Technology Institute

Mobile Innovations Forecast Phase II Introduction

The magic of advanced technology

By Raman Chitkara, Global Technology Industry Leader

Growth in contextual awareness capabilities will transform mobile devices into digital assistants.

Science fiction writer Arthur C. Clarke's Third Law states: "any sufficiently advanced technology is indistinguishable from magic." While people often focus on the word 'magic', the key phrase is actually 'sufficiently advanced technology'. As we move into Phase II of PwC's Mobile Innovations Forecast (MIF), we are now entering the realm of sufficiently advanced technology.

Until Apple's iPhone debuted in 2007, mainstream mobile innovation emphasised how well a mobile device *communicated*. Sufficiently advanced technology was defined according to the price/performance of placing phone calls, sending messages or displaying simple text or graphics. Four basic applications—phone, messaging, contacts, camera—provided the bulk of the end-user's mobile experience. The structure of the mobile industry revolved around the coverage, quality and price of cellular networks. Mobile devices lagged behind desktop PCs in storage, processing power and data handling capabilities.

However, the iPhone put mobile innovation on a completely different track. Since 2007, sufficiently advanced technology has referred to how well a mobile device *computes*. According to Daniel Eckert, Managing Director, Emerging Technologies at PwC, the innovative focus of mobile computing involves integrating a triad of communications, applications and sensing platforms. "These three platforms 'converse' with the user in a continual loop of personalised applications that draw information from a user's physical, virtual and social environments," he says.

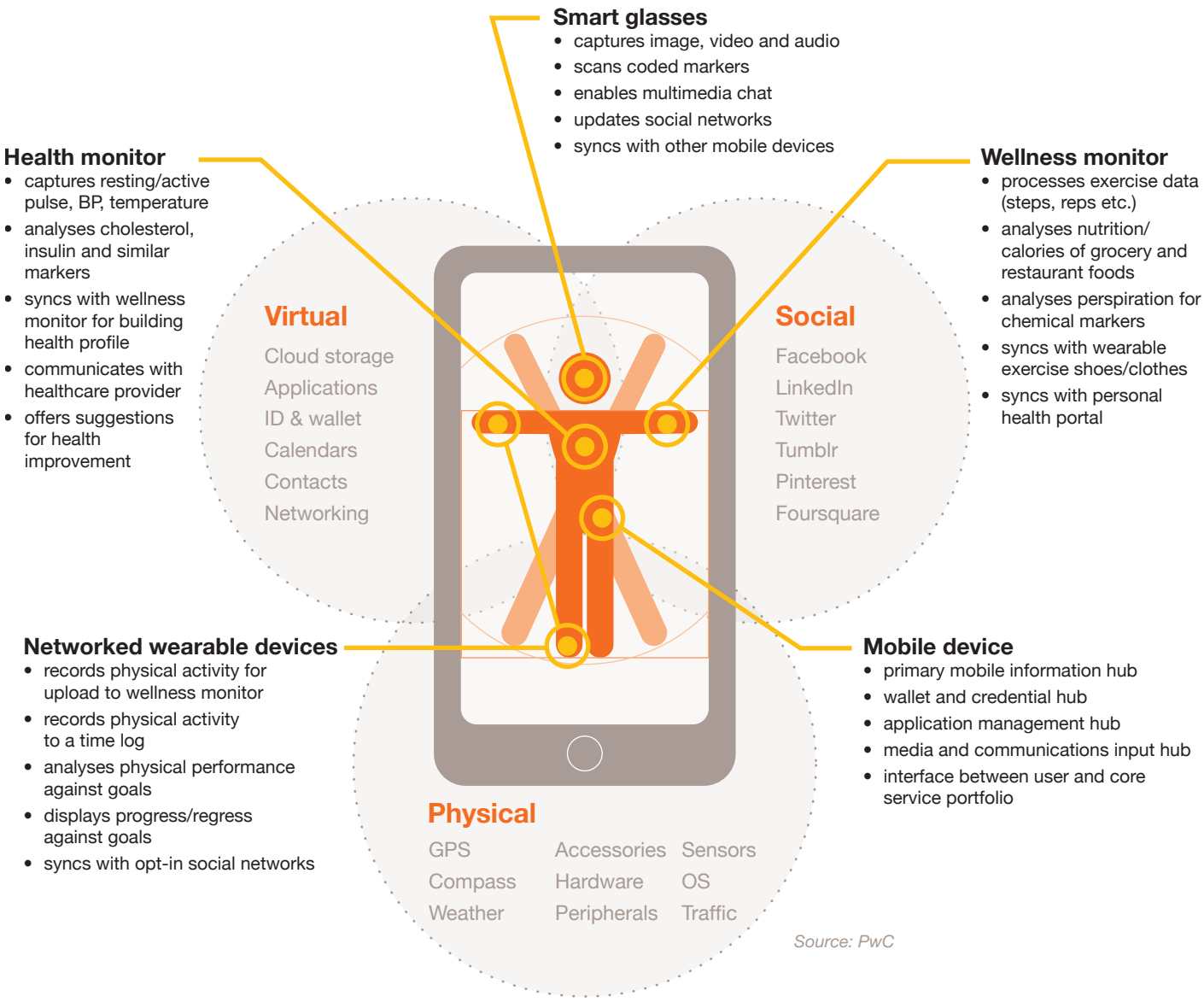
Daniel Eckert

Managing Director,
Emerging Technologies
PwC

As this process iterates, mobile devices and the supporting wireless infrastructure become far more than advanced communications tools. They become an extension through which a growing number of people participate in modern culture.

Compute-centric mobile participation goes beyond the idea of more people using more devices to communicate more frequently. Participation starts at the API level as mobile devices exchange information drawn from in-device sensors, plus information stored in the cloud or embedded in physical objects or landmarks. Participation also occurs at the user profile level, with mobile devices allowing people to broadcast preferences, intent or even telemetry about their physical bodies, location or social graphs. Finally, participation takes place at the aggregate level as more users with more powerful devices create and scale the feedback loops that power technical, economic and social ecosystems.

Figure 1: The contextual man



Source: PwC

The current situation

The first phase of the Mobile Innovations Forecast (MIF) introduced a quantitative model that analysed the rate of improvement in key technologies considered fundamental to mobile innovation. Readers of MIF Phase I have followed a steady stream of data and analysis regarding the likely trajectories of device and infrastructure connectivity; application processor speed; DRAM and storage improvements; as well as image sensor, display and mobile operating systems.

The rapid improvements in price and performance of these various technologies suggest that mobile innovation has become self-accelerating; that is, the results of each advance enable further advances to develop even more rapidly. But to what end are these innovations driving?

The next phases of the Mobile Innovations Forecast (New capabilities, New use cases, New business models) will attempt to answer that basic question. ■

Our research hypothesis is that new mobile capabilities to 2016 will enable mobile devices and services to become contextually aware and intelligent about end users in order to help them participate in modern life.

Given such profound technical and behavioural shifts, what knowledge of new capabilities is needed by the technology, telecom and media sectors to engage users for whom mobility is not just a physical fact, but also a state-of-mind? This is the core issue addressed by the next phase of the PwC Mobile Innovations Forecast (MIF). "Phase II, New capabilities," will identify and analyse the new technological advances—made possible by the enabling technologies covered in Phase I—that generate contextual intelligence from mobile users' physical, virtual and social environments.

PwC forecasts that the next phase of mobile innovation will revolve around capturing and modeling the contextual situation of mobile users. Such knowledge will become the primary resource for predictive mobile applications and services that will address mobile users' needs and desires in near real-time, and often before the users themselves reveal what they want.

As we enter Phase II of the MIF, PwC forecasts that the following new capabilities—each of which will be the topic of a future article—will form the basic architecture underpinning contextual awareness and intelligence in next generation mobile devices, networks, applications and services:

- Location and navigation
- Device sensors and user interfaces
- ID and security technologies
- Next-generation networks and clouds
- Mobile operating systems

These categories have always been part of the basic mobile technology stack. However, given the shift from communications to computation as the driving paradigm for mobile innovation, PwC expects that the purpose and nature of these technical categories will change dramatically.

This forecast exists within PwC's framework for understanding various dynamics affecting the broader technology sector. Mobile innovation is one of four market forces that are redefining customer demand, expectations and business opportunity for technology companies. The others are cloud computing, social technology or media and the emergence of intelligent devices. Individually, each is turning the rules of the broader technology sector upside down. Collectively, they are co-mingling in ways that paint a forward-looking picture that is starkly, even radically, unlike the past.

Context and companionship

The goal of Phase II of the MIF is to analyse which new technical capabilities help make mobile systems more context-aware, and which new capabilities help add contextual intelligence to users' interaction with their physical, virtual and social environments. Contextual awareness means that mobile devices are able to capture and analyse users' relationships to people, organisations, places and objects around them in the broadest sense, including but not limited to the proximate physical environment. Armed with such knowledge, a contextually intelligent mobile device or service can infer a user's needs, desires and even intentions without requiring the person to state them explicitly.

Contextually intelligent mobile services are fueled by data drawn at multiple levels. Some data streams are device, network or application-centric, while others are bound closer to individual

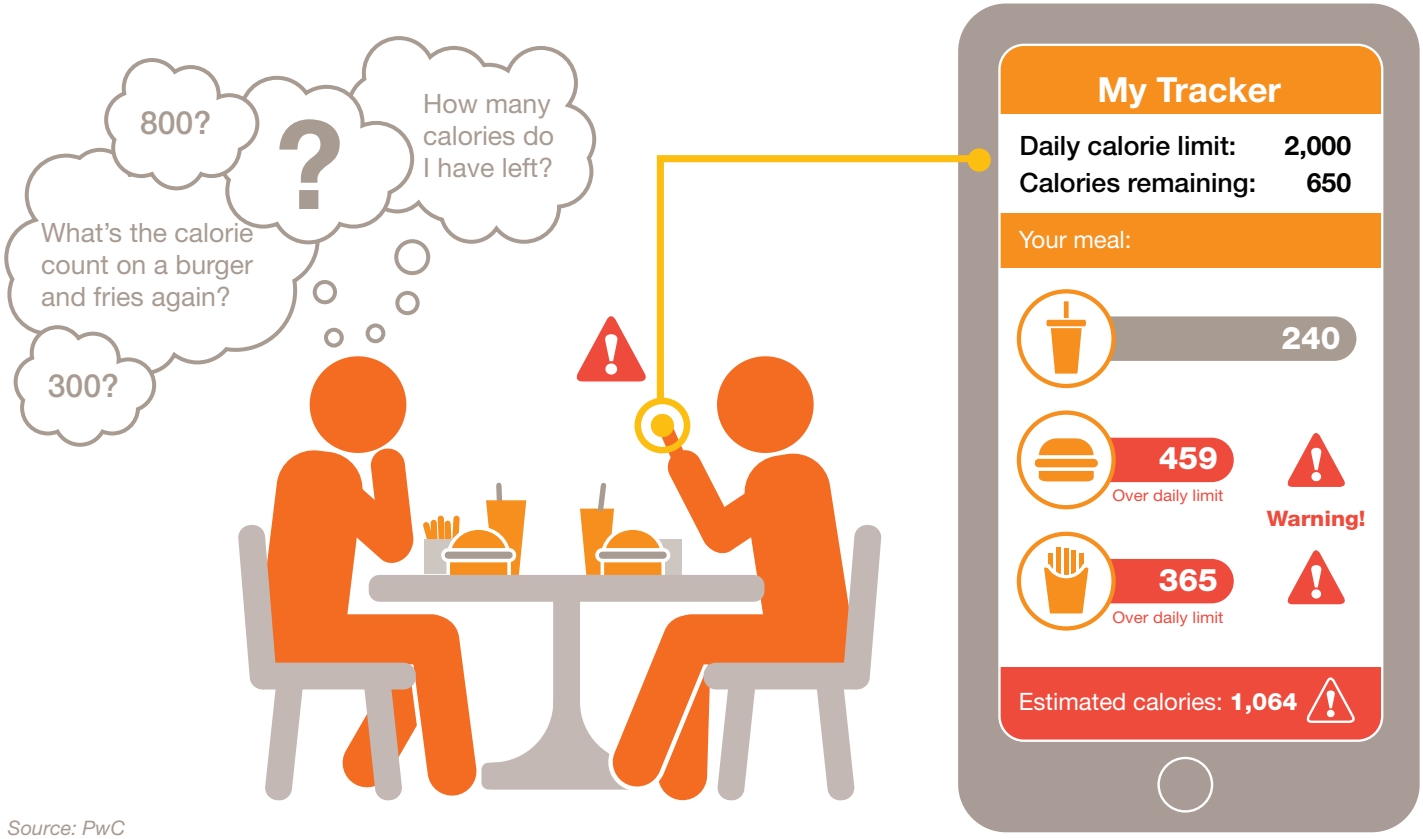
users, their relationships and their activities. The current consensus is that location and navigation data rank as first amongst equals within the palette of mobile contextual inputs for both opportunity and challenges. Other critical contextual inputs include user ID, device sensor data, data generated by networks and computing clouds as well as individual and social activity data by the user.

When thinking about contextual capabilities, it is useful to imagine the mobile device behaving more as a digital assistant than a communications and Internet access tool. A digital assistant tries to understand a mobile user's contextual situation to infer intent and to offer suggestions or services that help accomplish the user's goals.

One of the first steps for a digital assistant is to understand a user's immediate physical environment. Where is she located? Is the user stationary or moving? Is the device in a user's pocket, in a purse or in her hand? What other relevant landmarks or objects are nearby based on a user's prior experience or preferences? Who is nearby in the user's social network?

Such questions and many others help a digital assistant build a detailed simulation of the user's world. But contextual awareness and intelligence doesn't end with the digital assistant mapping a perimeter of interest points and objects around a user. A digital assistant must also utilise predictive models of the user's relationships to her applications, personal or preferred

Figure 2: A digital assistant



Source: PwC

information as well as her social world. What choices did the user make in the past in a similar situation? What are the user's stated preferences for this condition? What can be inferred? What did the user's friends or colleagues do in a similar situation?

The ultimate purpose for building models of observable entities such as environment and behaviour, and inferred entities such as relationships and intentions, is to help users optimise the choices they make. For any technology to succeed in adoption and use, it needs to empower a user to drive to a desired state. Consider health and wellness.[1] "Mobile digital assistants can provide patients with the information and immediate feedback loop they need to direct and reinforce desired behaviours," according to Chris Wasden, Managing Director and Global Healthcare Innovation Leader at PwC.

Chris Wasden

Managing Director and Global Healthcare Innovation Leader
PwC

For example, Japan's NTT DoCoMo launched a 'wellness phone' that includes a pedometer and health monitoring software. Data drawn from sensors in the phone is analysed and insights provided to the user along with advice on healthy lifestyle choices. Such a dialogue enables mobile devices and services to move beyond just utility functions (e.g., taking pictures of the food you eat) and move increasingly toward having an aspirational or lifestyle-centric relationship with users such as signalling when they are near their daily maximum amount of consumed calories.

PwC believes the ability for a digital assistant to join contextual information with a direct feedback loop distinguishes next-generation mobile devices from today's smartphones. We predict that more than simply storing data or processing applications, contextually aware mobile devices, applications and services will continually 'learn' about their users to provide better experiences the more they are used.

Context as a technical concept

According to researchers at the Georgia Institute of Technology,[2] context is any information that can be used to characterise the situation of an 'entity'—a person, place or object—that can be considered relevant to an interaction between a user and an application. For example, if a location sensor on a smartphone or tablet detects that a user is either in the United States or Canada, the search results in terms of distance to a point of interest can be expressed either as miles or kilometres. The

1 The rapidly evolving mHealth sector will be the focus of a future article in Phase III New use cases of the Mobile Innovation Forecast

2 Dey, Anind, and Gregory Abowd. "Towards a Better Understanding of Context and Context-Awareness" HUC '99 Proceedings of the 1st international symposium on Handheld and Ubiquitous Computing. (1999): 304-307. Web. 28 Nov. 2012. <http://smartech.gatech.edu/xmlui/bitstream/handle/1853/3389/99-22.pdf?...1>.

More becomes different

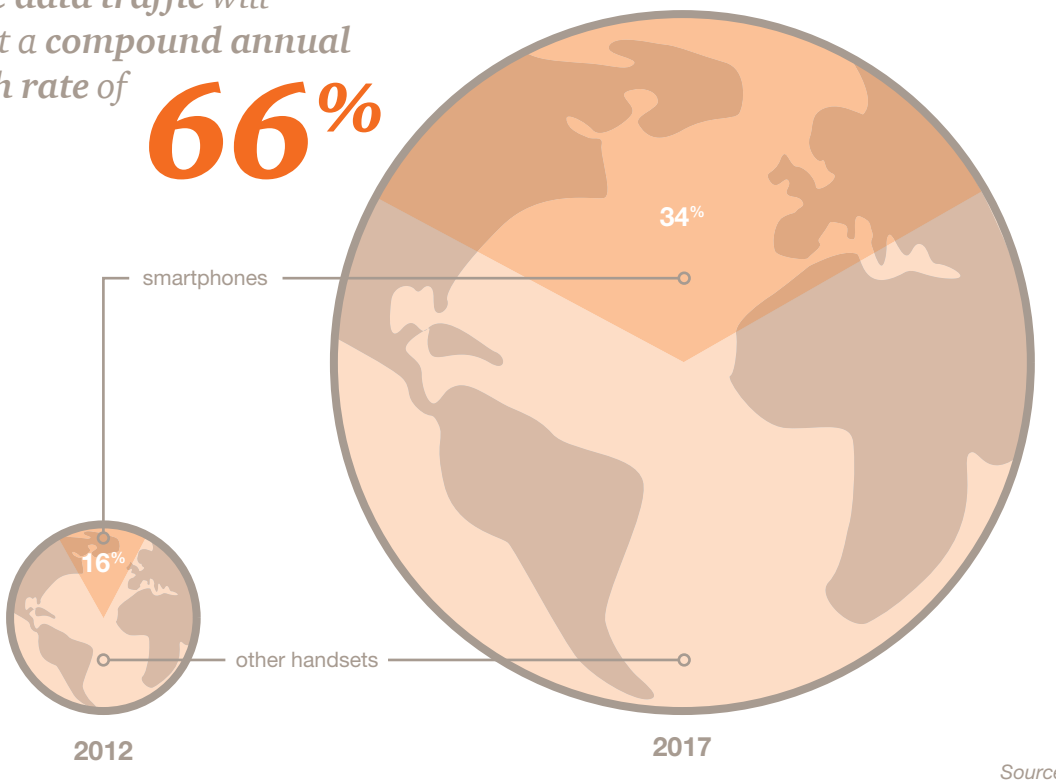
The most recent data from Cisco's Visual Networking Index Mobile Forecast suggests that we are well advanced into a smartphone-centric paradigm of mobile data usage.

Smartphones comprised less than 20% of total global handsets in 2012, but they were responsible for 92% of mobile data traffic around the world. According to Cisco, the typical smartphone in 2012 generated an average of 342 MB of data traffic per month, some 50X higher than a standard feature phone.

Cisco projects that mobile data traffic volumes will grow at a compound annual growth rate (CAGR) of 66% over the next five years to reach 11.2 exabytes per month worldwide by 2017, a 13X increase from 2012. There will be over 10 billion mobile-enabled devices by 2017, a combined figure larger than the world's projected population of 7.6 billion human beings.

Such a dramatic scale is changing the nature and scope of mobile innovation. New mobile capabilities on the supply side and broad, diverse markets on the demand side have started catalysing each other to grow faster and larger with each iteration. But even if we accept that mobile computing has become increasingly pervasive and self-accelerating, there remains the question—accelerating to what end? ■

Mobile data traffic will grow at a compound annual growth rate of **66%**



to reach ***11.2 exabytes*** *per month by 2017.*

Source: Cisco and PwC estimates

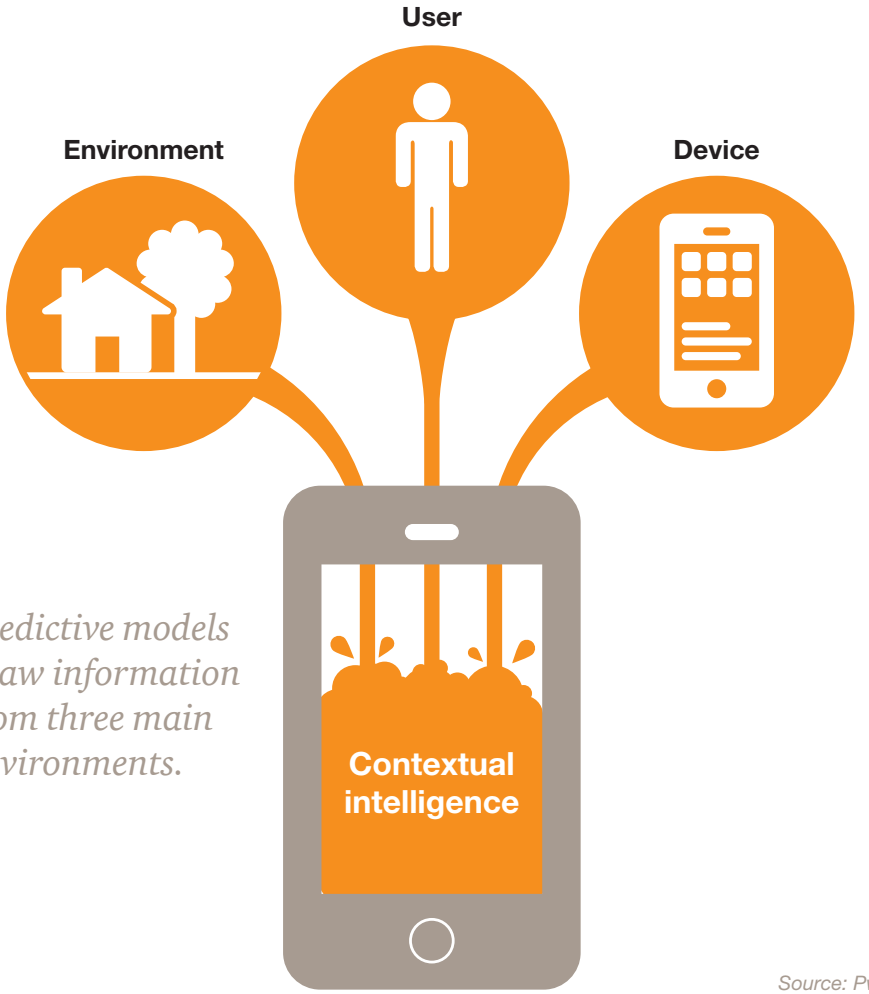
location data point not only describes itself (longitude and latitude), but it also becomes a contextual input to the display function of a mobile application (miles or kilometres).

Drilling further into how technical systems handle contextual inputs, another definition by Forrester Research[3] states that **context-aware technology** programmatically determines the use condition of itself and its user, and then adapts its own features and behaviour based on historical and current conditions, behaviour, preferences and circumstances.

Although both approaches provide a formal description of context for computing environments, they are limited by their attempt to capture as much as possible in a single definition. Rather than focusing on a single declaration of what context is, PwC believes that contextual intelligence in mobile computing emerges via predictive models that draw situational information from three main environments:

- The device environment (e.g., available power, OS, network, processing, storage, etc.)
- The physical environment (e.g., location, weather, lighting/noise levels, codes attached to physical landmarks or objects, etc.)
- The user environment (e.g., ID, applications, stored data, preferences, activity history, social connections, etc.)

Figure 3: Sources of contextual data



Predictive models draw information from three main environments.

Source: PwC

3 Ask, Julie A. "The Future of Mobile eBusiness is Context", Forrester Research. 1 May 2012.

Location is Ground Zero

It's clear that one of the most important contextual inputs is a user's physical location. Location has become a major driver for mobile application development. The providers of the main mobile operating systems (OS) such as Android, iOS, Windows and Blackberry, are fielding sophisticated APIs for app developers to pull location-based data into mobile apps. Giving developers better access to more granular location information will increase the richness of human-computer interaction and will open up opportunities to add value to more sophisticated user demands, especially navigating indoors.

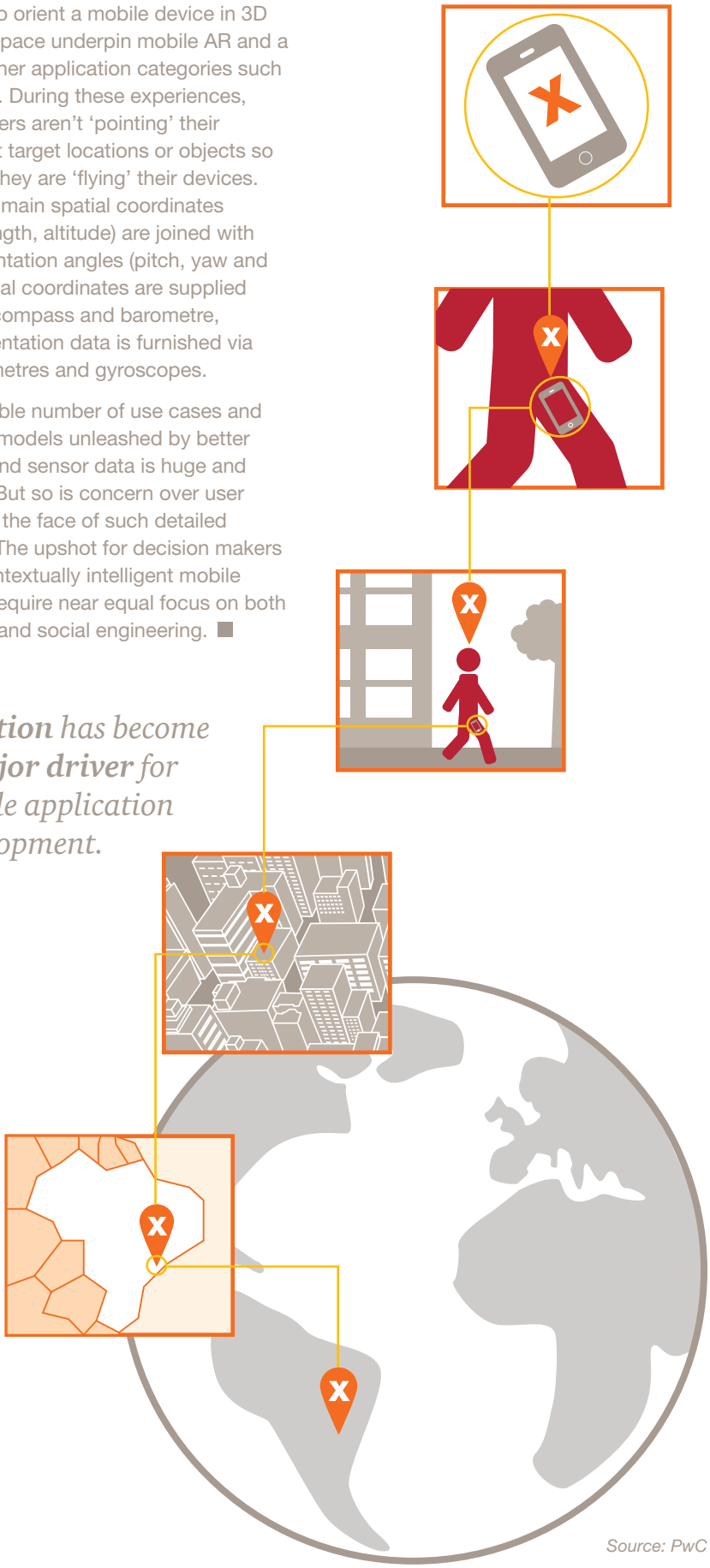
Indoor navigation is both a valuable application in its own right plus a contextual input into other mobile apps and services. Until recently, the price/performance of device sensors was a limiting factor, along with less advanced mobile OS and development environments. However, smartphones and tablets now contain more sensors than before.[4] The fusion of data from sensors such as GPS, compass, accelerometres, barometres, temperature and pressure gauges, promises better indoor wayfinding as well as scope for painting digital information onto physical landmarks and objects to enable new services such as mobile augmented reality (AR).

Popularised by new form factors such as Google Glass, mobile AR merges real-time digital information into a user's literal field-of-vision. The user simultaneously experiences physical reality with a digital overlay of information. The device displays information based on either image recognition of a specific target such as a Quick Response code (marker-based AR) or the more common version of mapping a device's location to a database of information targets attached to physical coordinates (markerless AR).

Sensors to orient a mobile device in 3D physical space underpin mobile AR and a host of other application categories such as games. During these experiences, mobile users aren't 'pointing' their devices at target locations or objects so much as they are 'flying' their devices. The three main spatial coordinates (width, length, altitude) are joined with three orientation angles (pitch, yaw and roll). Spatial coordinates are supplied by GPS, compass and barometre, whilst orientation data is furnished via accelerometres and gyroscopes.

The possible number of use cases and business models unleashed by better location and sensor data is huge and growing. But so is concern over user privacy in the face of such detailed tracking. The upshot for decision makers is that contextually intelligent mobile services require near equal focus on both technical and social engineering. ■

__Location__ has become a __major driver__ for mobile application development.



Source: PwC

4 Device sensors and their applications will be the topic of a separate article in this Phase II series.

These three categories characterise a mobile participant's situation regardless of whether that participant is another person, a place, an object, an application or a service. Depending on the expressed or inferred goal of the user, contextual information from one or more of these environments will be accentuated.

Going forward

This article launches Phase II, New capabilities of the Mobile Innovations Forecast. We will move up the innovation stack not only in coverage, but also methodology. Whereas the Phase I articles on mobile innovation analysed quantitative data drawn from the Mobile Technology Index, this series of Phase II articles will take a more qualitative approach based on deep interviews with mobile innovation thought leaders, both within PwC and the industry-at-large.

In terms of what readers can expect from these articles concerning new capabilities, we will build our analysis of context as a driving force from the ground up. There will be a series of follow-on articles which will:

- drill deeper into contextu-alisation as a technical and organisational concept;
- explore location and navigation as contextual inputs;
- examine the role of device sensors and new user interfaces that capture contextual information about the user and her surroundings;
- focus on ID and security issues affecting people, places and objects;
- highlight how next-generation networks and computing clouds allow contextual data to be stored and accessed in real-time; and
- look at how contextually focused services will impact mobile operating systems.

Granted there are numerous sub-domains to explore, but we feel confident that context-rich mobile experiences represent the future of mobile innovation. This isn't simply because contextual awareness and intelligence are now made easier through the sufficiently advanced technology identified in Phase I. Instead, we believe that the lasting impact of contextual technology lies in its ability to enable mobile technology to act more human. When that process works well, it does feel like magic.

Let's talk

If you have any questions about the Mobile Innovations Forecast or would like to discuss any of these topics further, please reach out to us.

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