

The logo for Qualcomm Research, featuring the words "Qualcomm" and "Research" stacked vertically in a white, sans-serif font. The background is a blue gradient with a pattern of overlapping, semi-transparent hexagons.

LTE Direct

The Case for Device-to-Device Proximate Discovery

February 18, 2013

Qualcomm Technologies, Inc.

Not to be used, copied, reproduced, or modified in whole or in part, nor its contents revealed in any manner to others without the express written permission of Qualcomm Technologies, Inc.

Qualcomm is a trademark of QUALCOMM Incorporated, registered in the United States and other countries. All QUALCOMM Incorporated trademarks are used with permission. Other product and brand names may be trademarks or registered trademarks of their respective owners.

**Qualcomm Technologies, Inc.
5775 Morehouse Drive
San Diego, CA 92121
U.S.A.**

**© 2013 Qualcomm Technologies, Inc.
All rights reserved.**

Contents

1 Executive Summary	4
2 The Market Imperative	4
2.1 Strategic Drivers and Implications.....	5
3 Obstacles to Scale	6
3.1 Consumer Privacy Costs	6
3.2 Privacy Legislation	7
3.3 Battery Drain.....	7
3.4 Limited Utility	8
4 LTE Direct	8
4.1 LTE Direct Interoperability	8
5 Mobile Operator Implications	9

Figures

Figure 1: Expansive Addressable Market for Proximate Discovery 5
Figure 2: Adoption Costs Still Outweigh Utility 6
Figure 3: Developers Feeling Pain of Battery/Accuracy Conundrum 7

1 Executive Summary

‘Mobile first’ is tactically a directive from the internet industry to provision most of its services with a mobile focus. Strategically, it’s the mantra of a revolution as the internet industry leverages emerging tools in ‘mobile, social, and local’ to establish disruptive new paradigms of services and consumer behavior.

Proximate discovery, the ability for a device to passively and continuously search for relevant value in one’s physical proximity, is at the core of this revolution. Much more than just a ‘friend finder’, proximate discovery is a platform fundamental in defining the next generation of services across an extensive set of use cases from advertising to M2M. Across a landscape that includes entrepreneurs, venture capitalists, and the biggest names of the internet proximate discovery is one of the key problems being addressed.

LTE Direct offers a compelling solution for proximate discovery. As a distributed, device-based system of discovery, it mitigates consumer adoption costs on behalf of application providers, and provides significant new levels of utility. LTE Direct thus enables proximate discovery to cross the chasm to scalable, mainstream consumer adoption. By doing so, it extends its value to a long tail of app developers that would otherwise be shut out, and provides a vehicle for internet leaders to define interaction frameworks of the future.

Mobile operators are expected to collect rents from the potential demand for access to the platform, but are also likely to gather several times more revenue from other markets – such as advertising – and other channels – such as data mining. The opportunity also represents a strategic advantage for mobile operators as they manage a critical cornerstone of over-the-top innovation and profits, as well as an operational gain as they leverage the solution to offload increasingly sizable categories of network congestion.

2 The Market Imperative

Back almost three years ago, before ‘proximate discovery’ became so in vogue among the leaders and entrepreneurs at the frontier of innovation in mobile, Eric Schmidt, Google’s Executive Chairman, famously spoke of a world where our phones would notify us of relevant value in our vicinity¹. The fact that the “serendipity engine”, as he called it, has become the primary strategic mandate in mobile today speaks to the central role mobile devices have taken in consumers’ lives, as well as the considerable perceived strategic and economic opportunity to be had by the market winners.

Proximate discovery (also known by the industry term ‘ambient awareness’) refers to a mobile application’s continuous monitor of its physical surroundings. The existing, cloud-based paradigm is based on the application perpetually tracking the user’s location and comparing it against a database of what is in the vicinity. Anything relevant will trigger a particular action (e.g., notifying the user of nearby value). Qualifiers for relevance are pre-determined, typically in collaboration with the user, and may involve anything from a social graph, a collection of interests, or context derived from a smartphone’s internal sensors.

What app developers cherish are all the things that proximate discovery enables, especially Eric Schmidt’s vision of serendipitous discovery, where applications deliver hyper-relevant, personalized notifications of people or services or events that one normally would have missed. It’s not about alerts of

frozen yogurt sales, or lonely people trying to make new friends. Everyone has a need to discover something, and passive proximity services allow each individual to be perpetually on the look out for whatever social or affinity interests he/she is partial to.

There is also a broad range of other potential applications that is contributing to industry enthusiasm and activity. Consumers could be alerted of nearby scarce services or events (e.g., concerts) they are passionate for; a doctor’s access to patient records could be restricted more than 100 meters from the hospital; gaming could integrate elements of the physical world (e.g., scavenger hunts); a hotel could know when its best customers walk through the door; a tourist could remain continuously notified of nearby items of interest; home lights could turn on when a car reaches the vicinity of a home; a parent could be notified if a child leaves the yard; pedestrians could be advised of crime alerts in the area; expatriates could identify others from their home country. The list – and the vision – goes on and on.

Discover	Leash	Trigger	Search
<ul style="list-style-type: none"> • Social Matching – Serendipitous people discovery (e.g., friends, experts, professional, dating, shared interests, etc) • Push Advertising – Ads pushed as hyper-relevant notifications to affinity monitors set by consumer • Venue Services – Notifications such as tourist bulletins or crime alerts 	<ul style="list-style-type: none"> • Geo-Fencing – Child, pet, elderly, etc. • Dwell Time – Auto notification based on time spent within geo fence • Credentialing – Qualify as within a boundary before action (e.g., send data, configure of device, etc.) 	<ul style="list-style-type: none"> • Auto-Authentication – proximity triggered automation (e.g., lights turn on when approaching home) • Loyalty Services – i.e., Autonomous ‘check-in’ and associated personalized push notifications • Gaming – Autonomous check in for scavenger hunts, virtual-physical world integration, etc. 	<ul style="list-style-type: none"> • Query-Response – Ad-hoc local commerce services (eg, TicketSale, RideShare, etc)

Figure 1: Expansive Addressable Market for Proximate Discovery

2.1 Strategic Drivers and Implications

Discovery for the emerging mobile realm will be a foundational platform for a new generation of mobile services that will offer both new consumer utility and disruptive new business models.

Discovery is already a central axiom of desktop internet behavior. Value is curated for us by others and brought to our attention in a personalized way. The New York Times suggesting news stories based on what your friends like, or Amazon suggesting products based on your purchase history are examples. Twitter and its self-proclaimed ‘Serendipity Business Model’ is another one. Twitter – with over 500 million active users, 340 million daily tweets, and 1.6 billion search queries per dayⁱⁱ – is essentially a news service that enables people to discover a set of curated information tailored around their particular set of interests. The problem is that – even as mobile has replaced the desktop as the primary means for Internet access – scalable, consumer friendly discovery is not available in mobile.

Mobile behavior is different than desktop behavior. The mobile Internet is much more closely associated with more pressing matters of what is useful to us now and what is in our physical proximity. Discovery, that is to say, is probably more important for mobile than it is for the desktop, and it’s certainly more commercially consequential.

That last point bears repeating. Hyper-relevant, proximate value is more actionable to the mobile consumer, and that translates to a very coveted monetizable opportunity. Take, for example, proximate discovery for advertising. Unlike today’s hyper-local advertising (which merely optimizes for relevance), proximate discovery can open a new category of advertising aimed at generating foot traffic from passers by. Imagine a world where a merchant’s value was pushed to every nearby pedestrian that really cared,

and imagine that pedestrian perceiving that notification as a satisfying service rather than an advertisement. Placecast – a start-up which delivers such ‘push advertising’ via SMS – headlines this game-changing potential, claiming that 50% of those receiving its advertisements walk into the store within 4 daysⁱⁱⁱ.

Combined with the economics (US merchants are expected to spend nearly \$23 billion by 2016 to be discovered by mobile local search^{iv}), this data validates the industry’s attention in proximate discovery. Google has acquired companies like Zagat and Frommer’s to integrate proximate discovery features into Google Places. Facebook acquired location-tagging service Gowalla and a proximate discovery start-up called Glancee and is expected to announce new proximate discovery services this year; Groupon acquired proximate discovery start-up Glassmap; Yahoo acquired proximate discovery start-up Alike; Twitter is famously showcasing its strategy of moving its Serendipity model to mobile; and Foursquare which – after turns as a friend-finder app then merchant loyalty app – is now betting its future on serendipitous discovery as it ramps up towards IPO.

3 Obstacles to Scale

Yet despite all the promise and anticipation, all the implications and opportunities, all the attention and investment, not a single ambient mobile application has crossed the chasm to any type of mainstream consumer adoption. In a world where consumers are indicating, in every dimension possible, a want and need for proximate discovery, Eric Schmidt’s vision essentially remains theory.

So what is the problem? There is no getting around the perpetual location tracking underlying cloud-based proximate discovery, and the associated privacy and battery limitations represent very keen pain points for the consumer. In addition, the value propositions of the market’s best solutions are still too limited in both the relevance and the scope of the value they can identify in discovery to be worth these costs for mainstream audiences. While progress can and will be made on both sides of the equation, the systematic impediments inherent to centralized discovery impose a permanent constraint to consumer adoption.

3.1 Consumer Privacy Costs

Apple became the subject of headlines and consumer ire last fall when hackers discovered a file in the iPhone and iPad operating system that stored, unencrypted and unprotected, a timestamped list of

How do you compare benefits to risk in sharing location with location based services?

	Total	MARKET				
		US	UK	Germany	Canada	Japan
Base	1500	300	300	300	300	300
The risk far outweighs the benefit - 1	29%	33%	30%	37%	30%	14%
2	15%	12%	17%	17%	15%	15%
3	13%	14%	13%	12%	11%	17%
4	22%	19%	24%	18%	19%	30%
5	12%	10%	9%	11%	12%	18%
6	4%	5%	4%	3%	6%	2%
The benefit far outweighs the risk - 7	4%	6%	2%	3%	6%	3%

Source: Microsoft survey

locations visited by the phone’s owner. Apple quickly released a patch to address the issue but the incident served as another of a string of jarring reminders that privacy is a key issue in this space.

Although it varies among demographics and geography, the privacy costs of location sharing tend to be extremely high for mainstream audiences anywhere. The privacy failures and disappointments

Figure 2: Adoption Costs Still Outweigh Utility

consumers are becoming accustomed to are raising these costs even higher, and whipping up an increasingly zealous, sometimes ugly backlash. This manifests in legislation and lawsuits (Apple, Facebook, and Microsoft have all been sued in the past year for tracking the location of their mobile users), as well as – of course – consumer adoption of location based services. The impact of location tracking has been examined and measured in many recent studies, and is consistently cited as a severe and primary barrier to adoption (See Figure 2 which underscores location tracking as too high a cost for the perceived benefit by a majority of people).

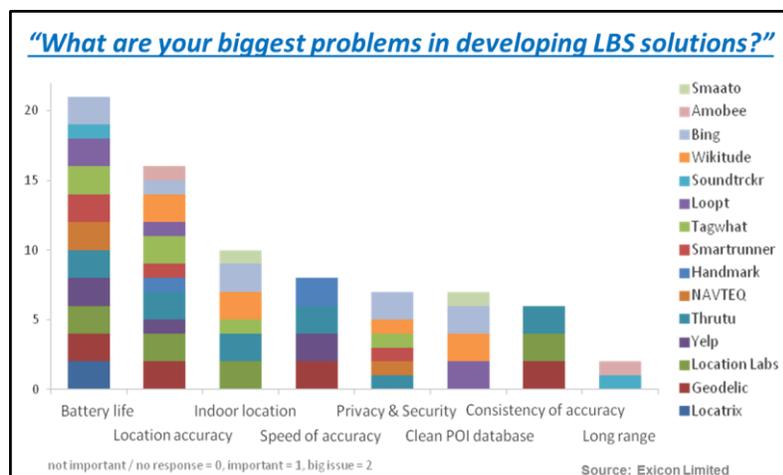
3.2 Privacy Legislation

Past security failures and media frenzy have also prompted a global government crackdown on the commercial use of location and other personal information. The United States, European Union, China, and India have all introduced directives and legislation aimed at curbing the ability of mobile applications to track location and gather data, and which will impose significant burdens on the application services. An EU directive, for example, will empower consumers to have their data deleted from an internet medium in which it’s virtually impossible to ensure thorough compliance. It’s expected that big companies will find the planned penalties steep, while small firms struggle to implement.

In addition, the legal details and approaches of the world’s biggest internet markets will differ dramatically. Geographical sensitivities vary, and application services will need to endure the complexity of accommodating multiple directives. When Google accidentally collected personal data from open wi-fi networks, for example, some EU countries required deletion of the data while others told Google to hold the information indefinitely. These issues will further raise the costs of app developers seeking to deploy cloud-based ambient awareness capabilities, as well as potentially hinder the commercial inter-operability across geographies.

3.3 Battery Drain

Battery drain remains a critical consumer pain point hindering adoption of every ambient awareness application. Walk around SXSW last year where proximate discovery apps established a global phenomenon, and inevitably you’d hear the question, “Have you un-installed your proximate discovery app yet?” Why? Almost always: Battery drain.



Even as hardware advances and optimization algorithms provide significant improvements, battery costs will remain as a hindrance to adoption for the foreseeable future, and any solution will entail some degree of compromise to location integrity.

Figure 3: Developers Feeling Pain of Battery/Accuracy Conundrum

3.4 Limited Utility

The value proposition of mobile serendipitous discovery is based on ‘affinity monitors’ set up by consumers to continuously detect the entirety of their proximity for any value related to those affinities, regardless from where it is derived. One monitor – for, say, ‘surfing’ – should provide for the potential to pick up surfing aficionados, surfing experts, surfing events and services, and surfing merchandise and offers. Network requirements in this space are huge. Arch-rivals Facebook and Google together could probably do it – provide sufficient network reach and hyper-targeted relevance – in theory. But who else could? Given the stove-piped nature of application services, providing cross-category discovery breadth in a relevant way is generally harder to scale in a centralized approach.

4 LTE Direct

LTE Direct (LTE-D) is a proposed 3GPP (Release 12) device-to-device (D2D) solution for proximate discovery. It dispenses with location tracking and network calls by directly monitoring for services on other LTE-D devices within a large range (~500m, line of sight). It does so continuously in a synchronous system that is extremely battery efficient, and can concurrently detect thousands of services in proximity.

LTE Direct runs on licensed spectrum as a service to mobile applications. It’s a D2D solution that enables service layer discovery. Mobile applications can instruct LTE-D to monitor for mobile application services on other devices and announce their own services (for detection by services on other LTE-D devices) at the physical layer. This allows the applications to be closed while LTE-D does the work – continuously – and notify the application when it detects a match to the monitor it set.

LTE-D is thus an attractive alternative to mobile developers seeking to deploy proximate discovery solutions as extensions of their existing cloud services. It is a distributed discovery solution (versus the centralized discovery that exists today) – apps forego centralized database processing in identifying relevancy matches, instead autonomously determining relevance at the device level by transmitting and monitoring for relevant attributes.

This approach offers crucial privacy benefits. LTE-D does not utilize the dreaded perpetual location tracking in determining proximity. And by keeping discovery on the device rather than in the cloud, it allows for user level controls over what is shared. Apps can consequently be enjoyed by users while cloud sharing is turned off (turning off cloud sharing with centralized discovery essentially turns off the app). LTE-D, moreover – with a negligible power impact – removes the battery headache on behalf of mobile developers.

In the increasingly competitive environment of mobile apps – where smartphone users download 60 apps but regularly use only six – adoption costs of privacy and battery are a decisive differentiator. This is paramount to the decision making process of app developers as they decide on proximate discovery capabilities.

4.1 LTE Direct Interoperability

LTE Direct radio signals – called ‘expressions’ – can be private and discreet (targeted securely for certain audiences only) or public (transmitted so that any application can receive them). Public expressions are a common language available to any application to discover each other, and this is the door consumer utility and adoption. If affinity monitors are to have value to consumers, they can’t let a lot slip through the cracks. If you set up a monitor for ‘tennis events’ and find out you missed a Roger Federer book

signing at the book store you passed today, how likely are you to continue using it? Public expressions exponentially expand the field of value. Facebook users monitoring for old high school classmates can find them, even if those classmates are theoretically using Yahoo or Google+ to broadcast themselves. Someone using Facebook to monitor for ‘photography’ may find a new exhibit opening (broadcast via Yelp), an SVP of photography at ESPN (broadcast via LinkedIn), or another photography expert (broadcast via Twitter). Most applications, constrained by the limits of their own network and database, can only monitor for narrow bands of value which doesn’t appeal to most people. Public expressions combine all applications – all value – into one single network, thereby expanding utility of system.

5 Mobile Operator Implications

The end result of LTE Direct’s differentiation in proximate discovery is demand. While leading application services may open their wallets for the tactical and strategic opportunities offered by LTE-D, there is also a market of hundreds of thousands of app developers that can complement and extend their value with proximity awareness. The 44 billion mobile app downloads expected by 2016 are just one reason developers are seeking to maximize their value.

Mobile operators are the likely global spectrum holders for LTE Direct, authorizing and controlling access to the system. Any application seeking to equip itself with LTE Direct ambient awareness must accordingly pay a toll to the mobile operator. Toll collection is big business these days. The market to supply API services to mobile application developers is expected to top \$100 billion by 2015^v. App developers pay for everything from access to Google’s map API to tools to manipulate a phone’s camera.

For mobile operators it’s a fantastical opportunity. The activity from serendipitous discovery could easily be worth hundreds of millions of dollars annually, even for smaller operators. Strategically, it’s a platform to attract flaunted over the top value and innovation – which has been moving further and further from the operator’s purview – and direct it back through the operator’s coffers.

Just how much are we talking about? Though conservative estimates have valued access of LTE-D proximity discovery services to mobile developers at more than \$4 annually per mobile subscriber^{vi}, there is a mass of market possibilities beyond it. Push advertising, for example, could be worth an additional \$12 per MNO subscriber by conservative estimates^{vii}, while loyalty services, home automation, and M2M – among others – further extend the opportunity. Data mining also represents yet another dimension that could provide additional revenue.

In addition to the strategic advantage and meaningful incremental revenue channels, mobile operators achieve material operational benefits via D2D data offload. D2D-based ambient awareness at scale eliminates the infinite network calls that would have been associated with cloud based proximate discovery, and also holds the potential for operator-directed D2D communication – thereby reducing proximity based chatter, like file sharing, that is increasingly clogging the networks.

LTE Direct is thus a multi-dimensional weapon for mobile operators in the battle for value chain power and control. As mobile becomes the primary internet medium of the 21st century, LTE Direct could stimulate a migration in the user’s emotive loyalty from mobile app back to the device, and represent an important weapon in the high stakes battle over next generation mobile services.

ⁱ Scott Morrison, “Google CEO Envisions a ‘Serendipity Engine’,” *Wall Street Journal*, Sep. 29, 2010 (<http://online.wsj.com/article/SB10001424052748703882404575520390567286252.html>)

ⁱⁱ Wikipedia, *Twitter*, <http://en.wikipedia.org/wiki/Twitter> (Feb. 18, 2013)

ⁱⁱⁱ Anne Bezancon, Founder & President, Placecast, *Street Fight Summit West*, June 5, 2012

^{iv} Mark Walsh, “Local Mobile Advertising to Reach \$24 Billion in 2016,” *Online Media Daily*, Jan. 27, 2012 (<http://www.mediapost.com/publications/article/166726/local-mobile-advertising-to-reach-24-billion-in-2.html#axzz2LHbt1Eru>)

^v Research2Guidance, *The Market for Mobile Application Development Services*, <http://www.research2guidance.com/the-application-development-market-will-grow-to-us100bn-in-2015/> (Jul. 6, 2011)

^{vi} Qualcomm estimate

^{vii} Qualcomm estimate