

Near field communication technology in Tourism

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Research paper

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Abstract

Technological progress and tourism have been gone hand in hand for years. The use of mobile devices such as smart phones and tablet computers has increased at a phenomenal rate in recent years. With the increase in the number of mobile devices more and more devices will be supporting Near-Field Communication (NFC), which is a short range and wireless technology for data transfer without physical touch. NFC technology will open up new opportunities for various stakeholders in tourism from destination level to tourism researchers. In this article earlier research on NFC technology is reviewed and categorized into four different topics: business models and ecosystems, software and applications, security and hardware, and threats and issues. Current and potential applications of NFC in tourism are also reviewed using existing case studies. Also managerial contributions of the study are presented.

Keywords: NFC, near field communication, tourism, technology, e-tourism, mobile devices

1. Introduction

In a technical sense Near-Field Communication (NFC) is a short range and wireless technology for data transfer without physical touch. The technology enables two-way interaction such as data exchange in electronic devices. Mobile devices can for example exchange pictures just by enabling NFC transfer and bringing two NFC capable devices close to each other. NFC devices can also read NFC tags, which are unpowered NFC chips that contain data. By reading a NFC tag a device can for example launch a pre-installed program or access a website link.

NFC was developed by Sony and Philips. Their joint venture aimed to standardize their Smart Cards Mifare (Philips) and FliCa (Sony). Smart Cards are used for electronic authentication and authorization. NFC is an open standard so it can be integrated into many electronic devices (Sony, 2002). On the consumer side the primary NFC device is a mobile phone or a tablet computer. In combination with NFC, the device will act as a smart-key to gain access to services from any other NFC device or tag.

According to Ricci (2011), mobile phones are becoming a primary platform for information access and a primary application area for mobile applications is tourism. Understanding the capabilities of mobile channel is of great importance (Ricci, 2011). Also Wang et al. (2011, pp. 1) state that “smartphones have the potential to significantly influence the touristic experience.”

Buhalis and Law (2008) refer to Poon (1993) and Sheldon (1997) when saying that technological progress and tourism have gone hand in hand for years. Buhalis and Law (2008) also mention mobile and wireless technologies one of the most interesting areas in technological innovation and tourism. NFC has been predicted to be one of the next big things in technological progress and it can potentially have a huge effect on both the tourism business and tourism research. Thus understanding the current state and future possibilities of NFC technology in tourism is important. NFC offers tourism many useful applications, deserving greater attention from tourism researchers and professionals.

According to Guttentag (2010), many relevant ICT developments are not made directly for the sake of tourism. However, these developments can have a great impact on tourism. Number of mobile devices such as smart phones and tablet computers is increasing and

travelers are using these devices before the trip, during the trip and after the trip. More and more ways to use mobile devices in travel and tourism are developed continuously making the topic very important from tourism management perspective.

NFC technology can be regarded as one of the recent ICT developments that has huge potential for travel and tourism. In this study earlier research in NFC technology is reviewed to examine the potential of NFC technology from tourism management perspective. The current state of NFC technology usage in tourism companies is also investigated by studying examples from several tourism companies and organizations. This study provides researchers a review of earlier literature clarifying what has been researched regarding NFC technology and tourism managers ways to implement NFC technology in their tourism business.

This paper is structured into four parts after the introduction. First, NFC technology is defined and its advantages compared to other forms of data transfer discussed. Then, earlier research on NFC technology is examined through literature review. Third, potential of NFC technology for tourism industry is studied by examining some of the applications of NFC technology in tourism. Research paper are presented in Chapter 3 whereas case studies are presented in chapter 4. Finally the results of this study are discussed in the last part of the study.

2. Definition and advantages of NFC technology

According to Ok et al. (2010), NFC is a short range wireless communication technology which is evolved from Radio Frequency Identification (RFID). NFC enables convenient short-range communication between electronic devices. Dubey, Giri and Sahare (2011) present a comparison table of different wireless technologies (Table 1). Compared to other technologies NFC has very fast set-up time and better usability, more use cases and better consumer experience. Madlmayr and Scharinger (2010) also compare NFC with Bluetooth, WiFi and RFID. According to them the advantage of NFC compared to Bluetooth and WiFi is the fast and automated connection. However, NFC could be used to set up a Bluetooth or WiFi connection automatically. In this sense NFC would serve as an enabler for Bluetooth or WiFi. The idea of NFC originates in Radio Frequency Identification (RFID) Technology. In contrast to RFID, where the focus is on identification, NFC is based on interaction.

Table 1. Comparison of different wireless technologies (Dubey et al., 2011)

	NFC	RFID	IrDa	Bluetooth
Set-up time	<0.1 ms	<0.1 ms	0.5 sec	6 sec
Range	Up to 10 cm	Up to 3m	Up to 5m	Up to 30m
Usability	Human centric	Item centric	Data centric	Data centric
	Easy, intuitive, fast	Easy	Easy	Medium
Selectivity	High, given, security	Partly given	Line of sight	Who are you?
Use cases	Pay, get access, share, initiate service, easy set up	Item tracking	Control & exchange data	Network for data exchange, headset
Consumer experience	Touch, wave, simply connect	Get information	Easy	Configuration needed

According to Ok et al. (2010), there are three NFC Forum defined operating modes for NFC: Peer-to-Peer, Reader/Writer and Card emulation. They state that (pp. 335) “In card-emulation mode the data is transferred from mobile-device to NFC-Reader; in reader/writer mode data is transferred is from NFC tag to mobile device or mobile device to NFC tag; and in peer-to-peer mode data is transferred between two NFC compatible devices.” These three operating modes are also included in the study by Siira and Törmänen (2010) and can be found in the NFC-Forum website (<http://www.nfc-forum.org/resources/faqs/>, accessed 8.11.2011).

Csapodi and Nagy (2007) list some of the user benefits of NFC technology. They state that the current state of mobile communication and consumer electronics is characterized by the convergence of devices and the growing need to connect these devices in a simple and secure way. NFC enables communication between two devices by just bringing them together or making them touch, while taking the devices away from each other stops the communication without any other user knowledge on networks or technology. This also increases security as if there are no other NFC-devices within a 20-centimeter radius, there is no communication.

NFC also supports a passive mode of communication, meaning that devices will not generate any RF fields and the complete communication can be powered from one side only, saving device energy consumption (Csapodi & Nagy, 2007).

Ok, Coskun, Aydin and Ozdenizci (2010) also list several advantages of NFC technology. First, mobile devices can be used both for information storage and as an NFC reader. Second, the technology is compatible with existing RFID structures, tags and contactless smart cards. Third, it is easy to use as users do not need to know anything about technology. Fourth, the short transmission range provides inherent security. According to Ondrus and Pigneur (2007) the performance of NFC technology is better than traditional payment cards and mobile methods.

Ok et al. (2010) presented the results of their study in a table which included benefits and future scenarios for all the different NFC operating modes. As can be seen from Table 2, there are many potential applications of NFC technology from access control to gossiping. However, focusing on just these three operating modes might neglect some of the crucial aspects of the technology. In order to examine the whole NFC phenomenon an extensive review of the literature is needed, likewise of how NFC technology is currently used by tourism businesses.

Table 2. Benefits and future scenarios for different NFC operating modes (Ok et al., 2010)

	Card Emulation Mode	Reader/Writer Mode	Peer-to-Peer Mode
Benefits	<ol style="list-style-type: none"> Physical Object Elimination Access Control 	<ol style="list-style-type: none"> Increases mobility Decreases physical effort Ability to be adapted by many scenarios Easy to implement 	<ol style="list-style-type: none"> Easy data exchange between devices Device pairing
Future Scenarios	<ol style="list-style-type: none"> Integration of id-cards, passports, finger-prints, driver-license Storage area for critical information to provide user's privacy and authorizing people to access those information 	<p>Many real-life scenarios can be adapted to NFC in this mode. In all of the scenarios, some data need to be read from an NFC tag, and additional jobs need to be done by NFC-enabled mobile phone.</p>	<ol style="list-style-type: none"> Secure exchange of critical data Gossiping

3. Research on NFC

A literature reviews was conducted using Google Scholar search engine to search for NFC related articles and studies. Search words used were “NFC”, “NFC technology” and “Near field communication”. First 20 pages of each search were examined to choose articles related to the topic and the chosen articles were examined more closely.

According to the literature review conducted for this study most of the earlier research on NFC is published in conference proceedings, typically in the area of information technology. Only three studies directly applicable to tourism were found and are presented later in this chapter. Lack of research on NFC technology, especially in the context of mobile ticketing, is also mentioned by Juntunen, Luukkainen & Tuunainen (2010).

Ok, Coskun, Aydin and Ozdenizci (2010) argue that most research efforts regarding NFC focus on the development of NFC enabled services and applications. Ok et al. (2010) reviewed NFC studies on the basis of the operation mode examined in each study. However, this approach cannot be applied to every research found in the literature review of this study. In this study a new classification is presented and earlier research on NFC technology is divided into four different categories: (1) NFC business models and ecosystems, (2) software and applications, (3) security and hardware, and (4) threats and issues. These categories are based on the literature review conducted. Some studies could have been discussed in several categories but it was decided to include them in only one category based on the main contribution.

3.1 NFC business models and ecosystems

According to Juntunen, Luukkainen and Tuunainen (2010), NFC technology and mobile ticketing services based on it has yet to take off. They state that the most significant reasons can be found in the challenging business models needed to realize NFC services. Juntunen et al. (2010) identified several critical issues that affect the commercial success of the NFC mobile ticketing service. Factors accounting for the slow adoption and diffusion of NFC services include lack of handsets supporting the newest standards, unclear revenue logics and number of current NFC services that are attractive to end users.

Benyó (2009) states that the main obstacle to the rapid market proliferation of NFC technology is that there is no business model for key stakeholders able to harmonize diverse interests and handle possible conflicts. The biggest question mark, according to Benyó

(2009), is the ability of key stakeholders to work out a business model that would be able to harmonize diverse interests and resolve possible conflicts.

3.2 NFC software and applications

Applications will be crucial to the success of NFC. Dubey et al. (2011) presented a generalized approach for NFC application development. They also analyzed how to possibly include the Mobile Network Operators in this development as well as how service providers can develop their own applications. Ho and Chen (2011) listed six different uses and applications for NFC technology: Electronic ticketing, data exchange, electronic wallet, rating, Bluetooth pairing and smart posters.

Fischer (2009) also mentions smart posters as advertisements. The posters work in such a way that a customer who sees the poster advertisement can, if he or she chooses, wave the phone over the NFC tag located on the poster and have a URL or icon transferred to the phone, which the user can then click on to be taken to the Internet site for additional steps. Therefore tags will be essential for the success of NFC technology. Siira and Törmänen (2010) regard tag management as one of the main challenges when creating an application with free-tag implementation.

Benyó et al. (2007) examined the design of NFC based applications and presented a new check-out and payment solution for retail stores based on NFC technology, especially a smart shopping cart. They conclude that with NFC based logistics it is possible to eliminate the need to stand in line in order to pay.

In order to eliminate the current indoor navigation problems Ozdenizci et al. (2011) introduced an NFC based low cost indoor navigation system called NFC Internal. This enables easy data transfer for indoor navigation just by touching tags spread over a building or a complex.

Several authors have presented NFC applications to utilize social media services. Hot in the City is an NFC application that allows users to make friends by touching other users' NFC devices through the peer-to-peer mode, and its users can also inform friends of their current location by touching hotspot tags (Siira & Törmänen, 2010). TaggyNet uses NFC to bring an advertising service and a location based service into social networks (Aziza, 2010). NFCSocial is a mobile application prototype which uses NFC technology to facilitate the

update of presence information on federated communication systems and social networks (Fressancourt, Hérault and Ptak, 2009).

3.3 NFC security and hardware

In many studies security and hardware are closely related to each other. Studies strictly examining NFC hardware are almost nonexistent, probably because most of the potential of the NFC can be harnessed through applications. Therefore security applications were included in this section instead of applications and services.

Madlmayr et al. (2008) reviewed security and privacy issues in NFC devices. They list seven cases that are vulnerable to attack: denial of service, relay data transferred over the radio frequency, skimming of applications in the secure element, managing in-device security, transactions over NFC peer link, issues due to the fixed unique ID and phishing. Mulliner (2009) also studied the vulnerability of NFC devices and described various kinds of attacks against NFC-enabled mobile phones and services. Mulliner (2009) also developed a set of tools for the security testing of NFC-enabled mobile phones and NFC services.

Kostakos and O'Neill (2007) regard the combination of automatic launching of midlets and the assignment of actions to tags as a possible problem leading to undesired situations. For example, two mobile devices too near each other could accidentally establish communication. A solution to this problem they propose disabling the automation in an application and requiring explicit user input. Fisher (2009) states that OTA management helps with security problems as it is possible to remotely disable all secure features. Siira and Törmänen (2010) found that less experienced users especially had problems in changing between NFC operating modes, as only one mode can be selected at a time in an NFC device.

Aigner et al. (2007) propose a system of virtual coupons that is protected against illicit use by using NFC in combination with inexpensive passive tags. Simply touching NFC targets with a mobile device enables pick-up and cash-in of virtual coupons in a highly secure and private way. Kostakos and O'Neill (2007) also propose using tag authentication as a security mechanism.

Chen et al. (2011) propose a secure mobile payment system solution for use in a traditional in-store environment. Their mobile payment solution combines government issued security credentials, the NFC secure element within the SIM and a 3G mobile network. The

credentials can be used for payment transactions to provide authentication, integrity and non-repudiation. Nor is there any need for the user to carry any payment or ID cards.

Mobile payments using NFC have been much discussed. For example, Ondrus and Pigneur (2007) present an assessment of NFC for future mobile payment systems and conclude that at least in Switzerland industry experts are quite enthusiastic about the future of NFC.

3.4 Threats and issues

Besides examining security questions in NFC technology, several authors report on the negative sides of NFC technology. There are several issues and threats that NFC users and developers should be aware of.

According to Kostakos and O'Neill (2007), one obstacle in using NFC is that users cannot easily type in or read information with their mobile devices while near field communication is taking place. The device's lights and vibrator can be used to notify users of the progress and status of the exchange.

NFC technology must moreover be adopted by both consumers and traders in order to develop the required infrastructure (Ondrus & Pigneur 2007). NFC technology is unlikely to succeed without a large number of NFC-enabled devices. In 2011 several mobile phone manufacturers released NFC capable mobile phones, such as Nokia with C7, N9, 603, 700, 701, 600 and Samsung with some models of Galaxy S2 and Google Nexus S (<http://www.nfcworld.com/nfc-phones-list/>, accessed 7.11.2011). SIM Cards are also being developed which can enable conventional mobile phones with NFC technology (<http://www.androidpit.de/de/android/blog/399812/NFC-in-SIM-Karten-wird-zum-weltweiten-Standard>, accessed 23.11.2011 and <http://www.nfcworld.com/2011/11/22/311485/visa-tests-iphone-nfc-in-poland/>, accessed 23.11.2011).

According to Siira and Häikiö (2007) maintenance of tags should be taken into account when an organization is adopting an NFC system. Maintenance includes, for example, changing the information on the tags, replacing destroyed or lost tags and removing unneeded ones.

4. NFC in tourism

Even though research on NFC in tourism is almost nonexistent, there are already some NFC applications currently in use in tourism. In order to give an overview of the existing literature and case studies, some potential applications of NFC technology in the tourism business are discussed, after which a selection of cases using NFC is presented.

4.1 Potential of NFC technology

Madlmayr et al. (2008) present five communication flows for NFC devices and the purposes for which they can be used. These are access, loyalty, payment, Bluetooth and WiFi configuration, VCard transfer, SmartPoster, data exchange, OTA (Over-the-Air) provisioning, ticket upload and money top up, i.e. preloading money.

Fischer (2009) describes several possible applications for NFC technology. According to him the most obvious and widely anticipated use for NFC is the electronic wallet. NFC phones can run multiple independent applications that could each replace a credit, debit, transportation, access, or loyalty card. NFC can also be used with vending machines, especially those enabled to connect to a service provider via SMS. These vending machines can be made NFC compatible simply by adding a tag that would serve as an enabler to set up the initial phone SMS.

Opperman & Hancke (2011) proposed using NFC to facilitate the process of data acquisition from a measurement or sensor device. With NFC technology users can simply touch the device with an NFC reader without knowing anything more about how the device works.

4.2 NFC Potential in Tourism

Madlmayr and Scharinger (2010) present several examples of NFC use in tourism which they categorize into information systems, workforce management and location based services. Even though the article focuses on tourism applications, only some examples relate to tourism.

Within the first category two examples are described. The first one is a field trial in Hanau, Germany. In this pilot test the public transport system is used to make bus schedules accessible via NFC as well as to integrate a payment system based on RFID tags. The schedules were displayed by an application which can be automatically downloaded on the mobile device. They moreover present a project on the tourist island of Sylt (Germany),

where an NFC based travel guide was developed. Around the island RFID tags were placed on tourist attractions, local restaurants and meeting points. When waved over the tag the phone was automatically connected to a website which provided further information.

The third example they introduce is a navigation system which uses RFID tags for positioning and an application to make navigation systems available when there is no WiFi connectivity or mobile phone accessibility. The examples described show a variety of potential in tourism. Nonetheless they only use the reader/writer mode of the NFC device.

Madlmayr and Scharinger (2010) conclude their study with the advice that a tourism destination should only use one application and harmonize their NFC services so that logos inform guests about the options and help them to avoid confusion.

All-I-Touch is a tourism related NFC application described by Kneissl et al. (2009). They argue that NFC is used not only in payment and ticketing but also to integrate a social component into NFC services. In order to increase the social component, the application All-I-Touch allows the user to place status updates within social networks simply by waving the NFC device over the tags of products, places and people.

Borrego-Jaraba et al. (2011) propose as a solution an orientation and navigation system within a destination using NFC technology. The system is based on smart posters. Their proposal is to offer visitor's location based services with maps and text information. NFC tags could be used to provide travelers with information on their location and with directions. Ondrus and Pigneur (2007) also suggest the use of smart posters. The advantage they point out is the option to receive more information by simply waving the mobile device close to a poster.

Several good examples of the potential of NFC technology are presented by Fischer (2009, pp.24): "The customer sees an advertisement, likes what he/she see, waves the phone, and orders the product right there. Imagine arriving at an airport, going to a hotel advertisement board, choosing a hotel that looks good, and waving the phone reader over the tag; the phone either offers the URL to go to the reservations Webpage or just dials the number, and stores the address in your phone. You confirm with the hotel. You then go to your rental car and wave the phone over the navigation system for a peer-to-peer connection; the address you got from the board is transferred into the navigation system, and you are on your way."

Some authors have studied how NFC technology affects user experiences. Ho and Chen (2011) presented a demonstration of how NFC technology can be used to improve user satisfaction. In their real life example a customer called Sam goes to restaurant A to have dinner. If Restaurant A is equipped with an NFC device, the restaurant can send him a filtered menu, special set or other discounts when Sam scans his mobile phone against the NFC device. For example, if Sam is a vegetarian the restaurant can send only their vegetarian menu to Sam's phone.

Ok et al. (2010) demonstrated the value of an NFC application with an automated check-in system for hotels as an example. In this example a guest receives room information and a digital key to her mobile phone the moment the rooms is booked. The guest does not need to wait in the check-in queue because she can go directly to her room and open the door with her NFC-enabled mobile phone. Checkout can also be accomplished using either NFC-enabled TV in the room or through an NFC enabled kiosk at reception.

4.3 Case Studies

As can be seen from the literature review, not much research has been done on NFC technology in tourism. However, there are several cases where NFC is currently used in tourism. To illustrate the current state of NFC technology a selection of these cases are reviewed.

4.3.1 Clarion Hotel Stockholm

The Clarion Hotel in Stockholm is the first hotel to use NFC Technology to replace hotel room keys. For this pilot test the access control company Assa Abloy, the mobile network operator TeliaSonera, the hotel door key specialist VingCardElsafe and the TSM solutions provider Vonyon joined forces (Clark, 2010b).

The trial was launched in November 2010 and lasted eight months. Within the test period thirty frequent guests received an NFC-enabled phone. When booking the hotel the confirmation was sent to their mobile phones. Prior to their arrival they were reminded to check-in electronically using their mobile phones. With the use of a special app the mobile phone was automatically enabled to be used as the room key. Checking-in at reception was therefore not necessary. Check-out was also possible by simply waving the phone close to the RFID tags located around the hotel or via the application on the mobile phone. After check-out the digital hotel room key was automatically deactivated. Besides the usability of this

process, security was also improved. An enabled phone can be blocked remotely if lost or stolen.

The goal of the pilot was to gather feedback from guests and employees. Therefore the trial was accompanied by a survey. According to this study the advantage most mentioned was the time saved in the check-in and check-out processes. Guests were also asked about additional NFC applications within the hotel. The option to pay for food, drinks and other services by mobile phone was mentioned by the majority of participants. Other applications mentioned were maps and information about the gym, restaurants, bars and public transport.

The advantage of this NFC system is that it also works with existing RFID locks. However, this will nullify most of the benefits of the system as the check-in process cannot take place automatically (Brown, 2011a).

4.3.2 The City of Nice

In France a number of NFC field trials have been made. In June 2010 the first pilot study for the general public was launched in the city of Nice under the name “Cityzi”. It is coordinated by the Association Française pour le Sans Contact Mobile (AFSCM). Those involved include four mobile operators, two banks and the operator of public transportation in Nice. To test the system the mobile operators put 4,000 NFC enabled phones on sale. The aim of the project was to enable visitors and residents to pay for their public transport with an NFC enabled phone, use smart posters to submit tourist information and to get updates on bus and train schedules. Even shopping in selected stores and earning loyalty points is possible (Balaban, 2010).

The term NFC was not used with the general public during the trial. The project ran under the name Cityzi and four logos indicating the availability of different services were produced. These logos can be used for marketing purposes and to inform the public about standard-compliant services. The logos are summarized in the table below.

Table 3. Logos of Cityzi (Clark, 2010a)

Logo	Description
	<p>A logo which shows a service or a contactless mobile device is compatible with AFSCM specifications.</p>

	<p>A 'ici Cityzi' ('Cityzi here') logo displayed prominently — in doorways and on cash tills, in the same way as card acceptance logos — in all places where Cityzi services can be used.</p>
	<p>A target mark, to show consumers where to hold their device when interacting with a Cityzi service via a poster, billboard or other NFC-enabled object.</p>
	<p>An icon displayed on the consumer's mobile device, allowing quick access to the list of Cityzi applications stored on the handset.</p>

For the public there a website was built to explain the options offered by Cityzi (www.cityzi.fr, accessed 26.10.2011). The website states four major options: Payment, Transport, Information Services and Loyalty Points.

According to Clark (2010a), for the pre-commercial pilot it was hoped that the information gathered would help to develop business models for a future commercial rollout. It was planned to expand the system to other parts of France. The French government offered funding for cities investing in the implementation of NFC. Nine cities were awarded funding in January 2011. In October 2011 a total of 42 cities across France responded to the funding offer. Therefore NFC services are expected to be introduced in two-thirds of French regions in the near future. So far the system has been implemented in Strasbourg. In addition to Nice, some of the parking meters in Strasbourg will be equipped with a contactless NFC terminal (Clark, 2011a).

4.3.3 Mobile Application EpicMix at the Ski Resorts of Vail

EpicMix is an application for mobile phones, designed for use in ski resorts and presented by Lindsey (2010). Running under the slogan “Capture. Connect. Share”, it was launched in

November 2010 offering the user the ability to track physical accomplishments and share the skiing experience within social networks. The service was offered in Vail Resorts (Colorado). In infrastructural terms all 89 lifts of the five Vail Resorts have been equipped with RFID scanners. The mobile application can be connected to Facebook and Twitter. The RFID lift ticket stores ski passes and location based data. When passing by an RFID detector, the location of the person is transferred to the application. As there is a very well developed WiFi connection in the Vail resorts, it is possible to find friends and family members on the mountain in real-time as well as to connect, share and message them via the application or another social network. In order to encourage users, they can earn virtual ski pins based on their vertical feet accomplishments. Trail conditions, weather and traffic are also displayed. The application works with iPhone and Android systems. This shows that the service of the application is focused on the passive RFID mode as iPhones are not NFC enabled so far.

The EpicMix application does obviously resemble location based social networks such as FourSquare. The difference is that the check-in process is automated and the setting is based on the skiing topic. Therefore the user does not have to actively use the service. It is also possible to see the skiing journey after the visit as the location-based data is tracked automatically on the EpicMix account. Social network updates can also be pushed automatically. So far there are three options for users to choose from: a notification of the first run of the day, an automated update, when earning a pin and one that announces when a user gains an experience level in the social media service. Privacy concerns with the service seem to be relatively low. The skier could turn off the RF functionality and fewer than ten people requested that their RFID chip be removed (Kenneth, 2011).

It is planned to extend the system so that there are RFID scanners not only at the entrances but also at other locations to enable precise tracking of a person's location. This could also lead to opportunities where the virtual and the real experience merge, for example rewarding active skiers with free drinks in a certain après ski bar (McCarthy, 2011).

Recently there has been more development using NFC technology to connect to social networks. The company "RealLifeConnect" (<http://blog.reallifeconnect.com>, accessed 2.11.2011) sells boxes which can be programmed by companies and offer users an automatic update of their own Facebook accounts such as a fan page, check-in at a location, connect and get friends or upload photos.

4.3.4 The Museum of London

In two museums in London (the Museum of London and the Museum of London Docklands) testing interactive services based on NFC technology in cooperation with Nokia has begun. The NFC trial of the two museums focusing on the history of London was launched in August 2011. Visitors can now access additional information at about 90 RFID tags. Besides the various information points, tickets for future exhibitions can be purchased and visitors can automatically “like”, “follow” or “check-in” on Facebook, Twitter and Foursquare. Additionally a “Sound Track to London” app can be downloaded. This application was built by Nokia and allows visitors to hear sounds of earlier eras in London’s history (Clark, 2011b).

The trial focuses on social elements. Therefore also a “Friends Scheme” of the museum has been introduced. At the entrance visitors can join this and then have access to special events, free entry to special exhibits, a museum magazine and 20 percent discount on goods at the gift shop. Inside the museum tags are used for downloading vouchers for discounts at the museum shop. The information points offer visitors additional information and photos. The trial tests the popularity and effectiveness of the system for at least one year (Swedberg, 2011).

The trial uses Nokia’s NFC Hub, which was also introduced in 2011. The system has a back end where businesses can host campaigns. The Hub tracks the use of every tag so that the effectiveness can be measured. The type of phone used can also be identified. In addition, Nokia supports business by selling and setting up tags and smart posters (Balaban, 2011).

4.3.5 Google Field Trials

The Internet Corporation Google has launched an NFC trial in three cities in the United States. From December 2010 to March 2011 Google introduced an NFC based marketing system to Portland (Oregon), Austin (Texas) and Las Vegas (Nevada). For visitors it was meant to be “the ultimate tourist pocket guide”. The pilot test gave stores NFC and 2D barcodes enabled window decals, with the claim “Recommended on Google”. Google aimed to make recommendations on their Google Places application easily accessible. Visitors could find or write recommendations by simply waving their phone over the sticker or scanning the barcode with the phone’s camera (Brown, 2011c). Additionally all information from Google Places such as opening hours, sales, contact information and other data were available to the

customer instantly, without having to search for the restaurant or store. The accessibility was achieved by simply holding an NFC enabled phone over the sticker. Within the Google Places application, several of Google's services were combined, giving the visitor the ability, for example, to compare restaurants via Google maps and navigate to a certain place (Gallaga, 2011).

Google is moreover testing its NFC payment service "Google Wallet", which was launched in September 2011. Besides trials in retail stores in New York for contactless purchases, Google is piloting a transit system in New Jersey based on their new NFC payment service. The service is available at selected stations only, but makes it possible to pay fares with NFC phones in combination with Google Wallet. In a public-private partnership, Google and New Jersey Transit will test the service (Clark, 2011c).

5. Discussion

In this study earlier research on NFC technology could be classified into four categories: (1) NFC business models and ecosystems, (2) software and applications, (3) security and hardware, and (4) threats and issues. In practice as well as in the literature the emphasis has clearly been on NFC software and applications. NFC technology offers numerous options to both tourism practitioners and researchers. As the result of the literature review and case studies different ways to use and study NFC technology in tourism are presented in Table 4.

For tourism practitioners NFC, especially NFC tags and smart posters, can help in destination service quality, branding and marketing. For example, the logos of Cityzi can be used for marketing purposes. NFC also enables paperless travel, making the mobile phone all a tourist might need when travelling to certain, technologically advanced destinations. According to Ondrus and Pigneur (2007) access control schemes based on NFC seem to be quite popular, meaning that mobile phones could consolidate their positions as a multi-function device. NFC also enables automatic check-in and check-out in accommodation companies, as in the case of the Clarion Hotel Stockholm.

Connecting NFC technology and social media networks seems to be a critical issue. It is already possible, as applications such as EpicMix demonstrate. The possibility to connect

NFC and social media is also one reason why NFC will be successful, as social media services such as Facebook are widely used both by consumers and companies. Connecting NFC technology, accomplishments and gaming can open up vast opportunities for application developers. For example geo caching would benefit from NFC tags, making it easy to track the caches one has found and share information in social networks.

There are currently a limited number of handsets supporting NFC. NFC has had problems in reaching the early acceptance stage since the first launch in 2003 (Ailisto & Alahuhta, 2010) despite the research on the topic. Even though the number of handsets is increasing, a breakthrough device such as the next version of iPhone with NFC support is needed. In Caceres the city is launching a program where visitors can borrow an NFC enabled mobile phone free of charge, enabling tourists to enjoy the benefits of NFC technology without having to own the device (Brown 2011b).

NFC tags and smart posters can be linked to websites and online content. This kind of usage is very expensive for foreign tourists because of high data roaming charges in many countries. However, NFC with the ability to track visitor movements without Internet connection (Ozdenizci, et al. 2011) is another option for NFC in tourism, providing means to track foreign visitor movements, for example, at events, amusement parks and nature parks.

NFC is an excellent way to increase interaction between the user and the world. Examples of this trend include among others Google Goggles and QR codes. NFC posters can provide a visual, real-world call to action (Titlow, 2011). A user who would otherwise forget to check-in at a restaurant or other tourism business using Foursquare can be reminded by a sign or a poster and making it easy to check-in by simply waving the phone, as seen in the Google field trials. NFC can reduce the number of actions a user needs to perform, thus increasing user experience and providing a secure and easy way to share information as well as making technology easier to adopt (Ho & Chen, 2011; Opperman & Hancke, 2011). For interactive advertisers and marketers mobile-based promotion has become an increasingly popular tool (Okazaki & Hirose, 2009) and NFC could make it even easier to use mobile coupons and discounts. NFC can be one of the technological developments mentioned by Pan et al. (2011) that changes the way travelers search for information, especially during their travels. Also Jun et al. (2007) predicted the increasing importance of mobile technology for providing real-time travel information.

The Trend-Research Company TrendONE (TrendONE, 2009) outlines how the technological development can result in a merge of online and offline worlds. They argue that with the integration of smart phones into our daily lives, the border between online and offline worlds will disappear. NFC as a technology will help to connect objects to each other and to information resources on the Internet. The development of mobile devices will lead to a variety of options, such as gesture control and face detection. The physical world will be overlaid by augmented reality services. NFC will serve as an enabler to access these services and information. The merge of online and offline world is called “Outernet”. In a world where data is accessible everywhere, filters will be needed. NFC enables the individualization of the information flow and grants users simple access to it.

Research on how to use NFC in tourism is an important topic for the future. At present there are more real world applications than there are studies conducted on the use and usability of NFC technology. NFC offers a wide range of topics for research, from increasing user experience to mobile ticketing and service chain profitability. NFC could also play an important role in context-aware information services in tourism (Paganelli & Giuli, 2008).

Table 4. NFC in tourism

	Tourism practitioners and tourists	Tourism research
Business models and ecosystems	Marketing Paperless travel	Profitability of NFC for different companies in service chain
Software and applications	Check-in and check-out with NFC in accommodation companies NFC payment options Ability to track visitor movements Connectivity with social networks Smart posters and destination tagging Tourist pocket guide and diary Easier check-in with Foursquare Gaming Loyalty cards Ticketing and timetables	Usability of NFC applications compared to e.g. QR applications. Social networks and NFC Mobile ticketing research New applications How to enhance user experience Interaction between the user and the world NFC based context-aware information services
Security and hardware	Infrastructure development Secure and private virtual coupons Tag authentication	Weather resistance of NFC tags and locks.
Threats and issues	Lack of handsets supporting NFC Maintenance of tags Data roaming charges	Communication between NFC devices

Google is also investing in tourism related NFC services. The infrastructure of Google as regards tourism services and NFC infrastructure is already very well established. The NFC enabled Samsung mobile phone Nexus S supports Android operating system by Google. Software components such as Google Places, Google Maps, Google Offers, Google City Pages, Google Wallet and many more have a huge potential for Google in the NFC and tourism markets. Harmonizing their services and infrastructure in a real world environment will be a challenge for the near future.

In tourism most of the businesses are small and medium sized. These companies will probably not have the resources for developing their own NFC applications. Thus the first to adopt NFC technologies in tourism are larger businesses, such as airlines and hotel chains. Adopting NFC technologies is a step towards paperless travel, meaning that tourists will need only to carry a mobile device with them. However, smaller companies can also use NFC tags as they are inexpensive and, for example, encourage coupon advertising to tourists using these tags.

Earlier research has been done using old Nokia phones such as 6131 and 6212 (e.g. Siira & Törmänen, 2010). Madlmayr and Scharinger (2010) point out new opportunities in the use of smart phones as NFC devices. With this integration the display can be used to integrate applications which can transmit complex information, the keyboard enables advanced interaction and with the network connectivity information on the web becomes easily accessible.

According to Kostakos and O'Neill (2007), NFC can make use of everyday objects as containers of hyperlinks and actions. For now NFC is competing in its reader/writer mode with the already well known QR Codes. Nonetheless there are some significant advantages of NFC: first of all devices can be connected much more easily. When reading a QR Code, an application on the smart phone needs to be started. An Internet connection is also needed in order to access the data. This is not the case with NFC technology, as waving the phone over another NFC device is enough to activate the connection. Furthermore, active NFC chips can store and pass on data without any Internet connection.

It is clear that NFC technology holds great promise for tourism industry. At the moment the NFC technology is not widely adopted in tourism industry. There are many reasons for this. According to Ailisto and Alahuhta (2010) mobile payments and ticketing with NFC are not yet widely used even though they are often regarded as key elements in the adoption of NFC technology. This is one of the main reasons for the slow diffusion of NFC technology. A lack of compelling applications has resulted in a “circle of diminished customer pull and fewer product launches by the manufacturers” (Ailisto & Alahuhta, 2010, pp. 472). Up until this decade there have been no real smart phones equipped with NFC capability nor there have been NFC capable devices that would have been very popular among consumers. At the current moment we are seeing more and more NFC devices such as smart phones being launched from several manufacturers including Nokia, HTC, Sony, LG, and Samsung.

If the number of devices supporting NFC continues to increase it is only a matter of time before a break through device such as the next iPhone model creates enough opportunities for companies to start using NFC profitably. The forerunners that were examined in this study are already using NFC technology to enhance customer experience, collect data, and promote a destination. Years 2012 and 2013 will be very important for the early adopters of NFC technology in tourism industry but there will also be huge regional differences between countries and destinations.

These technological developments will have a lasting impact on tourism practice. Questions which need to be answered are among others: What opportunities do these developments offer for destinations? What might tourism information look like in the future? What effect does augmented reality have in a navigation context? What will the adaptation process be like for consumers? Which services and applications will succeed and which will fail and why? Only time and further research will answer these questions.

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