device loaded with NFC modules can execute a P2P mode. As shown in Fig. 7, just by placing an NFC-capable device physically close to a target, users who obtain information through NFC can exchange that information with each other with-

out the need for separate pairing procedures.

Such a technological advantage allows for the obtaining of more NFC users which would thus introduce a new network business model in the agri-food industry, where word-of-mouth normally plays an important part of marketing. In actual fact, smartphones enable users to interact with each other, although traditionally people share information when they physically meet each other. The QR code on the other hand, is not appropriate for the exchange of information between people if that information is frequently changing.

4.3.2 Real-time Order Service Business Model for Agri-food Delivery

As shown in the above example about a referral network model, NFC can reduce communication costs as an object becomes a medium of communication between people, unlike physical face-to-face communication. For example, NFC can solve a simple order problem that a small milk delivery business might experience. A refrigerator can be the object that uses NFC communication to connect to and communicate with milk providers.

As a smart home or smart refrigerator exemplifies, an automatic ordering system that calculates the amount of dairy consumption on items such as milk or cheese that require frequent delivery, is not a new idea (Cook et al. 203). However, the adoption of such a smart home or smart refrigerator has not been successful in real life. The underlying reasons for this include problems in a functional focus, the life expectancy of a refrigerator, and price (Kuniavsky, 2010).

In other words, it would be difficult to develop a sensor that can calculate milk consumption in a refrigerator in the same way as a human does. Even when a refrigerator does have the technical ability to accurately calculate the consumption of delivered agri-foods, it is not easy to deliver order information in a usable form to any agri-food provider. In order to implement a standardized supply and demand system for agri-food delivery, decision-makers in the various value chains would need to cooperate with each other - which is not realistically feasible.

However, as the business model suggests, the problem can be solved if consumers were to attach an NFC tag directly to their refrigerator which would be made available to them by their agri-food delivery provider.

Fig. 8 Example : NFC tags for a Refrigerator for Delivered Agri-Food

Fig. 8 demonstrates how to attach an agri-food order tag to a refrigerator. This can be done through the use of a magnet or sticker, and would include an ID number for the agri-food delivery provider, a consumer ID number that the provider can recognize, and the name of the product that the consumer has requested to be delivered. Consumers can order agri-food delivery whenever needed just by scanning the distributed NFC tag with a smartphone, while a provider can automatically receive that order from a household in real time.

In the past, consumers needed to make a call to a delivery provider to implement a change in the supply of agri-food delivery because the consumption of much agri-food delivery (i.e., milk) is not consistent. The intuitive order system using NFC however, can solve such a problem at low cost and better efficiency by reducing the labor and economic costs that were incurred in the previous phone order system due to the frequent demand changes of such products. As well, it would help to reduce the waste of agri-food and thus improve the environment so that the consumer's experience of agri-food delivery can be enhanced.

5 Conclusion

The suggested agri-food business model provides a way to apply three modes of NFC, which include a Read/Write mode, a P2P mode, and a card emulation mode in an effective format. For example, the Read/Write mode can be used for the interaction of object tag information, while the P2P mode is designed to share information between people, and the card emulation mode can be used for re-

newing card memberships and so on. With these improvements, previous information tags (i.e., QR, magnetic cards, etc.) can be completely replaced with NFC tags.

The customization of this business model can provide many services that can be beneficial to both agri-food producers and consumers.

References

Cook DJ, Youngblood M, Heierman III EO, Gopalratnam K, Rao S, Litvin A and Khawaja F. (2003). MavHome: An agent-based smart home, IEEE.

Kuniavsky M. (2010). Smart things: ubiquitous computing user experience design. Morgan Kaufmann.

Mc Inerney B, Corkery G, Ayalew G, Ward S and Mc Donnell K. (2010). A preliminary in vivo study on the potential application of e-tracking in poultry using ink printed 2D barcodes, Computers and Electronics in Agriculture 73, 112-117

Rukzio E, Wetzstein S and Schmidt A. (2005). A Framework for Mobile Interactions with the Physical World, Proceedings of Wireless Personal Multimedia Communication (WPMC'05)

Synometrics. (2012). "RFID glass cylinder tag specification." from http://www.synometrix.com/RFID_glass_cylinder_tag_specification.shtml.

Wave D. (2012). "QR Code features." from http://www.qrcode.com/ko/qrfeature.html.

Kim, Kyung-Shik & Shin, Joon-Ho. (2011). NFC Technology and Certification Trend, TTA Journal 113

Kim, Joong-Tae (2008). Informatization Essay: Smart Tag RFID Usage Examples, Local Informatization 52, 72-79

Park, Se-Hoon, Kang, Nam-Ki, Park, Jong-Cheol & Cha, Jong-Beom. (2005). Ceramist 8(6), 1~ 76.

Issue Quest. (2011). New Growth Engine of Mobile Business - NFC Technology, Market Prospects and Business Strategies.

Jegal, Byeong-Jik. (2010). Smartphone Market and OS Trends, Semiconductor Insight 36

Junichi, Yah. (2010). Pointing Access Technology and Advancing Reality. Everything about Innovative Advancement of Smartphone and Web, Communication, Mentor