Technology Institute

Mobile Innovations Forecast

Phase II Wrap-up: Context as a driving force for mobile innovation

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In Phase I of the Mobile Innovations Forecast, PwC tracked the recent performance history of the core platform on which mobile delivers value and forecasted its trend line. The purpose of this exercise was to analyse how advances in display technology, imaging, infrastructure speed, application processors and other components contributed to bursts of mobile innovation.

The results of continued improvements in the price and performance of these components and others go beyond just better, faster and cheaper smartphones. By attaching powerful sensors, cameras, microphones and other data-capture technologies onto mobile devices, objects and locations, people have begun to perceive the outside world as an interactive experience just like the Web. Consequently, the mobile communications and information technology sectors are experimenting with a new model of customer engagement that relies on customising and blending content, geographic information, sensor data and predictive applications into a real-time, highly personalised experience for the mobile user.

The core data resource that makes this blending possible is contextual information about the user. Contextual awareness of the user's current

Synopsis

This article concludes Phase II: New technological capabilities of the Mobile Innovations Forecast (MIF). The five articles in this series argue that mobile innovation to 2019 will revolve around capturing and modeling the contextual situation of mobile users. Such knowledge will power predictive mobile applications and services that will address users' needs and desires, often without users needing to request them explicitly. 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' mobile experiences. Subsequent phases of the MIF will analyse new use cases and business models that are responding and co-evolving with contextual intelligence capabilities identified in this work.

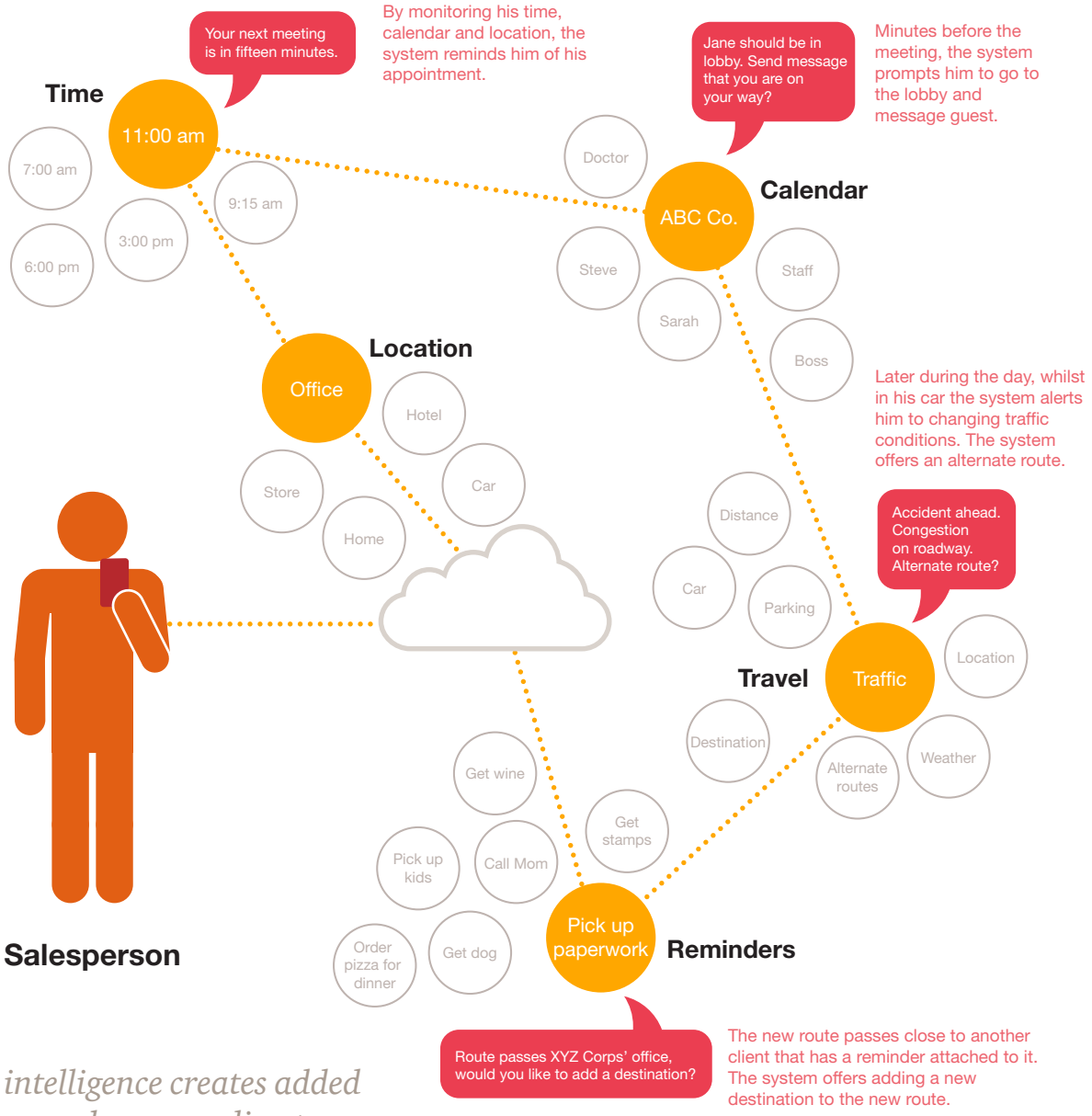
For new readers of the MIF, this forecast exists within PwC's framework for understanding the dynamics driving the broader technology sector today. Mobile innovation is one of four market forces that are redefining customer demand, expectations and business opportunity for technology and other industry sectors. The other tidal forces are analytics, cloud, social networking and the emergence of intelligent devices. Individually, each of these technology areas is transforming the rules for the broader technology sector. Collectively, these technologies are co-mingling in ways that paint a forward-looking picture that is starkly, even radically, unlike the past. ■

Day in the contextual life

The fundamental value proposition behind contextually intelligent services is that they learn more about the individual user the more often they are used. This leads to increasingly accurate and personalised suggestions or actions taken on behalf of the user by the system. Below are several example personas who interact with contextually intelligent services to navigate the decision points of their day, both physical and virtual. They are designed to be slivers of the possible contextual palette. Most people who live in the "real world" have more complex and layered contextual experience. The purpose of these examples is to show potential overlap of decision points where contextual intelligence can add value.

As users employ more contextual services for more daily tasks, the range and richness of their potential interactions will grow commensurately. ■

Day in the contextual life of a salesman



Source: PwC

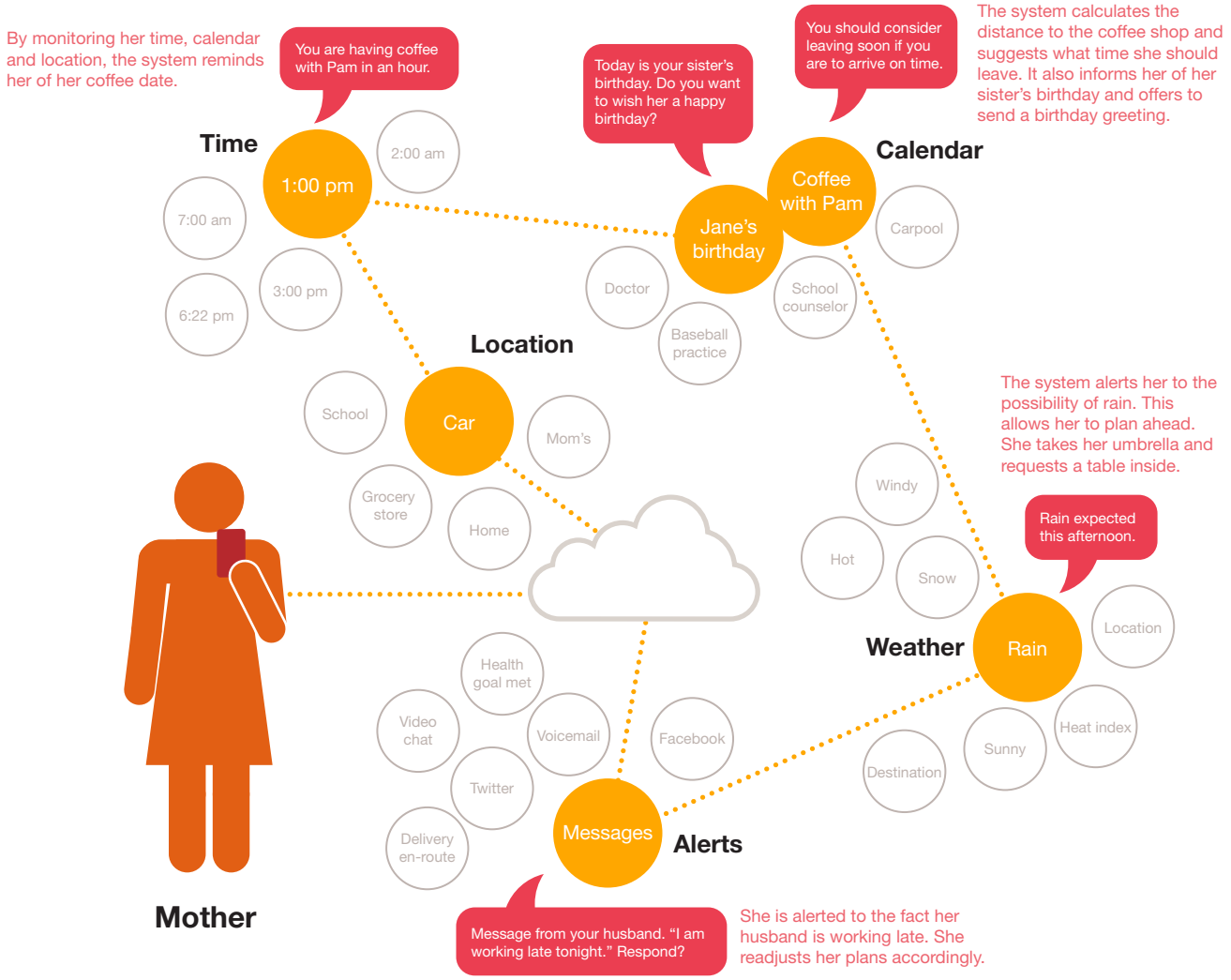
Contextual intelligence creates added value for the user by responding to unexpected circumstances with helpful suggestions for work-arounds or new opportunities based on real-time information and the user's past actions.

situation—where she is; what she likes; who she knows; how she has previously used a device or service and so forth—and having the intelligence to *act* on that knowledge, is becoming a core driver of innovation. PwC believes that the next few years will see mobile ecosystems reorienting around contextual awareness as a driving force for value creation.

But contextual awareness is only one side of the coin. Contextual intelligence is how service providers offer relevant content and functionality based on that knowledge. Contextual intelligence will drive new service experiences for users and thereby create new customer relationships. Not surprisingly, the competitive high ground for both mobile and industry-specific service providers will shift to leveraging personalised insight about the user from massive amounts of data generated by devices, locations, objects and stored information in the cloud.

At the industry level, contextually intelligent technologies and services will accelerate the merging of mobile communications with information technology, even as other industry sectors

Day in the contextual life of a mother



Source: PwC

In many ways, the mother's navigation challenges mirror that of the salesman. She has a busy schedule with many demands. However, her focus tends toward task completion more than appointments and meetings. Traffic affects her as much as the salesperson.

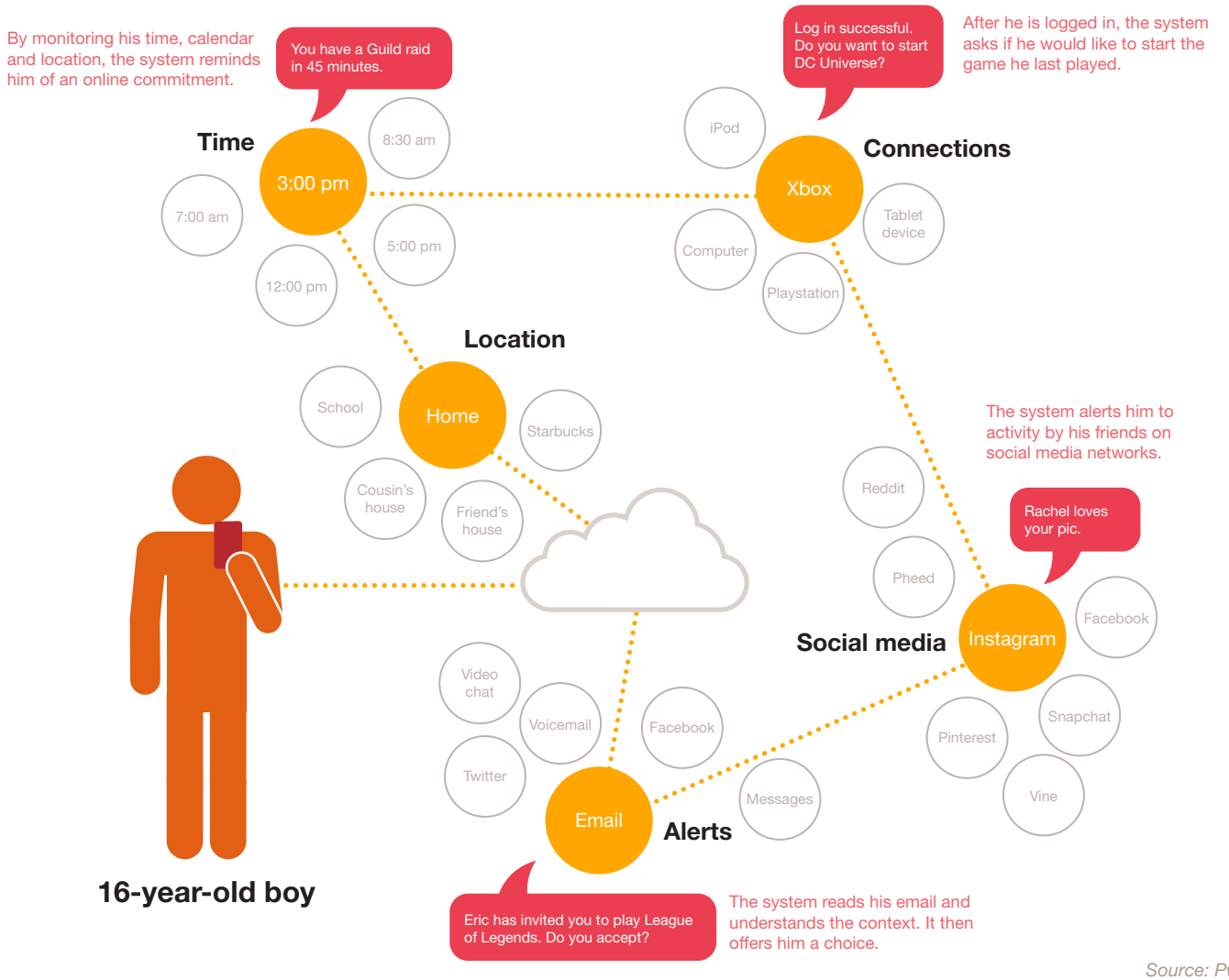
such as health, media, transportation and finance use contextual capabilities to integrate more deeply into mobile ecosystems. Contextually enhanced mobile devices, objects and locations will offer more than advanced communications or multimedia access. These systems will become on-ramps and exit points for entire service ecosystems that use mobile to engage their customers.

PwC believes that contextual awareness and intelligence capabilities to 2019 will emerge from the interaction of three core technical capabilities, as explored in earlier Phase II articles:

- Device and environmental sensors
- Programmable communications networks
- Natural language processing and machine learning

Each of these technical capabilities is powerful in its own right. Together, they enable a new type of cloud—a personal cloud of devices, information, applications, objects and locations surrounding the user wherever she goes. Dr. Paul Jacobs, executive chairman, refers to this personal cloud as a "digital sixth sense" because it uses contextual awareness and intelligence to augment a human being's five senses.

Day in the contextual life of a teenager



Source: PwC

Here the main contextual value revolves around integrating a personal profile across a range of interactive experiences. Many of these experiences relate to specific tasks such as games or school activities.

Device and environmental sensors

Device and environmental sensors create an accurate, robust depiction of the current condition of a mobile user. Applications can access and mine this data to adjust their operations automatically or generate suggestions or take action based on that user's condition. For example, a smartphone's calendar might indicate a 2pm meeting but at 1:50pm, the smartphone's accelerometer reports motion that is consistent with being in a moving automobile. The analytic/predictive model might suggest a standard "I'm running late" message be sent to meeting participants. The user can decide whether to send that pre-configured message, usually via a voice command.

Behind the scenes, sensor technology detects changes in physical, network and situational environments. Based on changes of state, a sensor communicates a signal to a processor or application that uses that information as raw material for a decision. Most low-level sensor 'conversations' within mobile devices and environments can be boiled down to "This is who, what and where I am right now, and based on my calendar information where I expect to be in the near future." Smartphones in particular are being loaded with sensors that measure temperature, barometric pressure and other environmental data that create a picture of a user's immediate physical situation. In turn, that information is matched with stored data about a user's activity history, personal preferences and other attributes to inform increasingly sophisticated suggestions and potential actions for the user.

As more sensors spread into more devices, places and objects, the smartphone is emerging as the core interface between a sensor-connected world and those who live in it. Service providers are instrumenting public environments such as sports stadiums and shopping malls with sensors and beacons, ID tags and other radio connected computing nodes. The goal for embedding sensors into devices, objects and locations is to enable the user to exchange information with her proximate environment to base a decision or get something in return.

The spread of sensors is really about connecting the power of the mobile device and the cloud with physical places and objects. Some call it the Internet of Things or even more grandly, the Internet of Everything. Regardless of word choice, in short order nearly every connected device or location will become a connected sensing node, a development with staggering implications for the mobile technology and services ecosystems.

Programmable communications networks

Communications service providers (CSPs) must now assume that every connected device is simultaneously a computing and sensing endpoint. It is a sensor-connected, visual media-centric world in which the user's personal cloud of devices, information and applications continuously interacts and exchanges data with numerous objects, locations and third-party provider clouds.

Making contextually aware and intelligent user experiences robust and seamless in such an environment requires significant network bandwidth to be sure. However, raw capacity alone is not sufficient to enable diverse mass-market contextual services. For that to occur, communications networks must become more than just fast data pipes. They must become 'smart' data pipes that connect situational data captured by the mobile device with data, analytics and applications across a service ecosystem.

This imperative will push cloud computing principles and technologies deeper into the design and operation of communications networks, thereby creating a new capability—the programmable network. Programmable networks are those in which software separates control of infrastructure elements from the underlying physical hardware to make a communications network behave more like a computing cloud. As such, communications networks become configurable services that are accessed via application programming interfaces. Some embedded functions, such as firewalls, become customer controlled and tailored services in their own right. However, the same firewall service might also become part of a larger customer-facing bundle, such as a live video health counseling session or a customer video conference with a tax professional.

Contextually intelligent mobile services are likely to accelerate adoption of programmable networks. As more sensor-packed mobile devices capture environmental data that must be analysed and returned to the user in real-time as a personalised, contextually relevant suggestion or action, the network infrastructure must handle communications traffic that exhibits high volume and high complexity.

At the technical and business levels, CSPs will use programmable networks to provide à la carte network services to third parties based on application or business requirements rather than the specific configuration of physical infrastructure. These third-party service providers (e.g., a bank) will engage users with various contextual experiences, at different price points and under different business models.

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One programmable network strategy being offered by CSPs revolves around a concept called networking slicing. A network slice is a logically isolated virtual network within the larger CSP network. The network slice offers its own service level guarantees that may span multiple data centres and network boundaries. Fundamentally, the network slicing concept brings to telecommunications the same model of on-demand, elastic resource allocation associated with cloud computing.

Natural language processing and machine learning

Whether users actively or passively exchange information with their devices and services, their contextual interactions whilst mobile are likely to be conversational rather than based on formal commands or menus. Consequently, a core capability for contextually aware and intelligent mobile services is natural language processing (NLP). NLP refers to the ability of a computing device to understand and converse in human language as human beings communicate with it. NLP is a hybrid discipline that combines expertise in computer science, artificial intelligence and linguistics. It is the technology and information foundation for the natural language interfaces used by virtual assistants like Apple's Siri, Google Now and Microsoft's Cortana.

PwC believes that broad adoption of contextual intelligence pivots on the ability of users to engage with their devices and services in a conversational

Figure 1: The network is the front door to the customer for many organisations

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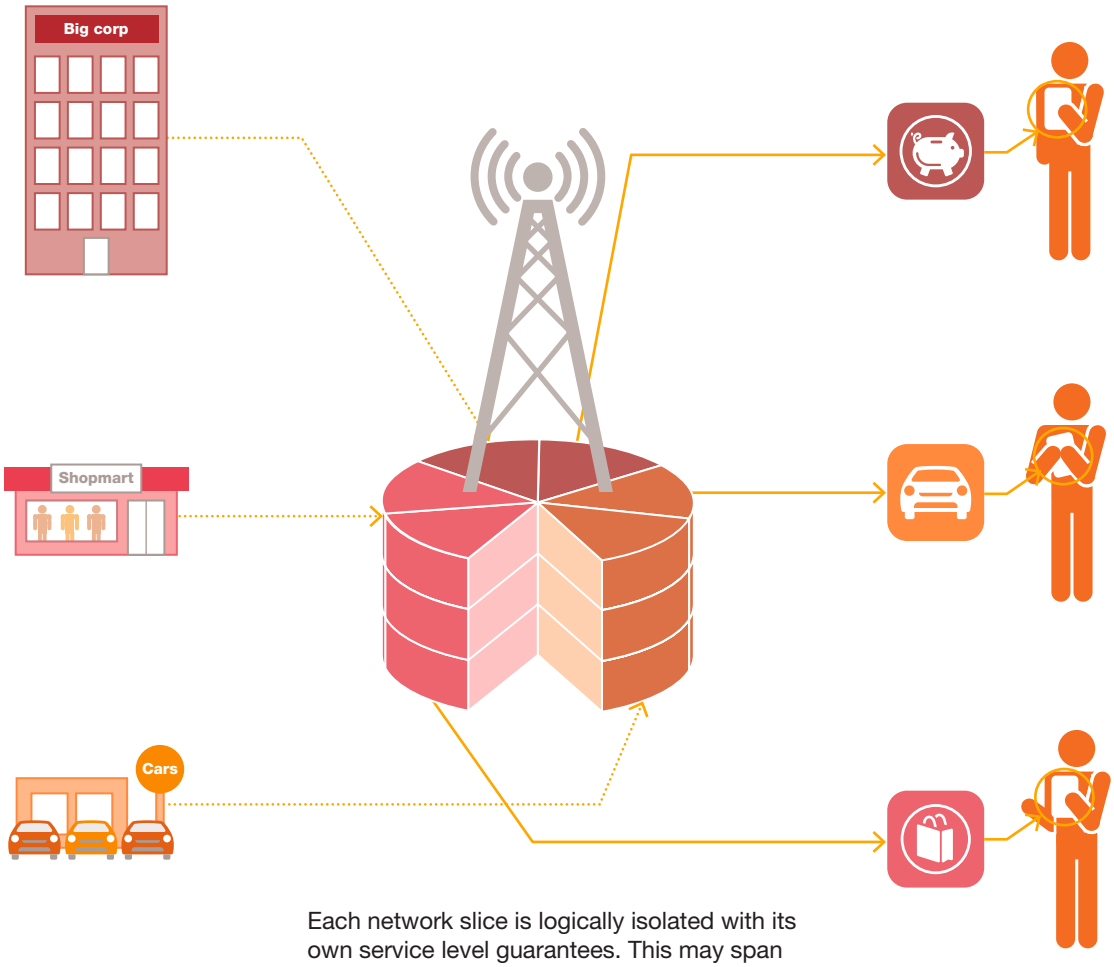

Each network slice is logically isolated with its own service level guarantees. This may span multiple data centres and network boundaries.

Source: PwC

manner rather than in a command and menu approach. Just as the graphical user interface transformed the desktop computing experience for ordinary people, and hyperlinking defined how people experienced the World Wide Web, NLP enables a fundamentally new interface between people, information and technology.

Whilst NLP creates a new model for human computer interaction, machine-learning capabilities create the 'decision intelligence' that enable contextual experiences in the first place. Machine learning represents a significant departure from traditional system development methodologies. For most of computing history, programs were built by distilling knowledge from human experts into a series of logical structures that enabled a system to respond in predictable, repeatable ways. So long as a target process lent itself to high levels of formalisation, the methodology worked reasonably well.

However, highly formal systems don't handle ambiguity or exceptions very well. Take NLP. Humans have tried and failed numerous times to develop a complete but manageable set of formal language rules that can handle the standard tasks and the exceptions of translation. Not only is human language rife with exceptions due to regional dialects and a host of other idiosyncratic factors, it is constantly evolving.

But by building a framework that enables software to start with some pre-programmed examples of previous, successful translations and then to compare those examples with a new sequence of words, a computer system might get closer to making a successful new translation. Add in scoring mechanisms for the system to track whether its current translation is closer or further from a target accuracy, and the system gains the ability to adjust its processing for the next translation attempt. Over time, the system will 'learn' to recognise statistically significant translation patterns that should grow in accuracy the more the system is used. In plain English, a machine learning system distills the rules it requires from the data on which it is exposed and trained, rather than having all that knowledge directly coded by the programmer.

Machine learning is foundational to contextual intelligence because it offers the ability to sift through vast data sets and classify preliminary patterns in a user's contextual data stream without direct human intervention. Sensor data logs, user transactions, check-ins, captured media, repeated location visits—these and many more will be sifted for patterns that fine tune predictive algorithms that anticipate, engage and perform actions for humans.

Based on these patterns, a key output of machine learning will be to place a human user into a contextual knowledge graph. This graph maps literal intelligence about the user's documented habits with relationships, classifications and genres derived from core contextual data such as location, ID, time and activity. This structured information is accessed by contextual applications for presentation to the user.

Machine learning in 2014 is focused mainly on improving NLP accuracy and performance. But the underlying principles of machine learning are applicable across the contextual value chain. It follows that the more contextual intelligence powered by machine learning is added to an interaction, the more sophisticated user behaviour becomes, which creates more opportunities to add value.

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A contextualised future

Historically, the innovative thrust of the mobile and computing industries has been to move communications and computing into ever smaller and more portable 'boxes'. Typically, mobile devices have held all of the computing elements of data, applications and connectivity in the same form factor.

In the book *Trillions: Thriving in the Emerging Information Ecology,* the authors declare that we are well on our way to a world of trillions of connected, computing nodes embedded in home appliances, mobile devices, wearable devices, physical locations and so forth. By the time this transition fully matures, connected computing won't be confined to any 'box' at all. Computation and data will be just an ambient feature of the user's environment.

This situation offers the mobile technology industry—for that matter, any service-oriented industry—one of its most pivotal design challenges and opportunities. Product design that previously encapsulated the entire value proposition into something for the user to accept or reject will evolve into something more akin to *process* design, through which users create and tailor their digital environments in which they live. Contextual information about the user, therefore, becomes a factor of production under this new model just like raw materials, labour and intellectual property.

In the coming months, the MIF will explore and analyse many of the implications for use cases and business models for the mobile ecosystem as this process demonstrates traction, not only in terms of market share, but in the far more substantial realm of changes in user behaviour. The opportunities are immense for a contextual future as are the challenges, both technical and social. But the inherent value of enabling users to converse naturally with their devices and services to get what they want, when and how they want it is hard to deny.

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 me.

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