Extending the Near Field Communication Market Opportunity with DASH7 Wireless Sensor Networking Technology

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Abstract

DASH7 and NFC (Near Field Communications) complement each other extremely well, as their features and functionality are completely different, but their technologies are suprisingly similar. This whitepaper describes the technical feasibility of integrating DASH7 components with NFC components and touches upon the functionality afforded by such an integrated solution.

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Introduction to DASH7 and NFC Technology

DASH7 is a wireless sensor networking standard that is used for applications requiring low power, "bursty" wireless communication. DASH7 is described by and named after the ISO/IEC 18000-7 standard for active RFID. DASH7 has extremely long range (hundreds of meters), providing excellent network coverage and making DASH7 ideal for large area sensor networking or supporting reliable communication with things on the move. Some common examples include building automation smart energy, tire pressure monitoring, and in-transit temperature monitoring of perishable goods.

NFC (Near Field Communication) is a passive RF technology usually based on ISO/IEC 18092 (a superset of ISO/IEC 14443 and ISO 18000-3), different from classic passive RFID by virtue of NFC's ability to act as both a tag and reader. Talk of NFC integration into cellular phones has become a consistent topic of technology journalism in recent years, and has approached a point where mainstream cell phone adoption seems inevitable [1].

NFC has extremely short range (approximately 4 centimeters [2]) providing excellent spatial isolation and making NFC ideal for replacing things like credit cards, or alternatively as a means of access control. Even today, most access control systems use ISO/IEC 14443 or 18000-3 passive RFID cards, and the hope is that, very soon from now, we can stop carrying dozens of cards in our wallets. Some advocate forgetting the wallet entirely.

1.0 DASH7, NFC, and Smartphones

NFC and DASH7 are both poised for integration into smartphones, and share enough in common that a single semiconductor and antenna package can support both to support both near term and long term applications.

1.1 Low Cost RF Silicon in 2010

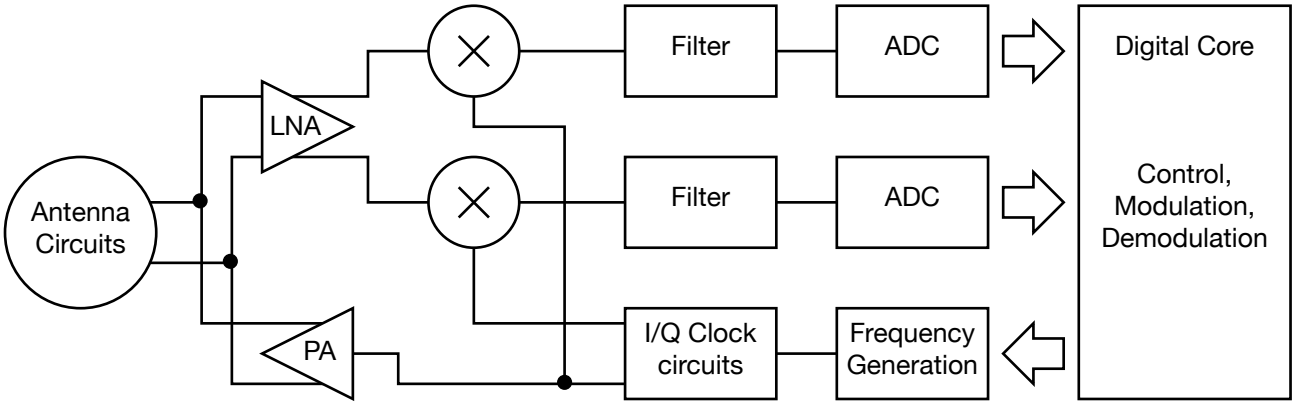

Figure 1: A simplified block diagram of a basic, coherent FSK or ASK digital radio. This architecture is frequently used for both active and passive RF.

In 2010, a sophisticated digital radio capable of operating with multiple data rates, carrier frequencies, and modulation schemes can be implemented on a single chip. The cost of these chips is also quite low — even sub-$1 in reasonable quantities — making it easy to understand why the hearts of most DASH7 and NFC products are chips like these.

Figure 1 suggests amplifiers for receive and transmit, mixers, and a feedback quadrature clock recovery circuit. This is an archetypical example of an analog front end for a coherent ASK or FSK system. Systems using forms of PSK can be more complicated, but neither DASH7 or NFC use PSK modulation.

Exploring further, there are hardly any more analog components. Digital modulation is applied directly onto the generated carrier, and demodulated digitally following analog to digital conversion (ADC). In most practical examples, the digital core that manages control, modulation, demodulation, and even some additional features (such as data encoding/decoding), is implemented as a compact RISC microcontroller.

Thus, if we begin with sub $1 DASH7 radio, the cost of adding NFC into the DASH7 radio silicon is limited to the development cost of adding NFC-capable baseband firmware into the digital core. In certain cases it may be desirable to enhance the amplifiers to enable high-power NFC usage, but for "tap-and-go" usage high-power is not needed.

ASK: Amplitude Shift Keying
FSK: Frequency Shift Keying
PSK: Phase Shift Keying

1.2 Frequency Matters

Many low power RF technologies other than DASH7 and NFC may share similar silicon radio architectures. Many versions of Bluetooth, for example, also use FSK modulation and have similar radio architectures. However, there are two problems with Bluetooth, or any other technology above about 1 GHz, and these prevent simple integration with NFC.

The first problem is semiconductor physics — not a problem that is easy to solve. NFC uses a 13.56 MHz carrier frequency, DASH7 operates in the 433 MHz band (center frequency = 433.92 MHz), and Bluetooth operates in the 2.4 GHz band (center frequency = 2.45 GHz). The digital circuits operate at the message frequency, and hence are quite isolated from any differences in the carrier frequency, large or small, but the analog circuits are isolated from nothing.

Building analog components that can cleanly operate at 13.56 MHz and/or 2.45 GHz requires the use of semiexotic

substrates in the fabrication of the semiconductors themselves. This strategy adds cost in a number of ways. First , there's the added cost of the semiexotic process (often GaAs) versus the standard silicon dioxide process. This process in undesirable enough that it is usual practice to build two completely separate radios, each using common silicon tuned to the respective frequency range, and bridging them with a third chip — an analog switch built with this more exotic technology. Needless to say, this adds cost, complexity, and "real estate" of the solution inside the product.

Alternatively, it is possible to build a cost effective, single chip solution on that uses both 433 MHz and 13.56 MHz. Semiexotic materials and processing are not required due to the smaller difference in frequency. Moreover, 433.92 is a 32x multiple of 13.56, so the act of multiplying or dividing the frequency within the Frequency Generation stage (usually a fractional PLL) is also simplified.

The second problem is the antenna. At the most basic level, there are two types of antennas: electrically small antennas, and electrically large antennas, and they operate in fundamentally different ways. Both DASH7 devices and NFC devices tend to use electrically small antennas, as their frequencies are low enough that it makes the implementation of electrically large antennas either difficult (DASH7) or impossible (NFC). Conversely, 2.45 GHz is a high enough frequency that the use of an electrically small antenna is impractical. It is possible to build a loop antenna that can act as an electrically small antenna for NFC, and an electrically large antenna for 2.45 GHz, but there are many other types of electrically small antennas, and most of the higher performing types cannot be transformed like this.

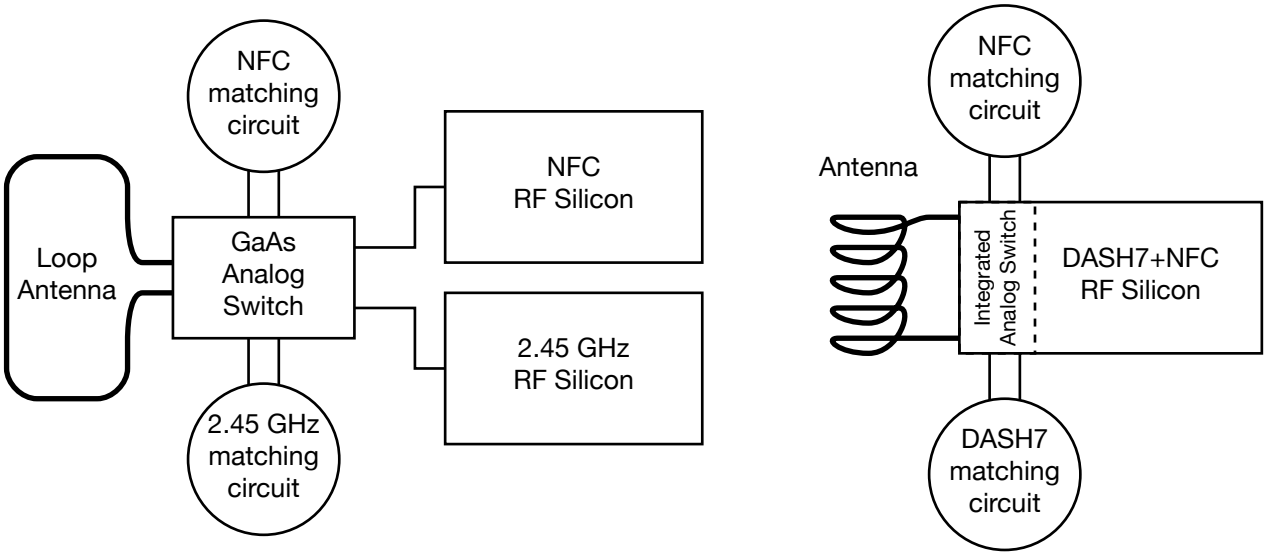

Figure 2: A solution combining NFC with DASH7 can be implemented with a single chip and a variety of compact antenna structures. A comparable solution combining NFC and a 2.45 GHz active RF technology requires multiple chips and limits the type of antenna to a single loop. The DASH7 solution allows superior NFC performance, less cost, and less size.

2.0 Empowering New Applications

Adding DASH7 functionality to a NFC chip creates myriad new application opportunities for NFC developers at minimal cost and creates economies of scope at the silicon/physical layer. For application developers, network operators, or media companies contemplating NFC and/or DASH7 investments, this means additional revenue opportunities with little or no change in budget outlay.

NFC is a short-range passive RFID technology whose "killer" application is the enormous-but-elusive mobile payments opportunity. As mentioned above, in the future we will probably just ditch our credit cards and instead wave our smartphones next to a cash register or vending machine in order to complete a purchase. Enhancing NFC silicon to include DASH7 functionality will accelerate the adoption of NFC for non-payment applications and ultimately for NFC generally.

2.1 Extending NFC's Value Proposition via DASH7

NFC is intentionally designed to be a very short range wireless protocol (4 centimeters or less [2]) due to its primary objective of enabling mobile payments. Some NFC signals are encrypted, but no amount of encryption seems to stop end users from freaking out about having their bank account raided, hence the emergence of metal wallet shielding products in the back pages of car magazines and the occasional infomercial. This issue, many agree, is a primary hurdle to faster NFC adoption worldwide. According to the NFC Forum website:

> Because the transmission range is so short, NFC-enabled transactions are inherently secure. Also, physical proximity of the device to the reader gives users the reassurance of being in control of the process [2].

This perception may be slow to change among end users. For example, early online retailers like Amazon or Buy.com experienced slow adoption among many market segments due to fears that their credit card information might be intercepted via the wired internet [3]. Never mind that handing a credit card to the bartender at Morton's Steakhouse or the busboy at Red Lobster (JP's favorite) might be less secure; for large numbers of end users, there is apparently something innately unsettling about transmitting credit card data wirelessly over distances longer than 4 centimeters.

DASH7, conversely, is not designed to perform in such a short-range fashion and thus is a very unlikely candidate for mobile payment applications.

However, as Section 1 of this white paper illustrates, adding NFC capability to a DASH7 device may require only a modest engineering effort by silicon vendors and no real impact on the bill of materials and a negligible increase in physical dimensions of the combined solution, which is hugely important to the handset producers. For mobile handset vendors or cellular carriers analyzing the business case for DASH7 and/or NFC, this is an important consideration.

While there are many applications for DASH7, only those that provide a "natural" and/or intuitive extension to existing NFC applications are the focus of this white paper.

2.2 Use-Cases for DASH7 + NFC

2.2.1 Use Case 1: Mobile Advertising

Some NFC vendors promote the use of NFC for purposes of mobile advertising, loyalty programs, couponing, etc. Still, NFC requires the same 4 centimeter proximity to a media asset like a movie poster, kiosk, or billboard. For certain customers willing to:

- pause directly alongside the media asset;
- invoke the appropriate application; and
- acquire the data in the NFC "tag" affixed to the media asset,

this usage model may be acceptable. However it is our hypothesis that a far larger set of customers would be willing to execute the same applications provided that they were executable a) from a longer distance, b) while moving, and c) in some cases, passively/without any conscious initiation of their own. While the prohibition against longer range NFC transactions is quite understandable from the standpoint of mobile payments, non-financial transactions like advertising or loyalty programs need not be bound by NFC's range restriction.

2.2.2 Use Case 2: Mobile Coupons

For example, Paramount may want to promote the upcoming release of "Iron Man 2" to potential moviegoers. In the default NFC scenario, a pedestrian walking past an Iron Man 2 movie poster in a subway station is required to initiate the above sequence to capture, let's just say, a 2-for-1 coupon to see the movie. In so doing, Paramount is limiting the potential number of triers of their promotion to those with the time and inclination to stop within four centimeters of the media asset and "download" the promotion to their smartphone.

Conversely, a combination DASH7/NFC-enabled smartphone could still support the default NFC scenario, but could also provide for a) longer distance distribution of the coupon b) "passive" acquisition of coupons according to a user's pre-defined "coupon acquisition criteria" (e.g. "auto-accept coupons for any movies starring Al Pacino" , and c) real-time interaction with the media asset (e.g. "answer the following three questions correctly and win a 2-for-1 coupon to see "Iron Man 2".) For the media company responsible for placing the movie poster and maximizing its effect (let's say it's an outdoor ad company like Clear Channel) there is the long-term potential to acquire information about the person interacting with your media asset, not unlike the use of cookies today in everyday web analytics. Today, companies like IRI or Nielsen provide estimates of audience reach/trial/repeat buying through costly statistical sampling and other measurement models that can potentially be replaced in some cases by a more interactive advertising experience using DASH7.

For the ad company concerned about the additional cost of adding a DASH7/NFC device to a movie poster, DASH7 devices are extremely affordable (less than $10 in many cases) and the battery lasts for months or even years, unlike Bluetooth or Wi-Fi batteries which can empty within days or hours. Better still, DASH7 offers an indoor experience (e.g. subway station, inside a subway train, shopping mall, supermarket, stadium, etc.) that is not achievable using GPS. Going further, DASH7 works even as the user passes by the poster in a moving car, bus, train or just while walking. Bluetooth, WiFi, or any of the various 802.15.4 "standards" can't do this.

Mobile coupons, incidentally, are expected to be a "killer app" for NFC in the near term, with forecasted revenues of $6 billion in 2014, according to Juniper Research [4].

2.2.3 Use Case 3: Loyalty Programs

Other analysts view loyalty programs as the "killer app" for NFC, particularly with the advent of new location-based services like Foursquare or Gowalla driving user participation. However, requiring an end user to actively "tap" their phone against an NFC icon in, let's say, a coffee shop, requires users to actively initiate an NFC "read event" behavior that may prove challenging across customer segments.

With DASH7, however, a user could set his or her preferences in the Foursquare or Gowalla application that would allow the user to be automatically "discovered" or "checked in" at the coffee shop/restaurant/gun store/etc. and thereby accrue loyalty points passively, i.e. by just being "in" the establishment, rather than requiring active/conscious user behavior to participate in the program. For example, a user sets his application preference to "let McDonald's discover me when I walk into one of their locations". Upon walking into a McDonald's, the user automatically receives a virtual Monopoly token (I hear you get a Monopoly game piece when you buy the tasty food there, and if you collect the right ones, you could own your own McDonald's one day … but I digress …). Our own market research suggests that restaurant owners like the McDonald's franchisee in this case would prefer that the "discovery" of the repeat customer be automatic/passive.

Additionally, it's possible that customized promotions could be created "on the fly", targeting a certain user's preferences. In JP's case, they might be working to get him to try the new McDonald's latte that is supposedly so awesome and might offer him a freebie, or a discounted latte if he purchased, say, an Egg McMuffin (mmmmm!). Such real-time promotions and loyalty programs are not easily achieved using NFC yet they are uniquely possible via DASH7.

Also – it's worth noting that while Foursquare, for instance, relies on GPS today to determine location, the plus or minus 30 meter accuracy of GPS combined with its non-performance in indoor environments like malls, stadiums, schools, hotels, etc. means that DASH7 can extend the options for those applications as well. Finally, DASH7's power requirements are about 10% of its next closest competitor (IEEE 802.15.4) and about an even smaller fraction of other technologies like Wi-Fi or Bluetooth.

2.2.4 Use Case 4: Smart Storefronts

Apart from loyalty programs, one area that has received some overdue attention recently is that of creating "smart storefronts" for local merchants seeking to attract new customers. In the case of restaurants, NFC vendors are promoting the use of NFC "tags" for restaurant owners seeking to provide prospective diners with more than just the clipping of the review from the local newspaper on the front door. The default NFC scenario works something like this:

"… To get information on local restaurants, for instance, users simply touch their NFC phone to the restaurant section of the poster and the … back-end system automatically delivers them information on local restaurants. The user can then view all the options and, after making their choice, can call the restaurant or view a map of its location." [5]

As is the case in the earlier applications, the default NFC scenario requires the user to be within four centimeters of the restaurant. However with DASH7, a driver passing by the restaurant at, say, 20 mph, could simply click a "get info" button on a smartphone to get a full restaurant review and

then decide to eat there. DASH7 is a stateless, low-latency protocol that allows a passing vehicle to acquire data about a place, a person, or a thing in ways that Bluetooth or WiFi cannot, while enabling data acquisition at a longer distance than short-range NFC or 2D barcodes (QR codes). Putting the issue of connectivity with things that move aside for a moment, some might still argue that Wi-Fi or Bluetooth are already resident on many smartphones and should therefore be the default wireless transport for a use case like this. What this argument classically overlooks is the high power draw of both technologies that renders the battery in the smart storefront sign/media asset dead in a matter of days or even hours.

2.2.5 Use Case 5: Social Networking

Some vendors are experimenting with Foursquare-like applications using NFC to "check in" to a place that is not covered by GPS or to exchange contact information with a new friend by "bumping" phones together. Other vendors are experimenting with "scavenger hunt" and other location-based gaming applications using NFC, whereby users locate objects and retrieve data from them via NFC. As in the above examples, all of these can be accomplished via DASH7 more conveniently, more accurately, and subject to end user preferences, passively.

For example, let's say Antonio is at a social event and wants to be notified whenever someone within two degrees of his Facebook network is in the same room. A friend of another friend his, Elvira, is in the same room and also wishes to be notified of the same. Using DASH7, the two can be notified of one another's presence and initiate get-acquainted rituals.

Similarly, Elvira is a distance runner who wishes to broadcast her Twitter and Facebook addresses to people in her network who are within two degrees of her immediate circle of friends and who are also runners. Manolo, a friend of Antonio's, happens to see Elvira running along the bike path by the river, and using his smartphone's augmented reality camera, is able to "see" what Elvira's Facebook address is and sends a message to her asking if she's looking for a running partner. Such an application is not accomplished via NFC, but it's accomplished uniquely via DASH7, which is able to "lock on" to moving things/people given its low latency whereas other wireless technologies like Wi-Fi or Bluetooth would find such a mission impossible. Peter Graves would have agreed. .

A very recent "problem" facing sites like Foursquare (to those of you not familiar with these services, apologies, but this stuff is growing like a weed in a lightning storm) is the issue of "cheating", i.e. people claiming to be in a place where they aren't and accruing loyalty points. While the Foursquare service actually allows people to "check in" from anywhere in the world (don't ask), they want to clamp down on people actually getting points for being somewhere when they aren't. DASH7, along with NFC, can provide a useful verification/authentication layer for various location-based services that rely on GPS as their primary location sensor [6].

2.2.6 Use Case 6: Licenses and Tickets

Another application of NFC is to enable authentication of certain licenses, permits, or tickets to prove authenticity. Yet with DASH7, it is possible to enable longer-range verification of certain permits (e.g. fishing license, building permits) or tickets (e.g. amusement park, ski resort). For state or municipal governments, this could substantially reduce outlays on license and permit enforcements and could facilitate wireless license renewals or terminations unavailable to users of paper-only users.

2.3 Security and Privacy

The importance of security in any wireless network is paramount for many customers. DASH7 supports public key cryptography, meaning that interactive experiences in any of the above scenarios can be shielded from eavesdroppers with minimal impact on the user experience while maximizing privacy. NFC and other passive RFID technologies are by design unable to support public key encryption, creating continued concern among privacy advocates that the presence of NFC-or passive-RFID enabled devices may be abused by government employees or other third parties wishing to monitor individuals. In many respects, DASH7 tackles these privacy issues head-on with its support of full public key encryption.

2.4 Implementation Costs

As described in Section 1, implementing DASH7 on a mobile handset will trigger little or no increase to the handset bill of materials. For non-handset devices (e.g. DASH7 device on the IronMan 2 poster), device costs are currently as low a $10 each and likely to fall further in the near future. Prices increase according to the amount of onboard memory selected or whether environmental sensors (e.g. motion sensor) are required. There is no monthly service charge required to use DASH7 (it uses unlicensed, globally available 433 MHz spectrum) unlike cellular alternatives, and device maintenance costs are minimized due to the multi-year battery life of DASH7 devices, a major consideration in total cost of ownership where labor can easily outstrip device costs as the largest long-term expense category.

2.5 Also Worth Mentioning

The synergies between DASH7 and NFC do not end with the use cases and analysis presented in this paper. An entirely separate but not unrelated set of opportunities exists around ways NFC can improve the DASH7 value proposition through alternative wakeup mechanisms, authentication, and other capabilities. These will be addressed in a separate white paper, along with ways other passive RFID technologies can enhance the DASH7 value proposition.

3.0 Conclusion

DASH7 is a logical extension to both NFC silicon as well as NFC software applications. As DASH7 is precluded from use as a mobile payments technology, it is ideally positioned to enhance NFC's global appeal for its non-payment applications and to generate new revenue opportunities for carriers, handset vendors, application developers, and advertisers that were previously unavailable in an NFC-only environment.

4.0 References

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