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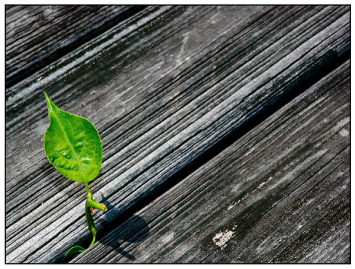

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Emerging Technologies

Welcome to the March 2014 issue of the *Technology Innovation Management Review*. This month's editorial theme is Emerging Technologies. We welcome your comments on the articles in this issue as well as suggestions for future article topics and issue themes.

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Overview

The *Technology Innovation Management Review* (TIM Review) provides insights about the issues and emerging trends relevant to launching and growing technology businesses. The TIM Review focuses on the theories, strategies, and tools that help small and large technology companies succeed.

Our readers are looking for practical ideas they can apply within their own organizations. The TIM Review brings together diverse viewpoints – from academics, entrepreneurs, companies of all sizes, the public sector, the community sector, and others – to bridge the gap between theory and practice. In particular, we focus on the topics of technology and global entrepreneurship in small and large companies.

We welcome input from readers into upcoming themes. Please visit timreview.ca to suggest themes and nominate authors and guest editors.

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Contribute to the TIM Review in the following ways:

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Editorial: Emerging Technologies

Chris McPhee, Editor-in-Chief
David Hudson, Guest Editor

From the Editor-in-Chief

Welcome to the March 2014 issue of the *Technology Innovation Management Review*. This month's editorial theme is Emerging Technologies, and it is my pleasure to introduce our guest editor, David Hudson, a lecturer in Carleton University's Sprott School of Business (sprott.carleton.co) in Ottawa, Canada, and Director of the Venus Cybersecurity Corporation (venuscyber.com) and the Lead To Win (leadtowin.ca) entrepreneurship program.

In April, the editorial theme will be Service and Innovation, and our guest editors will be Marja Toivonen (VTT Technical Research Centre of Finland), Risto Rajala (Aalto University), and Mika Westerlund (Carleton University).

Our May issue will be unthemed, and therefore represents a good opportunity to submit articles on any topic that fits within our scope. Please contact us (timreview.ca/contact) with article topics and submissions, suggestions for future themes, and any other feedback.

Finally, please note that Carleton University's TIM program and the TIM Review will be organizing a workshop on technology entrepreneurship and innovation for the first ISPIM Americas conference (americas.ispim.org), which will be held in Montreal, Canada, on October 5–8, 2014. I encourage you to read the call for papers (tinyurl.com/kqrp5od) and consider attending this unique conference.

We hope you enjoy this issue of the TIM Review and will share your comments online.

Chris McPhee
Editor-in-Chief

From the Guest Editor

In preparing to introduce this month's issue of the TIM Review, I was reflecting on emerging technology and the popular idea that the rate of technology change today is somehow greater today than it was in the past. I do not know whether the amount of change that businesses face today is more or less than in other eras, but I do know that the idea that emerging technologies can affect businesses and are often controversial – Do they matter? How can you know? What's wrong with the things that we do well today? – has long been studied.

In 1832, cholera epidemics were common, Darwin was sailing on the Beagle, Mendelssohn's music was found in new releases, Lewis Carroll and Charlotte Brontë were pop stars, the Rideau Canal between Kingston and Ottawa was newly completed, the source of the Mississippi was being discovered, and the practical production of electricity remained decades away. At the same time, coal-fired steam power had just moved into general commercial use and the method and value of turning iron into steel had also just been widely understood. This period is the heart of the Industrial Revolution and when the first World's Fair, "Great Exhibition of the Works of Industry of all Continents", took place in London a few years later, it was dominated by the fact as well as the hype of the application of steam-powered machinery to agricultural, manufacturing, transportation, military, utility, and other purposes (Grove, 1997; tinyurl.com/mlsk7ga).

In 1832, Charles Babbage also published *On the Economy of Machinery and Manufactures* (tinyurl.com/pq2v4zz). On the surface, Babbage writes about a range of significant and rapidly unfolding developments in manufacturing as steam-powered machines are put to diverse uses. Babbage describes many, then novel, applications of steam and how traditional manufacturing practices were inadequate compared to the new technology. He not only sees widespread industrial applications, he can imagine:

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- Computers: "The mechanical execution of such [a mathematical] engine … is not so far removed from that of ordinary machinery as might be conceived."

- Networks: "That the stretched wire might itself be available for a species of telegraphic communication yet more rapid."

- And even apps: "When the completion of a calculating engine [has taken place], the attention of analysts will naturally be directed to simplifying its application."

Despite Babbage's insight into technology and its potential uses, he makes a more significant contribution to discourse on how new technology disrupts business in the most general sense.

Babbage writes about a frame-breaking disruption to the manufacturing business practices of that day, a disruption that is no less significant than the arrival of the Internet at the end of the twentieth century. Consequently, although Babbage's exposition of all things mechanical as they relate to "manufactories" can be read as something of an *Industrial Revolution for Dummies* reference text, Babbage demonstrates a profound understanding that technology-driven change is significant to a wide variety of businesses and is likely to become more significant over time. In other words, Babbage writes as a consultant and provides sensible best practices for dealing with what is yet to come. He writes about the need for readiness for the change that can be expected even if it cannot be fully explained. He specifically compares the impact of machinery on factories to how steam inevitably makes sails obsolete and how it is necessary to see beyond the history, skills, infrastructure, and even romance associated with the old paradigm to embrace the new, noting: "It is the same engine that … weaves the canvas it may one day supersede" (Babbage, 1832; tinyurl.com/pq2v4zz).

Over a hundred years later, Schumpeter (1950; tinyurl.com/lmjcr5z) framed the advantage conveyed by technology as playing an essential role within the overall economic philosophy and practice of capitalism. In this view, new technology is not about optional or marginal improvement but is critical to competitiveness. His "creative destruction" is a process of imagination realized, with attendant risk of failure.

Later still, Rosenbloom and Christensen (1994; tinyurl.com/poqntys) would describe disruptive technology in terms of normal paths of incremental technological progress. They argue that disruptive technology is so because it is evaluated differently from previous technology and introduces new dimensions of performance. Disruptive technology creates the "innovator's dilemma" where incumbents often fail to capture new and more valuable markets because the technology obviates previous industrial practice, structures, and membership (Christensen and Overdorf, 2000; tinyurl.com/k27k7gk).

The topic of recognizing technology disruption as a business opportunity attracts ongoing inquiry and publication, in part, because it is far easier to identify disruptive technologies after the fact than before (Brynjolfsson and Hitt, 1998: tinyurl.com/k9ef54p; Danneels, 2004: tinyurl.com/n8wgfn7; Rosenberg, 1994: tinyurl.com/l3cgqmo; Tushman and Anderson, 1986: tinyurl.com/krgrrgn; Utterback, 2003: tinyurl.com/mpppw6l; Utterback and Abernathy, 1975: tinyurl.com/ncognj7). Babbage (1832; tinyurl.com/pq2v4zz) tackled the subject and argued for disruption of the established order at a time when Great Britain was the absolute global superpower in economic as well as military terms. He provides practical advice that can be applied today and is not dissimilar from contemporary advice.

For example, Babbage illustrated his treatise with examples of technology impact using descriptions of familiar products and processes for "easy access to the reader". His examples include books, bricks, machine parts, bolts, leather working, sheet music, boilers, mathematical tables, porcelain, jewelry, cutlery, bottles, watches, seismographs, and millwork. In other words, he takes an applied view and dwells little on the details of the technology. He is far more interested in the potential impact of technology. A modern example of similar advice is Monroe (2010; tinyurl.com/mokanur).

In considering the technology impact, Babbage argues for taking the broadest possible view of business operations. Chapter 12 of his book addresses the need to look at the complete operation and supply chain of the business: "The maker of an article [as] a manufacturer, in the more extended sense of the term, … must attend to other principles besides those mechanical ones on which the successful execution of his work depends". Keeley and colleagues (2013; tinyurl.com/mqzso5y) also explore how innovation potential exists throughout the entire operations of any firm and emphasize the importance of taking the broad view.

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Finally, Babbage uses first-hand experiences to understand technology impact and describes experiment after experiment. His exploration of technology potential involves working through implementations in the field. Deloitte (2013; tinyurl.com/cxjlq9o) also emphasizes the importance of experiments, trials, and prototypes in assessing technology impact. Babbage believes that hands-on field research leads to best practices by applying rigorous and forward-looking observational, data collection, and survey methods that consider business output and impact to employees. Babbage also encourages sharing within a community of practice to advance business practices using new technologies, noting that, "… many of these new … inventions, when their success is once established, become general amongst the whole body of manufacturers".

The articles in this issue provide a diverse set of examples of examining the impact of arguably disruptive technologies and how individuals and organizations can realize value from their use.

- **Chelsea Young's** article on HarrassMap considers how crowdsourcing technology can be applied to improve social services delivery at a very micro level and even social policy at a more macro level. Crowdsourcing has been applied for a variety of revenue-generating purposes, but this article highlights its potential to create other types of value.

- **Sarah Marshall's** article on IT consumerization in healthcare describes technology that is not necessarily disruptive in terms of its software and hardware but in terms of who chooses it and brings it into the workplace. The technology that people used when they BYOD ("bring your own devices") may or may not be emerging in the sense of being at the leading edge but they are disrupting workflows, business practices, and IT management, particularly in organizations that have a tradition of top-down control of IT.

- **Rebecca Neu's** article looks at innovation in biomedical technology that provides new approaches to treating serious medical conditions using 3D printing. The article suggests that this technology will do more than just revolutionize how hard-to-find or hard-to-produce industrial parts are sourced, it may bring the revolution to fields that never manufactured parts before.

- **GK Palem's** article examines what is, in fact, a broad set of technologies under the label of "big data analytics" and how companies can approach their use in a systematic manner. In an approach that Babbage would like, this article recommends building competence early by getting experience with the technology in use.

- The summary of **Arnold Kwong's** lecture highlights how cybersecurity is an opportunity space that has seen enormous technological innovation already. However, the growing rate and variety of threats argues that different approaches – that focus on different dimensions of performance and possibly disruptive technologies – are required.

- Finally, the summary of **John F. Tyson's** lecture on his experiences of the rise and fall of Nortel Networks illustrates the lessons companies can learn from past attempts to discover and commercialize emerging technologies.

Technology hype is not new, nor are some essential techniques for examining what technology can mean to business. It is possible that, as technology becomes more pervasive, the techniques for assessing potential impact need to be applied more broadly within organizations, particularly large ones with the greatest tendency to be caught in the innovator's dilemma. A critical eye is required but application understanding, a wide view of value creation potential, and hands-on experimentation may be as or more usefully applied by employees at large than by a small group charged with innovation and disruption.

David Hudson
Guest Editor

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About the Editors

Chris McPhee is Editor-in-Chief of the *Technology Innovation Management Review*. Chris holds an MASc degree in Technology Innovation Management from Carleton University in Ottawa and BScH and MSc degrees in Biology from Queen's University in Kingston. He has over 15 years of management, design, and content-development experience in Canada and Scotland, primarily in the science, health, and education sectors. As an advisor and editor, he helps entrepreneurs, executives, and researchers develop and express their ideas.

David Hudson is a lecturer in information technology and innovation in the MBA program at Carleton University's Sprott School of Business in Ottawa, Canada. He is a Director of the Venus Cybersecurity Corporation and the Lead To Win entrepreneurship program, and he is the Chair of the Advisory Board for the Province of Ontario Centres of Excellence Information, Communication, and Digital Media Sector. David also consults with F500 firms on innovation management. David's doctoral research at Carleton focused on IT consumerization and how employees create value for themselves and their firms when they "BYOD". Previously, he was the Vice President for advanced research and development at a large technology firm and has received Bachelor's and Master's degrees in Systems Design Engineering from the University of Waterloo, Canada.

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HarassMap: Using Crowdsourced Data to Map Sexual Harassment in Egypt

Chelsea Young

> *"Crowdsourcing is the process by which the power of the many can be leveraged to accomplish feats that were once the province of a specialized few."*
>
> Jeff Howe
> Contributing Editor, *Wired Magazine*
> tinyurl.com/lxbf7

Through a case study of HarassMap, an advocacy, prevention, and response tool that uses crowdsourced data to map incidents of sexual harassment in Egypt, this article examines the application of crowdsourcing technology to drive innovation in the field of social policy. This article applies a framework that explores the potential, limitations, and future applications of crowdsourcing technology in this sector to reveal how crowdsourcing technology can be applied to overcome cultural and environmental constraints that have traditionally impeded the collection of data. Many of the lessons emerging from this case study hold relevance beyond the field of social policy. Applied to specific problems, this technology can be used to improve the efficiency and effectiveness of mitigation strategies, while facilitating rapid and informed decision making based on "good enough" data. However, this case also illustrates a number of challenges arising from the integrity of crowdsourced data and the potential for ethical conflict when using this data to inform policy formulation.

Introduction

A recent report by UN Women found that 99.3% of women in Egypt report being sexually harassed and 49.2% report that this harassment occurs on a daily basis (United Nations, 2013; tinyurl.com/oxshu8h). This harassment occurs regardless of the women's age, their attire, or whether or not they elect to wear the hijab. Despite these alarming findings, victims of sexual harassment continue to face a high degree of stigma and shame. As a result, sexual harassment in Egypt goes largely unreported.

In 2010, Pennsylvania-born Rebecca Chiao decided to take a stand against the widespread sexual harassment of women on Egyptian streets, and with the help of several others, she developed HarassMap (harassmap.org), a crowdsourcing-based advocacy, prevention, and response tool that maps incidents of sexual harassment. Harassmap was inspired by the use of FrontlineSMS (frontlinesms.com) to distribute and collect information via text messages (SMS; tinyurl.com/d7mgla5), and it uses open source software that was originally developed by Ushahidi (ushahidi.com) for reporting and mapping incidents of post-election violence in Kenya.

HarassMap was originally launched as an initiative that was entirely run by volunteers. In 2012, the project received a two-year grant from Canada's International Development Research Centre (IDRC; idrc.ca) to explore the potential of crowdsourcing as a research methodology. This funding allowed HarassMap to bring on full-time paid staff; however, the initiative continues to rely heavily on its over 1000 volunteers (HarassMap; tinyurl.com/nwsojeg). At present, in light of the legal restrictions placed on the formation of civil society organizations in Egypt, HarassMap is currently operating as an incubated project of Nahdet el Mahrousa (tinyurl.com/k3b9tg4), an established civil society organization that provides capacity building and technical support to emerging social enterprises.

The data submitted by HarassMap users is used to support offline community mobilization campaigns that

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are designed to break down misconceptions surrounding sexual harassment, and it is used to challenge the social acceptability of such behaviour. By allowing victims to anonymously report sexual harassment, HarassMap hopes to overcome the cultural and institutional barriers that otherwise prevent women from reporting harassment. This innovative application of crowdsourcing technologies to address a social problem has proven successful in raising awareness and engaging community members to stop the taboo subject of sexual harassment in Egyptian society. HarassMap's success has garnered significant international attention, leading Harassmap's founders to provide coaching to activists in 28 countries and to assist in the establishment of HarassMap-inspired programs in eight of these countries (tinyurl.com/nm9ngm9).

In order to draw out some general lessons from this case, this article examines the application of this emerging technology in terms of its potential, limitations, and future applications. First, we examine the crowdsourcing technology and its potential impact at the individual, community, national, and global levels. Next, we discuss some of the limitations of this technology and their impact in the context of the HarassMap project. Then, we identify possible future applications of this technology. Finally, we conclude with insights into the potential of crowdsourcing technology to drive innovation in fields beyond social policy.

Potential Benefits

The most obvious potential benefit of HarassMap is to help individual victims and prevent others from incidents of harassment. However, further impacts may be felt at the community, national, and global levels, as discussed in the subsections that follow.

Benefits to individuals

At the level of the individual, the application of crowdsourcing technology enables HarassMap to overcome constraints that often prevent victims from reporting sexual harassment or from seeking the necessary support services to overcome trauma. This approach insulates victims from the social stigma and shame associated with sexual harassment, and it overcomes barriers in formal law enforcement channels that prevent the reporting and prosecution of these offences.

However, when considering the impact of this initiative on the individual, it is important to first discuss the nature of the problem that HarassMap seeks to address. Sexual harassment has a direct negative impact on women's mobility and participation in the public sphere. According to the Ilahi (2009; tinyurl.com/7rxu6hf), the fear of sexual harassment has led women to adapt their public behaviour by, for example, changing their appearance, avoiding eye contact with men, travelling only with a male companion, or restricting their movement to certain areas or times of the day. Unfortunately, this situation perpetuates a social construction of women devoid of sexuality and absent from the public sphere, and it leaves women vulnerable to accusations of blame for the harassment that they do experience if they have not conformed to traditional feminine roles linked to their behaviour and attire (Ilahi, 2009; tinyurl.com/7rxu6hf).

HarassMap helps to overcome these challenges by providing a platform where women can easily document instances of sexual harassment. Through the use of social media or SMS technology, women can share their experiences anonymously, free from the social stigma and accusations of blame. This model helps to facilitate social protection and greater social welfare by establishing a community of victims based on shared experiences.

The crowdsourcing model also allows victims to bypass institutional constraints within formal law enforcement channels that may prevent them from reporting incidents of sexual harassment. Such constraints are acknowledged in the Arab Human Development Report (2006; tinyurl.com/m5gpqr3), where it is noted that several Arab penal codes fail to adequately criminalize sexual harassment. Even when such behaviour is formally criminalized, Ambrosetti (2013; tinyurl.com/ptdaqab) explains that there is no guarantee that such laws will be able to overcome the "hegemonic perceptions and patriarchal norms" embedded in informal institutions to allow for their effective implementation. The absence of prosecutions of sexual violence against women is indicative of such a dynamic. This outcome is the product of a number of factors. First, such crimes are rarely reported to law enforcement officials for fear of retaliation, rejection, ostracism, or reputational damage (Aroussi, 2011; tinyurl.com/pe4b7t2). Secondly, individuals are often unwilling to come forward because they have little faith that anything will be done (Arab Human Development Report, 2009; tinyurl.com/ntggu3). Support for this second factor includes a report by UN Women (2013; tinyurl.com/oxshu8h), which found that 93.4% of sexual harassment victims in Egypt did not report incidents to law enforcement officials. According to Ilahi

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(2009; tinyurl.com/7rxu6hf), a major contributor to this dynamic is that police officers "are some of the worst harassers and therefore, it becomes pointless to seek help from them". This perception of the police also suggests the number of incidents of sexual harassment that are reported through formal channels may severely understate the magnitude of the problem.

Through the use of a crowdsourcing model, HarassMap is able to gather data on a sensitive issue that, despite being widespread, has received relatively little attention from formal law enforcement officials. The HarassMap example highlights a significant opportunity for further applications of this technology in environments characterized by strong organizational cultures or poor governance structures, where detection of specific issues may be similarly hindered by cultural or institutional constraints.

Community-level benefits

By publically documenting instances of sexual harassment, HarassMap helps to raise awareness among community members and challenge social misconceptions regarding sexual harassment. In Egypt, deeply embedded notions of gender inequality have perpetuated a view of women as a source of "social chaos" that has a corrupting influence on men (Ilahi, 2009; tinyurl.com/7rxu6hf). Not only do such notions imply that victims are responsible for the sexual harassment they incur, but they feed cultural practices that favour female purity, place women in a subordinate status to men, and make women vulnerable to forms of gender-based violence (Bowman et al., 2008; tinyurl.com/lndumc3). These perceptions have resulted in a number of formal laws and cultural practices that restrict women's access to the public sphere and effectively institutionalize sexual harassment (Arab Human Development Report, 2009; tinyurl.com/ntggu3). By documenting and reporting instances of sexual harassment, HarassMap helps to challenge the social acceptability of such behaviour and underscore the responsibility of community members to intervene to stop harassment. This data is then used to support HarassMap's offline community-mobilization campaigns, which seek to break down misconceptions that sexual harassment is limited to certain neighbourhoods or that it is only a problem facing women who wear revealing clothing. HarassMap's volunteers play a key role in accomplishing these aims by taking to the street to engage with community members to establish "safe areas" across the city where victims of harassment can find refuge. These community members are provided with training from HarassMap staff on the appropriate protocol when intervening to stop harassment. Currently, these campaigns operate on a monthly basis in 21 communities and 17 governorates in Egypt (tinyurl.com/klvl8bc). HarassMap also reports that approximately 80% of the community actors approached as a result of these initiatives have become involved in making their community a "zero-tolerance zone for harassment" (tinyurl.com/klvl8bc). Through these efforts, HarassMap challenges the prevailing discourse surrounding sexual harassment in Egypt and opens up a space for the development of informal support systems for women where victims can openly share their experiences in a safe environment.

Community-level lessons can also be drawn from the accessibility of HarassMap's model. By overlaying instances of harassment on a map with a marker that corresponds to the number of reports originating in these areas, HarassMap overcomes language and cultural barriers to communication, thereby allowing the message to be widely understood and dispersed (PSFK, 2011; tinyurl.com/6xcsag4). The visual representation of crowdsourced data has a positive impact on the usability and consumption of data among stakeholders, thereby improving the effectiveness of HarassMap's offline programming.

National-level benefits

At the national level, the information gathered by HarassMap may prove useful in facilitating prompt and informed decision making. The use of a crowdsourcing model permits HarassMap to quickly make available information that can be used to monitor the well-being of high-risk communities without requiring significant investments in human resources or infrastructure. Such a technology has tremendous potential for situations in which rapid response is a critical success factor (PSFK, 2011; tinyurl.com/6xcsag4). Crowdsourcing technology reduces lead-time, thereby allowing the data gathered on the platform to improve the efficiency and effectiveness of active mitigation strategies. For instance, by highlighting areas with frequent instances of sexual harassment, HarassMap can help law enforcement officials to allocate personnel more efficiently or to identify and arrest specific offenders. For examples of user reports, see the HarassMap interactive map: harassmap.org/en/what-we-do/the-map/

Global-level benefits

The success of HarassMap in Egypt has drawn attention to the issue of sexual harassment by international organizations engaged in development work, and has led

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to the development of similar initiatives in eight other countries (tinyurl.com/nm9ngm9). The spillover of this initiative into other locales is partially attributable to the adaptability and accessibility of the model. The prevalence of mobile technology in the developing world – in 2010, over 80% of the world's mobile devices were located in developing countries (United Nations Global Pulse, 2012; tinyurl.com/morpmnd) – has enabled HarassMap to overcome traditional issues of access and engage citizens to begin to address the collective issue of sexual harassment on a global level.

Given that mobile devices enable citizens in many different contexts to easily contribute to the initiative without significantly changing their routines, HarassMap's model may hold strong potential to enhance research on international development issues and transform the manner in which stakeholders engage in data collection. Crowdsourcing platforms represent an opportunity for researchers to overcome common barriers to data collection and gather "richer, deeper insights into human experience" (United Nations Global Pulse, 2012; tinyurl.com/morpmnd). For instance, by facilitating the rapid collection and organization of data, crowdsourcing can help researchers to provide analysis on current issues, thereby mitigating the risks related to the relevance of data. In contrast, traditional research methods carry a considerable time delay, which decreases the relevance of the findings as results become outdated. Crowdsourcing data may similarly prove valuable in mitigating environmental risks and ethical research issues. In areas prone to violence or in remote communities where issues of access may prove challenging for traditional data collection methods, such as surveys, crowdsourcing data can help to ensure the personal security of the researcher and the research subject. It is also possible that the anonymity afforded by such a model may prompt more individuals to come forward to share their experiences, thereby improving both the quantity and quality of the data generated from such platforms.

Reality and Potential Limitations

Despite HarassMap's noted success in raising awareness among community members and challenging prevailing norms regarding sexual harassment, there are nevertheless a number of limitations to this technology that may pose a challenge to accomplishing the project's goals.

The issue of security is particularly crucial given the problem that HarassMap seeks to address. For example, a common reality of such platforms is that the owner of the platform has little control over how the data will be used once it has been uploaded and published. Lloyd (2011; tinyurl.com/ornbt9y) draws attention to the risk that individuals who choose to share online reports on events relating to human rights abuses could be placed in significant danger should "oppressive officials" elect to identify the source of the data. This scenario draws attention to the need for platform owners to take precautionary measures to ensure the security of contributors. Examples of such measures may include protecting the anonymity of contributors and taking steps to anticipate how this data will be used once it has been published. (Lloyd, 2011; tinyurl.com/ornbt9y).

Indeed, HarassMap has implemented a number of precautionary measures aimed at minimizing such security risks. The most basic of these provisions is the anonymity afforded to the contributor. Upon filing a report, contributors are given the opportunity to provide a name and an email address (which remains confidential and is not published to the website), or they may elect to remain anonymous. These contributors are also asked to voluntarily attach a news report to their submission, if it is available. After the report has been submitted, it is examined by one of HarassMap's volunteers, who verifies the attached information and ensures that personal details, such as the name of the harasser, are omitted from the report before uploading it to the HarassMap website. Where corresponding evidence, such as a news report, has not been provided, a volunteer examines the report and, if it is determined to be reasonable, it is uploaded to the HarassMap website and flagged as an "unverified" report. This control relies on the value judgments of volunteers that have been trained to detect false reports. However, because this control process is not foolproof, there nevertheless remains a risk that the reports published by HarassMap may be inaccurate or false, which poses a number of risks for the project. First, a high incidence of unreasonable or inaccurate reports could undermine the integrity of the project and pose a serious risk to its sustainability. Second, false reports could be used by individuals to target specific neighbourhoods or demographic groups and, in extreme cases, may even provoke retaliatory violence. Given the potential impact of these risks, it is crucial that platform owners take responsibility for considering the potential uses of data and adopt measures to ensure that such risks are minimized.

Although such measures indicate a strong intent to provide assurance on the veracity of the data before it is

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published to the HarassMap website, the reality of the crowdsourcing model is that there is little that can be done to conclusively demonstrate the accuracy of large quantities of "good-enough" data collected in real time (Lloyd, 2011; tinyurl.com/ornbt9y). Goldman (2012; tinyurl.com/bwzn5lv) discusses these challenges in the context of a similar platform, Crisis Tracker, which mines crowdsourced data coming out of Twitter so that journalists and policy makers can rapidly make use of this information in crisis situations. Given the potential use of such data as evidentiary support in policy formulation, Goldman explores whether crowdsourcing platforms have an ethical or legal obligation to verify information before publishing it. Although Goldman (2012; tinyurl.com/bwzn5lv) acknowledges the shortcomings and risks associated with the use of this data, she concludes that to verify this information would require significant resources in the form of personnel and time, and that the appropriation of these resources may negate the benefits afforded by such a platform to begin with. In such a context, the organization in question must assess the risks and its own risk tolerance when deciding to publish this data.

Fruchterman (2011; tinyurl.com/pg7daqr) highlights an additional weakness of crowdsourcing data by noting that, where SMS technology is used to measure public violence, it is possible that the only reports registered will be those that have not been suppressed by aggressors. As such, the information gathered may reveal a false positive. He explains that it is likely that little information could be expected to originate in areas where technology or, more grimly, victims have been suppressed. As a result, such findings may provide the false indication that no violence has occurred in these areas, when in fact these areas are hotspots of violence. In the case of HarassMap, this scenario may by applicable to regions where there is a high level of stigmatization and shame facing victims of sexual harassment. Under such circumstances, this may produce an absence of reports from a geographic area that is, in actual fact, highly prone to such attacks.

There is an additional risk that the data gathered as a result of crowdsourcing may not form a representative sample. The assumption is that individuals with knowledge of HarassMap and access to mobile devices or computing technology may represent only a subset of the population. As such, the data gathered via HarassMap may not be indicative of the level of sexual harassment taking place in the community. This risk poses a serious challenge to the usefulness of the data gathered as a result of this platform. However, the increased availability of mobile devices in the developing world would seem to challenge any direct issues of access. What is more likely is that informal institutions and cultural constraints operating in these contexts may pose a greater barrier to the collection of representative data.

Although crowdsourcing data raises a number of concerns regarding integrity and quality of data, especially where such data is used to support policy formulation, some proponents have argued that the quality of this data may be "good enough" given its tremendous potential to facilitate the development of more responsive policy and to rapidly inform decision making in changing situations (United Nations Global Pulse, 2012; tinyurl.com/morpmnd). In this case, where the issue in question is highly taboo, the crowdsourcing model proves to be particularly adept in collecting hard-to-gather data.

Future Implications

Recently, social media platforms have been celebrated for their predictive potential, particularly those in the health sector. In Haiti, information coming out of Twitter accurately predicted a Cholera outbreak before officials had begun to understand what was going on (Hirschfeld, 2012; tinyurl.com/onmphev). In the case of HarassMap, it may be possible to prevent instances of violence against women using social media monitoring to identify high-risk areas through the flow of information, thereby allowing stakeholders to rapidly mobilize and target their resources most effectively.

A further extension of HarassMap may involve circumventing the need for individuals to upload their content directly to the platform. In its current state, HarassMap is dependent upon victims or witnesses having prior knowledge of the project and access to mobile devices in order to report sexual harassment. In the future, it may be possible to reduce issues of access by aggregating data coming out of multiple social media platforms, thereby enabling the mapping of sexual harassment without requiring participants to have prior knowledge of the HarassMap platform. However, given the vast amount of data available on such platforms, this possibility raises additional challenges such as organizing and making sense of this data and merging it on a common platform. It also raises additional ethical concerns related to privacy and ownership of information.

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Lessons Learned

This article has focused on the application of crowdsourcing technology to address the issue of sexual harassment in Egypt. However, many of the lessons emerging from this case study hold relevance beyond the field of social policy:

For organizations
The application of crowdsourcing technology in business has been celebrated for enabling greater access to internal expertise and knowledge (Guillot, 2013; tinyurl.com/kcfztn7). However, this technology may prove equally as valuable in enterprise risk management. For instance, crowdsourcing technology could be used as a tool to facilitate a holistic view of risk within an organization. By accessing "the wisdom of the crowd", crowdsourcing can be applied to raise awareness about risks that, on their own, may be triaged as low-priority but when aggregated reveal a very different story (Guillot, 2013; tinyurl.com/kcfztn7). As the case of HarassMap illustrates, the detection of specific issues or risks can be seriously impeded by cultural or institutional factors. In this sense, the application of crowdsourcing technology may prove valuable in navigating cultural and governance constraints to effective oversight.

Applied to specific problems, crowdsourcing technology can be used by businesses to improve the efficiency and effectiveness of mitigation strategies by facilitating rapid and informed decision making based on "good-enough" data. Similarly, crowdsourcing technology may present an innovative means for organizations to efficiently monitor the performance of high-risk projects.

For researchers
Perhaps the most notable advantage of crowdsourcing technology is the reduced lead-time associated with data collection. This factor carries enormous benefits for researchers. Crowdsourcing data enables researchers to provide insight into current issues, thereby reducing the risk associated with the relevance of findings. Where the issue in question is highly taboo, as is the case with sexual harassment in Egypt, the crowdsourcing model proves to be particularly adept at navigating issues of access and collecting hard-to-gather data. HarassMap illustrates how the use of mobile technology can further reduce these barriers to access and make it easier for actors to participate in research studies. This approach not only further reduces the lead-time associated with data collection, but it may also have a positive impact on the quality and the quantity of the data collected because this methodology minimizes the disruptive impact of the research on the participants.

Crowdsourcing as a research methodology may also be highly attractive from the standpoint of researchers engaged in data collection in remote or high-risk areas where traditional research methods may place the researcher in considerable risk. In such a context, crowdsourcing can be applied to reduce risks related to the personal security of the researcher and also the research subjects.

However, this case study has also highlighted a number of shortcomings related to the integrity of crowdsourced data, which may pose challenges for the application of this data in research studies. In particular, verifying the accuracy of crowdsourced data continues to be a concern that raises a number of ethical issues related to broader applications of this data. Despite attempts to screen this data for "reasonableness", as is the case with HarassMap, there nevertheless remains a risk that inaccurate information may be presented as fact and that the data may reveal misleading trends. IDRC is currently supporting HarassMap in investigating the usefulness of crowdsourcing as a research methodology.

For platform owners/entrepreneurs
The potential uses of crowdsourced data raise several concerns and potential risks for platform owners. Through a discussion of the potential consequences arising from the issue of the integrity of crowdsourced data, this case study has drawn attention to a number of ethical issues for actors engaged in collecting or disseminating crowdsourced data. Perhaps the most critical of these concerns is the issue of security. The case of HarassMap has underscored the responsibility of platform owners to ensure that this crowdsourced information does not cause undue harm to others. Platform owners must take responsibility for ensuring that unintended consequences are minimized. This difficult task may be made easier by implementing a number of controls, including screening reports for harmful content, flagging reports as unverified, and giving thoughtful consideration to the multitude of ways in which this information could be applied.

This case has also underscored the value in effectively communicating data and the impact that this can have on increasing the accessibility and consumption of in-

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formation. The manner in which HarassMap elected to communicate data had a profound impact on the usability of this information. The map itself serves as a helpful, high-impact visual aid for volunteers when they engage with community members regarding the problem of sexual harassment in their neighbourhood. This method of communicating data permits HarassMap to overcome language and cultural barriers to communication, allowing the core message of the initiative to be understood by a wide audience.

The question of sustainability is of critical concern to platform owners seeking to use crowdsourcing technology to address social problems. As in the case of HarassMap, the sustainability of these platforms as social enterprises may depend heavily on the benevolence of governments or multinational human rights organizations. Although HarassMap was able to survive for two years as an entirely volunteer-run initiative, it was able to expand the scope of its programming and thrive with external funding. Continued external partnerships that provide resources and support may be paramount to the project's survival, especially given that HarassMap continues to be a project and not a legal entity.

Platform owners that are not engaged in addressing social problems must nevertheless address the question of "who pays" for the costs associated with administering such platforms. This task may require platform owners in other domains to adopt innovative business models in order to generate revenue from an aspect of the platform.

Conclusion

Through the application of crowdsourcing technology to address the issue of sexual harassment, the case of HarassMap has revealed a number of unexpected lessons for researchers and practitioners. Whether this technology will prove successful in driving further innovation in this sector will depend largely on the risk tolerance of organizations in weighing the potential, the challenges and limitations, and the future opportunities of this emerging technology.

About the Author

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IT Consumerization: A Case Study of BYOD in a Healthcare Setting

Sarah Marshall

> *"Any change, even a change for the better, is always accompanied by drawbacks and discomforts."*
>
> Arnold Bennett (1867–1931)
> Novelist

The ubiquity and utility of mobile devices in the consumer domain has led organizations to consider the benefits and challenges of allowing their employees to BYOD, or "bring your own device". The consumerization of information technology is a natural transition considering that devices are now commonplace in the personal lives of employees; however, despite the potential benefits to both the organization and employees, the use of employee-owned devices raises issues relating to security, governance, processes, and even organizational culture.

This article focuses on the implementation of BYOD in a healthcare setting. First, the challenges of implementing BYOD in the healthcare industry are examined. Next, a case study of The Ottawa Hospital is developed to illustrate the practical benefits and hurdles that must be overcome when hospital staff begin using consumer IT devices in the workplace. Finally, recommendations are offered to help healthcare organizations develop and implement a successful BYOD strategy.

Introduction

IT consumerization, or the use of consumer products or technologies in the workplace, is an emerging trend in many industries today. Organizations choose to allow and even encourage their employees to "BYOD" (i.e., bring your own device; tinyurl.com/csmwf6e) in an effort to cut costs and increase employee engagement. When employees use their own smartphones, laptops, or tablets in place of distributed devices owned by their employers, they no longer have to carry multiple devices for work and personal use, and they no longer have to learn how to operate various makes and models of technologies.

As indication of the scale of opportunities, consider that, in Canada, there were 17,350,000 subscriptions for mobile devices in 2012 (Euromonitor International, 2013; tinyurl.com/lcde9pu), and it is expected that over 1 billion tablets will have been sold worldwide by the beginning of 2016 (Rafalin, 2012; tinyurl.com/ou7yhsh). Thus, organizations that are considering a BYOD implementation are likely to find that a great many of their employees already have their own mobile devices that could be used in the workplace.

A survey conducted by Dell (2013; tinyurl.com/oyv7zpz) found that companies that have implemented BYOD have realized a 74% productivity increase. In a hospital, such productivity increases could be seen, for instance, when tests are ordered online by a nurse and a physician must also log in to the system to provide approval. Without mobile devices, physicians typically have to compete for shared desktop computers or return to their offices to approve requests on their own desktop computers, thereby increasing the likelihood of further delays due to interruptions, emergency meetings, etc. With mobile devices, and especially BYOD, physicians can instantaneously approve tests or even order tests themselves, thereby minimizing the wait time for the patient and minimizing time required for follow-up by the nurses.

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Access to real-time information also ensures that all clinicians have the most current patient data, which is necessary for effective decision making (Rafalin, 2012; tinyurl.com/ou7yhsh). But, there are also benefits for patients, for example, who can easily be shown up-to-date images on a mobile device to better understand their condition or recovery. Of course, such benefits could be realized with hospital-owned mobile devices, but a hospital's efficiency and capacity to deliver these benefits is enhanced by BYOD.

However, there are a number of challenges to overcome when employees use their own devices, including security, compatibility, and data-sharing issues. These challenges are further elevated in the healthcare industry, where patient confidentiality is paramount. In this article, these challenges will be examined, and then a case study will provide a real-world example of a hospital providing mobile devices to its employees and then evaluating additional support for employee-owned consumer IT devices. Finally, recommendations will be offered to healthcare organizations considering support for BYOD.

BYOD Challenges in Healthcare

The key challenges for BYOD in a healthcare setting are introduced below. Although most of these challenges are relevant to the implementation of mobile devices in healthcare generally, in many cases the challenges are exacerbated by the introduction of employee-owned devices.

1. **Security:** the most critical risk factor for organizations implementing BYOD is the risk of security breaches. In healthcare, this risk is often focused on the security and privacy of patient information. The Ponemon Institute reported that, although 81% of healthcare organizations store sensitive patient data on mobile devices that are either owned by the hospitals or its employees, 49% of these organizations do not provide any security for that data (Rafalin, 2012; tinyurl.com/ou7yhsh). Furthermore, phishing scams (tinyurl.com/48zm2) are not uncommon in the industry, and employees are not always cognizant of how to detect them (Rafalin, 2012; tinyurl.com/ou7yhsh). Organizations are able to apply strict firewalls and security measures to their own devices; however, BYOD users are reliant upon their own security mechanisms and may be more exposed to viruses or malware if their own settings are not as strict.
2. **Governance:** for a BYOD program to work effectively, standardized protocols and clear guidelines for both employees and IT staff must be put in place. A survey by KnowBe4 and ITIC (2012; tinyurl.com/qzojgky) found that 71% of businesses that permit employees to BYOD have no official policies, which may prove confusing for employees and increase the risk to the organizations.
3. **Legislation:** in healthcare, there are strict regulations that companies must adhere to with regards to personal health information. For example, in Ontario, Canada, the Personal Health Information Protection Act (PHIPA; tinyurl.com/qy7pzno) and other associated laws provide stringent rules, including hefty fines that are levied whenever a organization's device is lost or stolen (Inside Counsel, 2013; tinyurl.com/k5axvdd). Technology exists to remotely "wipe" a device by deleting its data; however, this technology requires the device to be registered, and employees must weigh the benefits of using their own device at work against the need to comply with the organization's policies on the use and configuration of such devices.
4. **Device type:** an organization may limit the types of devices employees can use as BYOD (Meneghetti, 2013; tinyurl.com/luaklyl). An organization may stipulate that only devices from a particular manufacturer are allowed, either because of security risks, hardware interoperability concerns, or a requirement for particular applications that only run on particular devices. At The Ottawa Hospital in Ottawa, Canada, only Apple devices, including iPads and iPhones, are currently used, in part because the mobile versions of the organization's clinical and electronic health record applications were developed for Apple devices only (tinyurl.com/qz9er9l). As an example of security risks, McAfee reported a 76% increase in malware on Android devices in 2011, which calls into question the security features of the device itself (Euromonitor International, 2013; tinyurl.com/lcde9pu). The availability of devices in a particular form factor may also play a role: although Apple only has about a 20% volume market share of Smartphones, they have an approximately 50% volume share of tablets (Euromonitor International, 2013; tinyurl.com/lcde9pu). These considerations may affect an organization's decision of whether or not to support employee-owned devices; they must balance the desire to support a wide range of devices against interoperability and security

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needs. Also, they must consider the affordability of certain device types and the wishes of their employees to own particular devices. A related challenge is that BYOD programs have the potential to discriminate against those employees who cannot afford to purchase their own devices. BYOD is based in the assumption that employees are able to (and want to) purchase required devices and maintenance.

5. **Internet dependency:** the high dependency of mobile devices on Internet access requires effective contingency planning in the event of Wi-Fi downtimes or spikes in demand. In a hospital, not being able to access patient files in a time of crisis can be the difference between life and death. Furthermore, the use of employee-owned devices may overwhelm Wi-Fi networks due to their ease of transportation. Currently, the locations of computer workstations in hospitals are typically fixed, such as within certain units or rooms, so that the network and Wi-Fi demand in a given area is predictable and can be managed easily. An abundance of freely moving devices would likely change the Wi-Fi demand dynamics as staff move about the hospital with their devices over the course of a day.

Case Study: The Ottawa Hospital

The Ottawa Hospital (TOH; ottawahospital.on.ca) is the largest teaching and acute care hospital located in Eastern Ontario, Canada, and it is part of the Champlain Local Health Integrated Network (LHIN). Three previously individual institutions, the Civic Hospital, the General Hospital, and the Riverside Hospital were amalgamated in 1999 with the intention of providing patients with full care solutions. As such, services or specialities were able to be fully consolidated to one facility/location; this was a strategic move that enabled all relevant staff, equipment, and supplies to be located in one area. For example, all cancer care including research, surgery, chemotherapy and radiation, appointments, diagnostic imaging, and laboratory services are located at the General Campus. Staff at the hospital total approximately 12,000, including approximately 4,000 nurses, 1,400 physicians, and 900 residents. Additionally, as a teaching hospital, there are many residents and students that come to the organization for specialty training. As the largest hospital within the Champlain LHIN, TOH maintains some of the main repositories for documents, including patient history in their electronic health record system and diagnostic images in their picture archiving communication system. For these reasons, enabling clinicians to access healthcare information from any device connected to the Internet, whether a desktop computer in an office or a handheld mobile device is imperative.

Mobile Devices at The Ottawa Hospital

The traditional method for healthcare documentation and administration has always been based in paper – paper charts, paper order forms, and paper summaries of tests and procedures performed. In an attempt to become a word-class healthcare organization, ideally ranked in the top 10% in North America, TOH decided to focus on many goals, including quality and safety of care. To ensure high quality and safe outcomes for patients and also to remain on trend in business, TOH has begun to digitize their tasks. For the most critically ill patients, healthcare organizations experience approximately 1.7 medical errors per day (Maslove et al., 2011; tinyurl.com/kjnrfyj), such as when staff fail to administer medicine at the appropriate time or order incorrect tests. To reduce the likelihood of error, improve efficiency, and provide higher-quality healthcare, digitized systems have been or are continuing to be implemented to allow clinicians to view diagnostic test images on mobile devices, order tests from those mobile devices, an enable instant approval of requested orders. TOH has chosen to implement a computerized system that enables physicians to order tests using mobile devices, which they can also use to view the results.

To enable clinicians to use the newly implemented digital systems, TOH chose integrate mobile devices into their infrastructure. They chose Apple's newly released first-generation iPad device as their starting point because it provided an extremely portable device – as opposed to a laptop or a "workstation on wheels" (WOW) – that still had a sufficiently large screen. However, due to privacy considerations, a single iPad was registered to each physician. Although costly, this approach meant that a device could be remotely wiped in the event it was lost or stolen, and it also allowed additional security measures unique to the individual to be installed on the device. A pilot program with a select group of users enabled support services to learn how to manage unexpected issues. The success of the pilot program encouraged the organization to move forward with this strategy, the benefits of which are described in the profile of the TOH's experience on the Apple website: apple.com/ca/ipad/business/profiles/ottawa-hospital/

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BYOD at The Ottawa Hospital

The computerized physician order entry system was evaluated in the summer of 2013, with an emphasis on the impact on employees and how the system may have changed routine practices. The research yielded two results that are relevant to BYOD.

First, although the iPads were initially made available only to physicians and residents, nurses also perceived value in accessing patient information, ordering tests, and communicating with physicians using mobile devices. However, providing iPads to each nurse would be extremely costly, and the sharing of devices between shift workers might not be practical. A potential solution is to allow nurses to use their own devices as a BYOD extension of the existing mobile system.

The second result highlighted a more critical issue. Some residents complete what is known as a "visiting elective", where they come to TOH for a one- to four-week rotation in an area of specialty. As part of their duties in caring for patients, these residents must access patient information and order tests as required; however, because they will be at the organization for only such as short time, they are typically not provided with full access to computer systems, nor are they provided with an iPad. Instead, they may rely on other staff members to access the systems on their behalf. But, these residents can end up in situations where they are the on-call resident for an overnight shift. If a patient's status becomes critical, the on-call physician or resident is expected to order the required test using the computerized physician order entry system. Until recently, visiting elective residents were unable to complete this task on their own, but TOH is now providing visiting elective residents with access to TOH applications, even though they are not being provided with one of the hospital's devices or mobile access.

Prior to the pilot run with iPads for physicians, Apple devices were not supported at TOH. As of August 2012 at least, the hospital's policies still had not been amended to include statements of support for staff using Apple devices, and therefore compatibility and functionality were not guaranteed. Second-generation iPads were provided to staff prior to completion of full testing, which concerned some of the Citrix developers because they had not fully tested the device with current applications. Finally, requests by individual employees to participate in BYOD have increased steadily since the introduction of iPads at TOH. BYOD iPads are now supported, but the current program will only provide access to non-sensitive data, and users must register their devices with the identity and access management group. However, some prominent clinicians, mainly physicians, have signed non-disclosure agreements and can therefore access all data, including sensitive data, on their own iPads. However, they must permit TOH to wipe their device should it be lost or stolen. This access is not common practice, and employees are not encouraged to bring their own devices. If they do bring their own devices, they may be able to connect to the internet, but they are not able to log into patient file databases.

At TOH, the vision, security systems, and policies are not yet in place to fully support BYOD technologies. However, their early experiences with mobile devices have helped achieve two of their most valued goals: i) to become a paperless, digitized workplace, and ii) to provide timely, accurate, world-class care for patients (tinyurl.com/qz9er9l). BYOD has the potential to be the next step in the radical transformation the hospital is embarking upon.

Implementation Recommendations

Although challenges remain, the early experiences with mobile systems and BYOD at TOH have been encouraging. Should any healthcare organization such as TOH want to implement a full BYOD program, the following recommendations are offered:

1. Senior management and IT professionals must work collaboratively to design an appropriate mobile device policy that details codes of conduct and expectations. All staff must be made aware of these policies and the potential risks of BYOD to both the organization and the employees themselves.

2. Robust security systems and contingency plans must be implemented, taking into consideration any additional risks associated with employee-owned devices. At TOH, for example, the staff already use two-factor authentication grid cards, but security tokens may be required to provide enhanced security for a BYOD program.

3. Management must anticipate changes in workflows and routines and institute corresponding organizational change initiatives.

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Conclusion

As the experience of TOH demonstrates, IT consumerization can present challenges to organizations on two related but distinct levels: i) supporting consumer mobile devices in the workplace and ii) supporting employee-owned devices in the workplace, or BYOD. In both cases, the organization must put in place the necessary technical infrastructure to support mobile devices; in the case of BYOD, the organization must implement an additional layer of policy and technical support to manage the risks to privacy and security.

With the ongoing emergence of IT consumerization, the question is not whether or not to BYOD, but how best to manage its implementation to realize its benefits while minimizing its risks. In a healthcare setting, the security and privacy challenges of BYOD are paramount, and yet, the potential benefits of allowing employees to use consumer IT devices are tangible because they can impact not only the productivity of hospital employees but also the health of the people under their care. The case study examined here illustrates that the healthcare industry is making concrete progress, and we can expect to see an increasing presence of consumer IT at the bedside and throughout our hospitals.

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3D Printing: A Revolutionary Advance for the Field of Urology?

Rebecca Neu

> *"There's actually a major health crisis today in terms of the shortage of organs. The fact is that we're living longer. Medicine has done a much better job of making us live longer, and the problem is, as we age, our organs tend to fail more, and so currently there are not enough organs to go around. In fact, in the last 10 years, the number of patients requiring an organ has doubled, while in the same time, the actual number of transplants has barely gone up. So this is now a public health crisis."*
>
> Anthony Atala
> Surgeon and Professor of Urology
> tinyurl.com/pzyr55b

Over the past decade, 3D printing has garnered considerable attention due to its broad applications, its ease of customization, and its increasing affordability. What began as the straightforward replication of simple objects has now progressed into a sophisticated industry for the fabrication of detailed products, which stands to threaten conventional forms of manufacturing and change the face of consumerism. More recently, the technology has found a footing within the medical field with the promise of applying 3D printing for the process of organ generation. With the reality of an aging population, the need for replacement organs globally will increase proportionately, while the number of donors remains static. In the field of urology specifically, the need for organ transplants is ever increasing as the number of patients in renal failure continues to rise. This article reviews the development of biological 3D printing, or biofabrication, within the field of urology and examines both the pros and the cons of this emerging technology. The cost implications of this technology for healthcare facilities are considered, as well as the entrepreneurial opportunities that arise from the emergence and evolution of 3D printing.

Introduction

Not long ago, it was thought that space travel was beyond the scope of human capacity, yet astonishingly, technological advances allowed a human to walk on the surface of the moon in 1969 – a feat unimaginable to humans living a mere century before. Since that time, humanity has seen the emergence of a number of truly impactful scientific and technological breakthroughs such as the development of personal computers, the establishment of the World Wide Web, and the complete mapping of the human genome. In line with such impactful discoveries, research has progressed to include the concept of three-dimensional (3D) printing, which may be one of the top ten most disruptive technologies of the coming decade (Hyman, 2011; tinyurl.com/m9vdytj).

What is of concern to manufacturers is that the process of 3D printing has the potential to pose a significant threat to traditional forms of manufacturing. In fact, 3D printing has most recently been described as a sort of "futuristic hot glue gun" (Hart, 2012, tinyurl.com/8xosxgm). Such sophisticated technology is truly remarkable in that it provides access to items with complex interior designs using digital templates created using well-known computer-aided design (CAD), computer-aided

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engineering (CAE), and computer-aided manufacturing (CAM) software (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4). This technology is predicted to have a significant impact on consumerism, allowing customers to instantly manufacture a series of tangible items using readily available and inexpensive personal printing systems (Hyman, 2011; tinyurl.com/m9vdytj). This innovation will eliminate the need for consumers to travel to conventional "brick and mortar" stores to purchase physical products and will ultimately spark a retail movement which will transition from selling the physical (i.e., manufactured goods) to selling the virtual (i.e., paying for intellectual property or software files) (D'Aveni, 2013: tinyurl.com/puxnkgz; Hyman, 2011: tinyurl.com/m9vdytj).

Although the applications of 3D printing in the manufacturing world are evident and numerous, this technology has the potential to have a multitude of applications transcending numerous industries. As one can imagine, application of the art of 3D printing within the medical field, such as in the synthesis of replacement organs, could have the potential to effect significant social change.

The inherent benefit of 3D printing technology is that the resulting goods are completely customizable, where subsequent alteration does not require significant retooling but rather only involves changing small portions of code in a design file (D'Aveni, 2013; tinyurl.com/puxnkgz). This new approach holds significant benefits for the medical field, such as in the design of customized prosthetic limbs, for the generation of ceramic scaffolds for use in bone replacement therapies (Leukers et al., 2005; tinyurl.com/lswrb9s), and for applications in organ biofabrication, also known as organ printing (Kasyanov et al., 2011; tinyurl.com/kvfodab). As the world's population continues to grow as a result of extended life expectancy, there will be a considerable increase in the need for replacement organs (Atala, 2011; tinyurl.com/62ew9wl). In fact, over the past ten years, the need for organ transplants has doubled in number; however, unfortunately, the number of organ donors has remained static, leading to a global health crisis (Atala, 2011; tinyurl.com/62ew9wl). The advent of both open source and 3D printing technologies will allow physicians the world round to offer revolutionary and customized medical solutions to patients while mitigating the organ shortage crisis (Ozbolat and Yu, 2013; tinyurl.com/km8bqw5).

As a secondary consideration, the concept of biofabrication will become invaluable in the realm of teaching hospitals. Ready access to biologically perfect organ replicas via 3D printing could provide specimens from which medical students could be taught. These biological models would enable young physicians to hone their diagnostic and surgical skills (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4). Organ models derived from 3D printers could further be combined with 3D reconstruction technologies or virtual training in order to create opportunities for more multi-disciplinary training (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4).

In this article, the applications of 3D printing will be directly applied to the field of urology, focusing on the pros and cons of this technology in the area of organ generation. The benefits and challenges faced by medical facilities keen on adopting this technology will be investigated, and some of the entrepreneurial opportunities that such innovation creates will be discussed.

Application of 3D Printing to the Field of Urology

The current statistics regarding the possibility of renal disease and the number of patients living with the illness are staggering. In Canada, Turin and colleagues (2012; tinyurl.com/m2ugz22) estimate that 1 in 40 males and 1 in 60 females will develop end-stage renal disease in their lifetime. Furthermore, the number of patients in the end stages of renal disease has tripled over the past 20 years, with the greatest increase being observed among older patients (Canadian Institute for Health Information, 2011; tinyurl.com/pyy7rzd). In 2009, over 37,000 people in Canada were living with end-stage renal disease; approximately 3,000 of them were on the waiting list for a kidney transplant in 2009, but only about 2,000 kidney transplants were performed (Canadian Institute for Health Information, 2011; tinyurl.com/pyy7rzd). These patients must endure regular dialysis visits until a suitable organ can be located for transplant.

In a recent TED Talk, Anthony Atala (2011; tinyurl.com/62ew9wl) demonstrated the power of 3D printing in the field of urology by illustrating its potential application to the science of kidney regeneration. This technology holds significant promise, especially considering the high death rate and costs associated with treating the disease, as discussed in the next section. Atala's research demonstrated how large organs with complicated vascular systems are difficult to replicate, but given sophisticated 3D imaging technologies, physicians can gain an accurate representation of the organ's characteristics. A biological blueprint can then be formulated from which a new organ can be printed, employing the patient's own cells, in as little as seven hours (Atala, 2011; tinyurl.com/62ew9wl).

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The process of biofabrication is not unlike that of regular printing; however, it involves the deposition of living cells and other biological material that can be grown into new human organs (Song et al., 2010; tinyurl.com/pvyrdrx). Bioprinting is flexible in that it can accommodate a broad variety of materials including organ-specific cells, blood vessels, smooth muscle, and endothelial cells (Ozbolat and Yu, 2013; tinyurl.com/km8bqw5). If successful, this technology could ultimately revolutionize the field of nephrology, reducing or eliminating the need for kidney donation from living or deceased donors, and would eliminate complications arising from immune suppression and transplant rejection.

Managing End-Stage Renal Failure

Given the changing demographics in Canada and elsewhere in the world, healthcare systems globally will be further financially burdened in the coming years due to an aging population and consequently, medical systems will be severely strained as they attempt to meet the complicated and costly needs of their aging populations. As a result, the possibility of providing 3D-printed replacement kidneys presents an attractive solution for nephrology departments, thereby severing the long-term patient dependence on the department and its resources.

Currently, the annual cost to administer dialysis in Canada is around $60k per patient (requiring three visits a week to the hospital for haemodialysis treatments lasting roughly four to five hours each) where comparatively, a kidney transplant costs roughly $23k per procedure followed by $6k in annual costs for anti-rejection medications (Canadian Institute for Health Information, 2011; tinyurl.com/pyy7rzd). Further options exist such as peritoneal dialysis, which allows a patient to dialyze at home using a portable cycler and a series of solutions of varying concentrations. From the perspective of a hospital's nephrology department, this form of dialysis is preferable – second only to organ transplant – because it does not require the patient to come into the hospital three times weekly, is less costly, reduces the demand for dialyzing machines, and reduces the need for nursing staff. However, although less expensive than haemodialysis, this option requires daily dialysis (using a cycler) or multiple sessions within a 24-hour period (employing gravity) and remains a cost to the healthcare system while placing a social burden on the patient.

Considering the social and financial costs of current therapy options, the technology of 3D kidney printing holds promise for not only providing a superior quality of life for suffering patients but also reducing the long-term costs of care. In the sections that follow, the benefits and challenges of 3D printing within the field of urology are examined with a focus on the problem of kidney transplants specifically.

Benefits of 3D Printing within the Field of Nephrology

Improved survival rates and quality of life

Despite modern advances in medicine, 36 Canadians died of end-stage renal failure while awaiting a kidney transplant in 2012 alone (Sher, 2012; tinyurl.com/pw5haap). Unfortunately, this equates to 36 lives that could have potentially been saved by 3D printing technology, which could help meet the ever-growing organ demand and reduce the number of deaths from renal disease.

From a social perspective, being on dialysis is extremely debilitating. Haemodialysis, as an example, requires that the patient be dialyzed multiple times a week. Although this treatment must be incorporated into the patient's routine, it can be both physically and mentally exhausting. Dependence on a machine for one's existence can leave a patient feeling completely isolated and depressed. The surgical input of a port through which a patient receives their therapy can make simple tasks such as bathing or swimming either challenging or impossible. Ultimately, end-stage renal failure can leave a patient feeling completely helpless. The development of 3D biofabrication could reduce the waiting times for organ transplants, and minimize the dependency on dialysis for many patients.

More relevant models and less dependency on animal testing

The process of tissue regeneration is very complicated. The growing of organ tissues has been tested and improved upon using animal test subjects, typically mice and rats. The advent of 3D printing means that both scientists and physicians can come to more relevant results using biofabricated models while lessening the need for animal involvement as part of the research and development process (Hart, 2012; tinyurl.com/8xosxgm).

Reduction or elimination of organ waiting lists

There are 93,000 people in the United States (Danovitch, 2013; tinyurl.com/odrl7hf) and 3,000 people in Canada (Canadian Institute for Health Information, 2011; tinyurl.com/pyy7rzd) waiting for a kidney transplant. Unfortunately, as noted by Atala (2011; tinyurl.com/

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62ew9wl), the need for kidney transplants continues to grow while the number of donations has remained steady. The advent of on-demand kidney fabrication (in addition to other organ fabrication) should, in the short- to medium-term, reduce the stress on organ waiting lists and should eventually reduce the amount of time that patients spend awaiting an organ.

Elimination of organ rejection
When a patient receives an organ, from a living or a deceased donor, the organ is matched to the recipient based on blood- and tissue-type compatibility. Although significant advances have been made with respect to the development of post-operative kidney anti-rejection medications (Kidney Foundation of Canada, 2013; tinyurl.com/n5w4skc), organ rejection remains a hurdle that is difficult to overcome given the frequent lack of perfect organ match. However, the ability to print a living organ, with the appropriate vascular system built from the patient's own cells, nearly eliminates the risk of kidney rejection. The costs associated with both anti-rejection medications and hospital care for patients suffering from organ rejection would be substantially reduced.

Reductions in the illegal trade of organs
The scarcity of organs available to patients internationally has spurred an underground market for the sale of both organs and tissues. The need for organs is further amplified in some countries where formal programs for the donation of kidneys from deceased patients are hindered by sociocultural, political, or legal reasons (Shimazono, 2013; tinyurl.com/nmv5kw). The trading of organs across international borders is of considerable concern and remains a significant health policy issue for organizations such as the World Health Organization (Shimanozo, 2013; tinyurl.com/nmv5kw). However, using 3D printing technology to build replacement organs such as kidneys will help to increase the supply of viable organs and to meet the increasing international demand, thereby reducing the incidence of illegal "organ harvesting" activities for the black market.

Challenges of 3D Printing within the Field of Nephrology

Complexity of printing process
3D printing brings about images of technology with the same complexity as printing with an inkjet printer (Sangani, 2013; tinyurl.com/lb56t7d); however, the process of biofabrication is complex and requires many sequential steps. As described by Kasyanov and colleagues (2011; tinyurl.com/kvfodab), the process begins with the generation of a prototyping blueprint specific to the patient. Although kidneys are similar from person to person, each kidney bears unique features. This uniqueness requires the generation of a kidney design that is specific to each patient. Next, robotic printers follow the biological process of tissue growth using sophisticated bioreactors that accelerate the process of tissue maturation. To further complicate the matter, intricate vascular trees must be incorporated into the system in order to ensure viability of the organ once it has been printed. Altogether, the process is extremely complicated – far more complicated that the common examples of consumer 3D printing, such as printing a rubber duck or a replacement bolt.

Complexity of design software
Unfortunately, physicians cannot simply convert X-ray and MRI images into design templates from which biological scaffolds can be replicated. For example, due to shrinkage of the model after printing, a kidney's vascular tree – through which blood will be circulated –cannot readily be predicted (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4). Because such size changes cannot be accurately predicted and incorporated into a printing file, the design process needs to be iterative. The required interventions complicate the design and execution process while increasing the cost (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4).

Mimicking kidney functions
It is not enough to produce a structural replica of an organ; the new organ must be able to perform all its required functions before being transplanted into a patient. As an example, if a bioprinted kidney is incapable of secreting erythropoietin (which serves to stimulate red blood cell production), then the organ is worthless. In order for the printed organ to fully replace the real organ, complex structures containing cells of different types must be printed (Ozbolat and Yu, 2013; tinyurl.com/km8bqw5).

Potential trivialization
Some researchers have expressed the concern that the readily accessible nature of products via 3D printing will cause people to be careless with their health (Ratto, 2012; tinyurl.com/k4armur). The ease of obtaining a replacement item might encourage people to engage in risky behaviours, thinking that 3D organ replacements offer a quick and simple remedy. However, the availability of replacement organs must not be taken for granted and must not be perceived as an excuse for increased risky behaviour such as heavy drinking,

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which increases the risk of sclerosis of the liver, or smoking, which increases the risk of lung cancer. Even once the technology is further refined, the biofabrication of replacement organs, and the surgery and care associated with them, will by no means constitute a trivial solution and should not be regarded as such.

Technological limitations

Although the field of biofabrication has developed considerably over the past years and remains promising for the future, the technology surrounding 3D bioprinters is still in the developmental stages (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4). Even though there are many biological applications for the technology, most are not currently feasible given the existing technology limitations. The research field of tissue engineering has seen explosive growth over the past five years where testing is still primarily limited to animal specimens (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4). However, it is anticipated that such prototyping technologies will continue to be developed at an accelerated rate in the coming years.

A key area for further research focuses on the complex stages of organ replication, which must be strictly defined and standardized to improve overall organ quality and production efficiency (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4). Such standardization will allow physicians to benefit from the technology and to assist each other throughout the fabrication process. Given the numerous possibilities that biologically based 3D printing presents the medical field, research must become more multidisciplinary, bringing researchers, universities, private companies, doctors, research facilities, and biomedical engineers together via the collective exchange of information (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4). Cooperation among numerous disciplines will not only prove to develop the technology more quickly, making it accessible to deserving patients, but it will drive innovation as more applications are unveiled.

Recommendations to Nephrology Departments and Hospitals

Although much work remains to develop and refine the process of 3D printing for the biofabrication of organs, such as kidneys, hospitals should become engaged in the development and advancement of the research so that they may one day offer the fruits of this technology as solutions to their patients' needs. In the short-term, research funds would need to be allocated to researching nephrologists that can work collectively with other research facilities in refining the technology. Research objectives should include the development of sophisticated printers that have the ability to print cells or aggregates in a layer-by-layer fashion, for example, by sequentially depositing layers of a gel that is impregnated with a patient's cells (Mironov et al., 2003; tinyurl.com/lyywbus). Ozbolat and Yu (2013; tinyurl.com/km8bqw5) suggest a focus on improving cell and biomanufacturing technologies in addition to technologies for *in vivo* integration. However, one of the largest obstacles for 3D organ printing is vascularization, or the development of blood vessels within the printed organ, which is required to keep the organ viable and functioning after transplantation (Ozbolat and Yu, 2013: tinyurl.com/km8bqw5; Mironov et al., 2003: tinyurl.com/lyywbus).

Further, the adoption of such new technology will necessitate the standardization of kidney bioprinting techniques and design software. Such software, as previously indicated, can be very complex (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4) and is further complicated by the intricate nature of the body's vascular system (Kasyanov et al., 2011; tinyurl.com/kvfodab). As a result, significant financial resources would have to be expended by healthcare facilities to purchase such proprietary software in addition to providing in-depth training programs to surgeons. Such training programs should include the fundamental aspects of prototyping and bioengineering, given that surgeons would now be assuming the roles of bioengineers.

As with the introduction of any new technology, there is likely to be some degree of resistance, which may impede the adoption of the technology. Support from all levels of management and the identification of champions for the technology are key ingredients for encouraging adoption, as would be training and other opportunities to expose staff to the new technology.

Entrepreneurial Opportunities

As an emerging technology, 3D printing is a rich field for entrepreneurs. However, given the ongoing exploration into biofabrication using 3D printing technology, it is not possible to delimit the full scope of entrepreneurial opportunities in this domain. Thus, just a few examples of such opportunities are listed below:

1. *Printer supplies and maintenance:* Given the highly sophisticated and intricate nature of biological 3D printers, the printing apparatuses will require regular

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maintenance to maintain the highest levels of accuracy and precision. A company equipped to deal with printer maintenance could similarly provide repair services and printing supplies.

2. *3D print shops:* To take advantage of this new technology, hospitals may have to purchase bioprinting machines, which will further necessitate the construction of printing or manufacturing labs that would preferably be adjoined to operating rooms for utmost efficiency (Díaz Lantada and Lafont Morgado, 2012; tinyurl.com/p7k4xx4). Alternatively, hospitals could partner with third-party print shops that specialize in biofabrication.

3. *Research and development:* Currently, most 3D printing uses readily available materials, such as polyethylene, which are deposited layer-by-layer to yield a tangible object. Organ biofabrication, however, uses gels and matrices that are impregnated with donor cells and are then used in the printing process. Although, large pharmaceutical and biotechnology companies may come to dominate this space, opportunities exists for niche R&D companies.

4. *Software development:* Bioprinting software will require continual iteration and improvement as the 3D printing technology evolves and matures. Given that the scope of biological printing will likely continue to change, the need for specialized biological blueprint software will increase accordingly. As per the evolving nature of the technology, such firms could attempt to establish partnerships with researchers, bioengineers, physicians, and hospitals that are currently researching this technology. Such relationships could provide an opportunity for a company to grow and mature in conjunction with the technology. Software firms not only have potential to contribute to the early stages of software design but can also hope to seek long-term benefits by offering technical support and software training services to the hospitals that carry their software.

Conclusion

Although the process of 3D organ printing hold much promise for patients suffering from renal failure, the technology remains in the development phases. The replication of complicated venous systems embedded in most organs remains a significant hurdle and makes organ biofabrication more complicated than, for instance, the 3D printing of simple mechanical parts. However, these obstacles may be overcome in the near future through collaborative research partnerships.

Beyond the current paradigm of printing and then transplanting a biofabricated organ, the future holds the prospect of printing 3D mini-organs, which will fulfill only a certain lacking function of a major organ (Ozbolat and Yu, 2013; tinyurl.com/km8bqw5), and would not necessitate replacing the entire organ, thereby avoiding invasive surgery. Similarly, there is the prospect of *in situ* biofabrication, where a replacement organ would be directly printed into a patient while they undergo a surgical procedure (Ozbolat and Yu, 2013; tinyurl.com/km8bqw5).

Thus, the technology continues to advance at an astonishing rate, targeting human problems which were previously deemed to be insurmountable or even hopeless. Despite the challenges that remain, as time progresses, sustained research and development may continue to yield groundbreaking discoveries in 3D biofabrication to improve the lives of those suffering from renal failure.

About the Author

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Formulating an Executive Strategy for Big Data Analytics

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> *"Without big data analytics, companies are blind and deaf, wandering out onto the web like deer on a freeway."*
>
> Geoffrey Moore
> Organization Theorist and Author

The recent surge in big data technologies has left many executives, both of well-established organizations and emerging startups, wondering how best to harness big data. In particular, the analytics aspect of big data is enticing for both information technology (IT) service providers and non-IT firms because of its potential for high returns on investment, which have been heavily publicized, if not clearly demonstrated, by multiple whitepapers, webinars, and research surveys. Although executives may clearly perceive the benefits of big data analytics to their organizations, the path to the goal is not as clear or easy as it looks. And, it is not just the established organizations that have this challenge; even startups trying to take advantage of this big data analytics opportunity are facing the same problem of lack of clarity on what to do or how to formulate an executive strategy. This article is primarily for executives who are looking for help in formulating a strategy for achieving success with big data analytics in their operations. It provides guidelines to them plan an organization's short-term and long-term goals, and presents a strategy tool, known as the delta model, to develop a customer-centric approach to success with big data analytics.

Introduction

The idea of analyzing terabytes of data in under an hour was, for most people, unimaginable just a few short years ago. But, thanks to big data, it is a reality today. But what is big data? When trying to understand what big data is all about and how it helps any organization, the concept can be represented in two different ways: i) big data as a storage platform and ii) big data as a solution enabler.

As a storage platform, big data is a means of storing large volumes of data from a variety of sources in a reliable (i.e., fault-tolerant) way. For example, big data solutions can reliably store real-time data from sensors, RFID tags, GPS locators, and web logs, thereby enabling near real-time access to millions of users simultaneously.

As a solution enabler, big data offers distributed computing using a large number of networked machines to reduce the total "time-to-solution". For example, exploratory analysis on large volumes of credit card data to identify any signals of fraud, known as fraud detection, usually requires hours or even days to complete. But, with big data techniques, such complex and large computations are distributed across multiple networked machines all running in parallel, thereby reducing the total time it takes to arrive at a solution.

These two representations big data – as a storage platform and as a solution enabler – go hand-in-hand and lead to what is commonly referred to as "big data analytics". Thus, big data analytics enables an organization to reliably collect and analyze large volumes of data. Furthermore, by being domain neutral, the applications of big data transcend verticals, meaning that these concepts can benefit all domains.

Some of the prominent examples where big data analytics have been used successfully by the author include:

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1. Usage based insurance: Why should an aggressive driver and a decent rule-abiding driver pay the same amount of insurance premium? What if a good driver could receive discounts on their insurance as an incentive for following safety regulations that not only save lives but also reduce the driver's total carbon footprint? Usage-based insurance implements that concept by calculating the insurance amount based on the actual usage behaviour and not on preset calculations, made possible by monitoring the driver behaviour and providing incentives to the driver based on their driving habits, including even infrequent hard braking or sudden acceleration. As will be discussed in this article, big data's cloud-storage and stream-processing architecture makes this scenario possible.

2. Predictive maintenance: What if fleet managers knew beforehand how many of their vehicles were going to break down, say, in the next 100 days? And further, what if they not only knew how many vehicles, but they also knew which exact vehicles were going to break down and with which exact failure reason? Can they make alternative arrangements and save extra labour costs and repair costs and improve productivity? Thanks to big data analytics, it is all possible. Once again, the stream-processing architecture described in this article can be used to predict machine component availability and minimize downtime.

3. Epidemic outbreak detection: What if public health officials could analyze disease-causing factors and detect epidemics in real-time before they can spread out of control? One of our recent case-studies on public health data lead us to model the disease-causing factors and create an epidemic outbreak detection mechanism, all of which was made possible through the real-time stream-processing architecture for big data.

4. Sentiment Analysis: Retailers thrive on capturing market share with promotions, discounts, and sales leads. But often the voice of the customer is lost somewhere in the social media feeds and the real sense of "what works and what does not?" and "who is the potential customer and who is not?" is left uncaptured. What if an organization could capture all the social media data and monetize all the intentions to buy? What if they could gain unprecedented levels of insight into what exactly the customers are thinking about their products and which one of their competitors' products are stealing their market share? Text-mining algorithms applied to large social feeds make this possible when facilitated by big data analytics facilitates.

This list is by no means exhaustive, but each example draws upon the approach to big data analytics described in this article and depicted in Figure 1. And, these examples illustrate why big data analytics is one of the most prominent opportunities to emerge into mainstream computing in recent years. It promises easy adaptation "straight out of the box" to almost all sectors, such as healthcare, banking, retail, manufacturing, and so on, making it a very interesting opportunity for both information technology (IT) service providers and non-IT service consumers.

The cost-saving potential and new revenue opportunities big data analytics promises for businesses is another driving factor for its adoption. For example, a few of my own clients from the automotive domain that implemented big data analytics to manage their spare-part inventory and work-labour schedules based on condition-based monitoring and predictive maintenance in the recent years have reported an average of approximately 25% lower maintenance costs and 75% less machine downtime, along with overall productivity increases of 25% due to predictable work schedules and work-life balance. Similarly, customers from the retail and finance sectors are seeing new opportunities to gain customers through big data social media analytics and advanced recommendation engines capable of profiling and analyzing customers' shopping behaviours in real time. All these innovative cost-saving and revenue-generation opportunities are encouraging solution providers to include big data analytics in their service and product portfolios.

Although the general approaches to analytics have become familiar to most executives, the integration of analytics with big data presents new challenges. The key challenge is that this integration must occur in two places: i) with the real-time streaming data and ii) with the persistent historical data. Analytics then uses one or both of these datasets depending on the nature of the problem being solved and the depth of the solution.

For example, as shown in Figure 1, real-time streaming data collected from vehicles (e.g., to analyze driver behaviour) or shopping carts (e.g., to analyze the shopper behaviour) or patient health records (e.g., to detect epidemic outbreaks), is usually processed against a pre-stored historic profile data containing information such as other drivers' profiles, shoppers' profiles, disease-factor profiles, etc. The historic data is often large in volume, ranging from terabytes (1012 bytes) to petabytes (1000 Terabytes) based on the domain in question, and resides in a reliable cloud storage that is readily accessible across all data centres.

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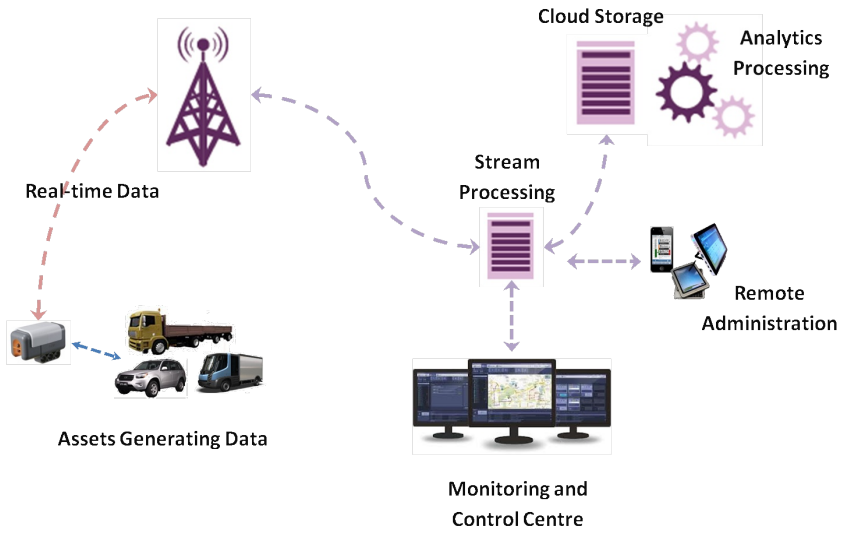

Figure 1. A typical schematic of a big data analytics solution

Processing the real-time data to identify any patterns similar to patterns in historic data is achieved through what is called stream processing. During stream processing, algorithms known as complex event processing (CEP) engines crunch the data that is streaming in real time to detect observable patterns of anomaly or significance in relation to the old data. However, sometimes, the old data may not be in a ready-to-use format (e.g., missing data points or un-normalized data set) and hence, has to be pre-processed before it can be used in the stream processing. This problem is resolved by having a dedicated analytics-processing unit that runs alongside the cloud storage, taking care of scheduling batch processes at regular time intervals to ensure all the data collected is pre-processed correctly and is in a readily usable state for the real-time stream-processing calculations.

The results of the stream-processing algorithms are then converted into statistical scores for computing a numeric index that can point to an actionable business insight, such as the eligibility of a driver for insurance based on an assessment of risk, recommendations or discounts for shoppers, alerting health administrative departments, and so on. The results are also stored in the cloud storage to act as the historical data for future data that comes in later.

A central administrative command centre will keep track of the whole operation to ensure operational compliance, and also take care of any alerts, such as taking actions to implement quarantine measures in case of epidemic outbreak signals, sending repair personnel to the breakdown spot in case of any machine or vehicle breakdown, etc. A well-designed big data analytics platform also allows remote administration capabilities, in addition to the centralized command centre, to allow the concerned personnel to be notified about any important alert or event no matter where they are, through the use of a mobile short message service (SMS) or other similar techniques, and let them take corrective action in real time, thereby reducing the total time to respond.

Big data architectures such as these have been proven to work reliably in a wide range of business cases irrespective of the domain, and they are the most basic setup required for any organization dealing with big data analytics. In the following sections, we discuss how to build such executive capabilities into their organization so that they can build similar architectural models and tools into their own operations, and how they can implement the required strategy using a customer-centric approach. Next, guidelines on laying out the short-term and long-term goals are presented, followed by competency-measure criteria to evaluate what it means to be successful in this big data analytics field. We conclude the article with a few remarks on some of the pitfalls to watch out for when implementing these techniques.

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The Vision

A typical vision statement for any big data analytics organization or division would be: "to become established as the leading big data analytics solution provider in the industry". However, there is one primary challenge that needs to be resolved before such vision can be realized. Although big data analytics transcends verticals in scope, with applications to almost all sectors ranging from automotive to retail to energy and utilities, operators in the respective sectors usually lack sufficient knowledge of its usage or benefits. Thus, many organizations have become aware that they need big data, but they do not know exactly what they need it for.

This gap between an organization's perceived need for big data analytics and its level of understanding about the domain creates a unique situation where the solution providers are now responsible for thinking about the requirement for the customers, instead of customer coming up with their own requirements as happens in traditional projects. This situation puts extra burden on the providers, because they have to provide not only solutions, but also the problems!

Even if the big data analytics solution provider somehow understands the customers' needs and comes up with a solution, there is no guarantee that the existing methodologies or solutions in place for the customer are compatible with big data solutions. Most of the operators in the field still use traditional systems and databases that are geared towards traditional processing and that are not suitable for real-time analytics or large-scale data processing. The cost and effort of integration alone can turn away many customers from embracing any kind of big data solution.

Such a challenge requires solution providers to educate their customers on the applications of big data analytics to their respective domains and provide solutions that are easy to integrate into their existing infrastructure. Thus, in the initial stages, an organization's focus should be on the *solution enablers* – either building solutions in-house or adapting open source solutions, such as: i) a stream-processing framework that enables customers to rapidly adapt their existing infrastructure for real-time analytics, and ii) an Internet of Things (IOT; tinyurl.com/5qr2nq) platform that enables solutions for cloud storage and big data analytics, seamlessly bridging the gap between their existing systems and big data solutions.

However, owning the solution enablers is just a small step towards building a foundation, and it alone cannot make the vision statement come true. A full and solid foundation has to be built upon and followed-up with medium- and long-term strategy goals to realize the grand outcome. The subsections that follow illustrate a sample set of short-, medium-, and long-term goals and the steps to be taken to realize each of these goals. Short-term goals are aimed at laying out the technology foundation and building a strong customer base for sustainable revenue generation, whereas the medium-term goals strive to support the delivery functions for retaining the acquired customer base and reinforcing the customer bond with high-quality outputs and optimal schedules. Long-term goals are aimed at leading the market with innovative solutions and strategic partnerships.

Short-term goal: Lay the foundation
The following immediate activities focus on establishing the foundation upon which solutions will be built:

1. Platform building: The stream-processing and Internet of Things platform should act as the foundation for big data analytics solutions to be built upon for customers from various segments. It should encompass complete end-to-end workflow starting from real-time event capture to end-user analytics and cloud storage in a demonstrable form to clients. Targeted list of customers should be used for marketing campaigns and workshops to showcase the platform capabilities in a way that is customized to their needs. Proposals for a proof of concept also should be developed.

2. Competency building: Big data analytics is a cross-domain endeavour, and competencies need to be built for various domains for which solutions are being targeted. Competency building should focus on filling the gaps between the customer requirements and resource competencies on identified verticals. This task primarily involves increasing the analysts' comfort level with the big data technologies and the platform workflow. The integration between the two technologies happens at this stage, and analysts should proactively build customer solutions in a demonstrable form while working closely with the big data platform leaders, and the big data teams should take the analysts' feedback into account when planning platform improvements.

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Short-term goal: Market penetration
Other immediate actions should focus on market penetration by improving the customer base and reach of solutions with pro-active solutions and promoted brand identity:

1. Proactive solutions: Initial response time is one of the key factors for high customer satisfaction ratings. Proactively identifying customer requirements and planning the solutions ahead, improves initial response times enormously and gives the impression of thought leadership. To start with, use cases should be identified and solutions should be proactively built for one particular vertical (e.g., automotive, healthcare) that the firm knows well and, once reasonable customer foundation is achieved, activities for the remaining verticals can be slowly expanded. Of course, if the organization is well established with enough resources and budget, it is also possible to start with multiple verticals in parallel, though in such cases, accountability and success tracking becomes a major and unnecessary burden. It is always suggested to start with identifying a core field of skill and then expand, rather than trying to tackle them all at the same time. Table 1 lists solutions that can be built for each different vertical and can be used as a starting point.

2. Brand name promotion: Brand loyalty often dictates market penetration and customer reach. Webinars, whitepapers, and research articles are a good way to expand the customer reach: they not only educate the customers but also promote brand name and associate leadership status to brand identity. Brand identity and customer education can be enriched by cultivating a publication culture among engineers. Organizations should also incorporate knowledge triage systems and encourage open knowledge sharing among teams both internally and externally, where possible. By putting their people first, creating an identity for them, and making them leaders, companies become identified as leaders in the market.

Medium-term goal: Architectural standardization
Organizations can improve the quality of the solutions and shorten the time to market through architectural standardization, as follows:

1. While developing cross-vertical solutions, recurring problem patterns should be identified and reusable tools and middleware frameworks should be created.

2. Variety in data is one of the main challenges for big data when dealing with cross-vertical solutions. In such scenarios, schema-neutral architectures capable of supporting dynamic ontologies should be designed and used for establishing standards.

3. Best-practice guidelines should be widely published and enforced among all teams to standardize the offerings and improve the solution quality.

4. Big data technologies are vast in scope, starting from large-volume data storage to real-time, high-velocity streaming and analytics. A culture of subject matter experts should be promoted and efforts should be made to increase the pool of specialist talent. These subject matter experts should be held accountable for the quality of solutions their respective teams deliver.

Long-term goal: Drive the leadership message
The organization's long-term goals should be aimed at establishing a leadership position in the market:

1. Big data technologies are still evolving and their integration with analytics platforms remains challenging. There is an urgent need for research on creating more seamless integration possibilities. Any organization that takes the lead in such research and produces viable options is bound to become a de facto integration leader.

2. Organizations should promote internal architectural practices and best-practice guidelines as industry standards. New optimized protocols for low-latency, real-time near-field communications are good examples of opportunities in the big data standards arena, which can serve as architectural best practice guidelines. Companies that promote and drive these standards in the initial days of the big data evolution can become established as industry leaders.

3. Partnerships should be sought with leaders in various segments and open challenges should be identified. Success in big data analytics requires strong cooperation between big data technology experts and leaders from various customer segments.

4. By developing innovative solutions for the identified open challenges, organizations can lead their industry.

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Table 1. Example list of big data analytics solutions for diffent verticals

Industry	Solution
Automotive	Fleet management • Predictive maintenance • Optimal workforce scheduling and inventory control Eco-routing • Sensor-based traffic monitoring • Emergency response and passenger safety
Healthcare	Public health • Real-time disease progression monitoring and epidemic outbreak detection • Healthcare cost predictions based on living conditions and dietary habits Clinical decision support • Health information exchange with electronic health records • Diagnostic assistance
Retail	Real-time asset tracking Supply chain monitoring
Finance	Usage-based insurance Real-time fraud detection Credit-score modelling
Energy/Utilities	Smart-grid usage prediction and dynamic load generation based on smart sensors Real-time monitoring of operational metrics for failure prediction

The Strategy

Clearly stated business goals lie at the centre of any successful organization. But what defines success? How should an organization be measured on its achievements? Typically, an organization is judged based on the quality of its "4Ps": people, partners, processes, and products. Although people and processes are internal to organizations, partners and products are external indicators of success, and more often than not, they serve as cross-comparison criteria. For organizations dealing in big data analytics, there are three broad categories of such comparison criteria:

1. Current offerings
   - Solution architectures
   - Data handling capabilities
   - Discovery and modeling tools
   - Algorithms
   - Model deployment options
   - Lifecycle tools
   - Integration capabilities
   - Support for standards

2. Solution strategy
   - Licensing and pricing
   - Resources dedicated to the solutions
   - R&D spending
   - Ability to execute the strategy
   - Solution roadmap

3. Market presence
   - Financials
   - Global presence
   - Client/customer base
   - Partnership with other vendors

Based on the span of operations fulfilled from the above criteria, the capabilities of solution providers are broadly categorized into three levels, which progress with increasing complexity and indicate the maturity of an organization in being able to deliver solutions around analytics:

Level 1. Data analysis services
- The customer provides data and pays for analysis insights derived from that data.

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- The insight outputs delivered to the customer are not reusable and are valid only for the particular dataset provided.

- If there is new data, the customer has to use the service again (and hence pay) for insights on the new data.

- The customer will not be aware of the tools used or methodologies applied in deriving the insight.

- There is no lock-in. When new data becomes available, the customer is free to choose any other service provider.

Level 2. Model-building services

- The customer provides a business problem and a sample dataset related to that problem, and pays for a model that solves the problem.

- The model output delivered to the customer is reusable for different datasets for the same problem.

- If there is a new business problem, the customer has to use the service once again (and hence pay) for new models that can solve the new problem.

- The customer will be somewhat aware of the tools used and methodologies applied, given that the model will be deployed onto customer systems and their staff will be trained to use it with different data.

- The customer is locked in only for the duration of the model validity. For new business problems, the customer is free to choose other providers for model building.

Level 3. Expert systems production

- The customer defines the business nature and pays for expert systems that can build models of any business problem that can possibly arise in the course of stated business operations.

- The expert system delivered to the customer is reusable for the lifetime of the business.

- The expert system will be capable of solving not only the present business problems stated explicitly by customer, if any, but will also be capable of predicting potential future problems and helping alleviate them even before they happen.

- Based on the licensing criteria, the expert systems delivered to the customer also would be capable of being applied to other business domains because the domain knowledge is separated from business data right in the architecture.

- The customer will have to be fully aware of the modelling techniques and methodologies to be able to derive most benefit out of the delivered expert system.

- The customer is locked in for the lifetime of their business. Switching providers is not easy or feasible.

Leaders in predictive analytics solutions are expected to offer a rich set of *algorithms* to analyze data, *architectures* that can handle big data, and *tools* for data analysts that span the full predictive analytics lifecycle. This diversity of offerings is achieved through competency building, architectural standardization, research drive cultivation, and other strategic drives, as presented below:

1. People
   - Competency building
   - Recognition and proliferation of subject matter experts
   - Research drive cultivation

2. Processes
   - Architectural review processes
   - Best practice guidelines
   - Reusable frameworks and tools for standardizing solutions

3. Partners
   - Educate customers on what is possible with big data analytics
   - Bridge the gap between existing customer solutions and big data requirements
   - Market penetration by laying out new industry standards
   - Brand name promotion with whitepapers, blogs, research articles, and webinars

4. Products
   - Reduce the initial response time with proactive solution approaches
   - Lead the pack by researching and implementing solutions for open challenges

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The grand strategy that encompasses all these activities can be summarized, for brevity, as a three-point triangle known as the delta model (Figure 2). The three options represented in the triangle are the milestones for the strategic vision. The strategy starts by aiming for the first point, at the right-hand side of the triangle, the *Best Solution* positioning.

Best Solution positioning
This positioning aims to become the best solution provider in the market. It acts as the base for attaining sustainable revenue for targeting next positions and instills a brand-name presence in the market with reasonable customer base. This, however, cannot be the final position for various reasons:

1. The position is rather inward and narrow, based on the prevailing product economics. Frequently the solutions are standardized and only restricted to Level 1, and the customers are faceless.

2. The way to attract, satisfy, and retain the customer is through the inherent characteristics of the solution itself. Quality of insights delivered and quick turnaround time are what make the customers come back.

3. Yardsticks for success at this level are the relevant competitors that the organization is trying to surpass or equate.

4. Commoditization is a real threat and is often an unavoidable outcome, because there is not much scope for innovation or creativity at this level; delivering Level 1 insights is vulnerable to imitation.

5. The measure of success is product share, which ultimately can fragment the business activities into a set of solution or product offerings.

Total Customer Solutions positioning
In the left-hand side of the triangle sits the option of *Total Customer Solutions*, which represents a 180-degree departure from the *Best Solution* positioning. In this phase, rather than selling standardized and isolated services/products to depersonalized customers, the organization will be providing Level 2 solutions consisting of a portfolio of customized products and services representing unique value proposition to individualized customers. This positioning improves the customer bonding and provides a continuous stream of revenue to enable experimentation, as follows:

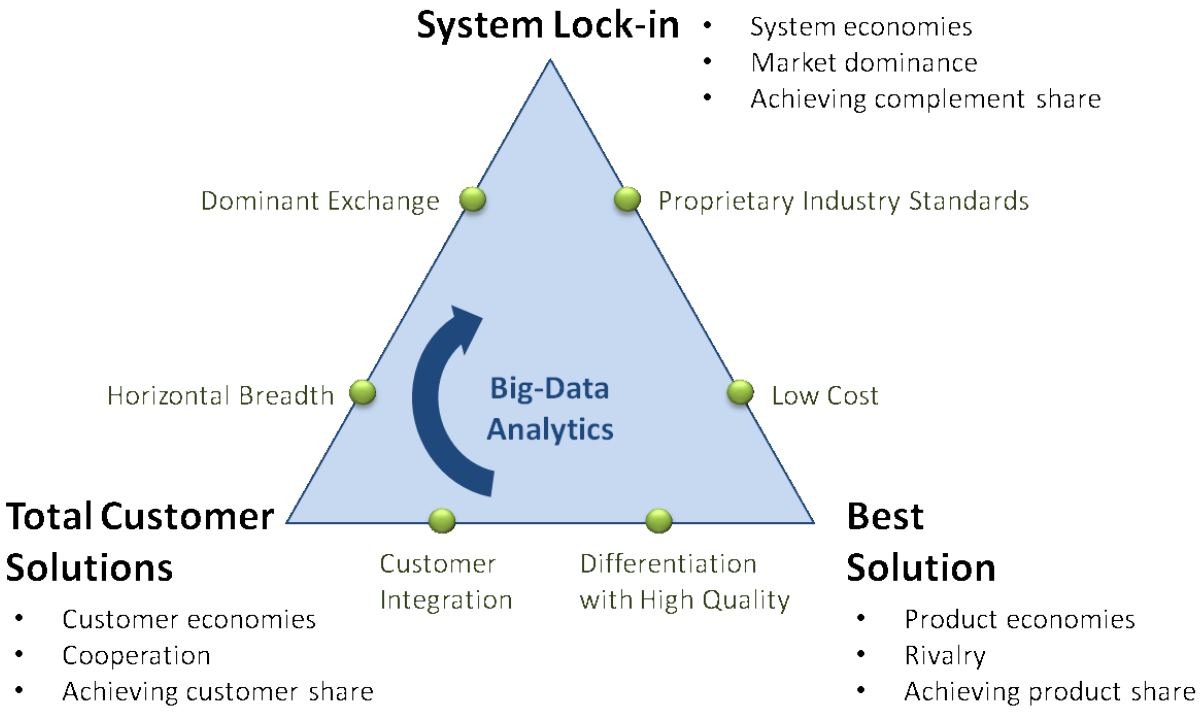

Figure 2. Strategy for the big data analytics business drive

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1. Instead of acting alone, the organization engages the relevant set of partners that constitute the extended enterprise.

2. The relevant overall measure of performance becomes the total customer share.

3. Not limited by the internal product development capabilities, the joint efforts become the key success factors, such as contributing to the open source big data frameworks and driving their proliferation.

4. Although this position is relatively safe, with reasonable customer lock-ins, it is not safe enough given that the competitors are not locked-out yet and they can still take away the customers with better offerings.

System Lock-in positioning
At the top of triangle stands the most demanding strategic option that every organization craves for, the *System Lock-in*. In this stage, the organization will be addressing the full customer network as the relevant scope, with gaining of complementor's share as the ultimate objective, and the system economics as the driving force, as follows.

1. Those who are successful in reaching this position gain de-facto dominance in the market that not only assures a customer lock-in but also a competitor lock-out.

2. Complementors play key roles, because they are the basis for consolidation of the success. For example, application developers are the complementors for Microsoft, who are not on the payroll of Microsoft but contribute to the success of its products. Similarly, Android developers contribute to the success of Android, and so on. A Level 3 expert system with open standards and third-party plugin application programming interface (API), for example, can provide such system lock-in.

The *Best Solution* strategy rests on the classical form of competition, which dictates that there are only two ways to win: either through low-cost provisioning or through high-quality differentiation. The problem, however, is that differentiation is seldom a source of sustainable advantage because, once the strategy is revealed and becomes publicly known, technology often allows a quick imitation that neutralizes the sought-after competitive advantage. In the big data analytics case, everyone has access to the same set of tools for building Level 1 solutions. The low-cost provisioning option does not provide much room for success either. After all, how low can one go and how many players can enjoy simultaneous low cost advantage?

The transformation toward a *Total Customer Solutions* positioning requires a very different way to capture the customer and a very different mindset. To achieve this shift, the organization has to engage three options that need to be pursued simultaneously:

1. Segmenting the customers carefully, arranging them into proper tiers that reflect distinct priorities, and providing differentiated service to each tier based on the identified priorities. For example, customers looking for Level 1 analytics solutions cannot benefit from preferential treatment as much as those who are looking for Level 3 analytics solutions.

2. Pro-actively identifying the challenges in the customer's business domain and proposing solutions to alleviate them even before they happen, thereby displaying thought leadership and gaining customer trust.

3. Expanding the breadth and reach of the solutions to provide full coverage of services to the customers.

Once in the *Total Customer Solutions* position, the organization is left with the final, hard-to-reach positioning on the top of triangle: the *System Lock-in*. One powerful way to achieve this position is through the development and ownership of the standards of the industry, perhaps with open API and third-party solution compatibility.

Another way to achieve system lock-in is through *dominant exchange* strategy. For example, by designing the solution as domain-neutral and schema-invariant, the Internet of Things system will be capable of becoming a dominant data exchange platform, poised towards achieving a system lock-in strategic positioning in the long run, when envisioned and executed correctly.

Conclusion

The present-day challenges in big data analytics require solution providers to first educate their customers on the applications of big data analytics to their respective domains, and then provide solutions that are easy to integrate and amenable to their existing infrastructure. A good roadmap to get started in the big data analytics market includes short-term goals aimed at laying out

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the technology foundation and building a strong customer base for sustainable revenue generation, with medium-term goals striving to support the delivery functions for retaining the acquired customer base and reinforcing the customer bond with high-quality outputs and optimal schedules. The long-terms goals aim for leading the market with innovative solutions and strategic partnerships.

The delta model outlined in this article is a customer-based approach to strategic management. It is based on customer economies and, as such, is well suited for both established organizations and initial startups, because the emphasis is on achieving success by customer bonding, rather than on working against the competition. Implementing this delta model thus requires thorough understanding of the customer needs and openness towards partnerships. Big data technologies, at least in today's world, thrive on open source efforts and hence are aptly suited for such a model of partnerships, where crowdsourcing and open development are the fundamental mode of business.

Some of the pitfalls one may encounter in implementing such a strategy, however, are: lack of customer interest in cooperation, limited partnership opportunities, and a scarce pool of capable technical resources. Especially for startup companies who are yet to establish their brand, the prime opposition towards any innovative big data analytics solution comes directly from the customers' apathy towards such solutions. Skeptical and suspecting, many a customer today is not yet ready to share the business data with the big data analytics entrepreneurs. A question of security for their data on the open plains of big data cloud architectures is the major contributor for these suspicions on the customer's part. Adding to this is the scarcity of qualified technical resources capable of innovating on these big data technologies, making the companies treat the competitors more and more as opponents than as prospective partners. Such a heavy inward focus towards attracting, engaging, and retaining the customers and resources, is making the companies lose global focus, rendering them as just another group of disconnected functional silos. Until the technology platforms mature and become capable of resolving such customer security concerns, and until the technical resources become available in abundance, this situation continues to present both a challenge and opportunity for big data entrepreneurs.

About the Author

Gopalakrishna Palem is a Corporate Technology Strategist specialized in distributed computing technologies and advanced predictive analytics solutions. During his 12-year tenure at Microsoft and Oracle, he helped many customers build their executive strategy for various technology initiatives, driving the brand-name promotions and improved revenue targets. He offers consultations for C-level executives in technology management strategy and is actively engaged in guiding researchers and entrepreneurs in knowledge modelling systems, algorithmic information theory, and systems control and automata. He can be reached at gopalakrishna.palem.in/

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TIM Lecture Series

Web Infections and Protections: Theory and Practice

Arnold Kwong

> *"The reality of the Web is that you will never be totally safe – you will take damage. The question is, how are you going to deal with it?"*
>
> Arnold Kwong
> Managing Director, Extratelligence

Overview

The TIM Lecture Series is hosted by the Technology Innovation Management program (carleton.ca/tim) at Carleton University in Ottawa, Canada. The lectures provide a forum to promote the transfer of knowledge between university research to technology company executives and entrepreneurs as well as research and development personnel. Readers are encouraged to share related insights or provide feedback on the presentation or the TIM Lecture Series, including recommendations of future speakers.

The first TIM lecture of 2014 was presented by Arnold Kwong, Managing Director of Extratelligence, whose lecture described aspects of his organization's research into web infections and protections over a 15-year period. The event was held at Carleton University on February 27th, 2014.

Summary

Kwong began the lecture by describing the key concept underlying the research effort at Extratelligence, which examines emerging threats against computers, networks, and infrastructure by new techniques and attack vectors using the analogy of biological infections and public health to use as a source of methodological treatment and mathematical models for computer-based agents that cause disruption or damage. Over time, the research has explored the strategy, protocols, and futures involved with ongoing countermeasures, conduct of technical practitioners, and the behaviour of the immersive Internet environment we now live in.

Threats, targets, threat vectors, infectious agents, and infections

In the parlance of the research, the process of looking at Internet-based problems, commonly referred to as "viruses", "malware", "Trojans", and the like, considers perpetrators, targets, threat vectors, infectious agents, and infections.

The key lessons learned from the research are:

1. The infections must be treated like a long-term public health problem.
2. Infections will continue to occur.
3. There are no "magic bullet" cures for infected software and hardware.
4. There are not even techniques that will substantially reduce vulnerabilities.
5. "Good behaviour" is not enough to protect you from infections.
6. Infections will spread with astonishing speed on the Internet.
7. There is no "magic immunity" from infections – even "disconnected" systems can be compromised.
8. Damage from infections cannot be completely contained by prior planning or techniques.

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Data privacy

In the instance of data privacy, the research developed a nomenclature of data privacy breaches, meaning that the data is under the access, control, or administration of other, unintended enterprises or people. This nomenclature has at least two dimensions: i) intentional (i.e., it was given up knowingly) and ii) unintentional (i.e., it was given up unknowingly or without anyone asking). Furthermore, the breach may be "active", meaning the is transmitted out from a source, or "passive", meaning the data was generated with or without the owner's knowledge.

The key lessons learned about data privacy are:

1. A little paranoia is a good thing.

2. You living your life will cause data to "seep" – and make money for somebody.

3. Convenience often trumps privacy in real life.

4. People will make money by collecting and monetizing your privacy.

5. You do not have to be a target to have data collected.

6. Staying "safe" on the Internet is not protective.

7. Being "off the net" does not mean you have control over information about you.

However, individuals can mitigate their risk through constant vigilance and by not "oversharing" their data. Where possible, individuals should create an use "virtual personas" rather than reveal their own data. Similarly, they should also avoid using other people's computers (e.g., for Google logins). In addition, individuals can take the following technical steps:

1. Firewalls: install and maintain firewalls.

2. Anti-spam and anti-virus solutions: install them and keep them up to date.

3. Web browsers
- Use https where possible (SSL/TLS) (EFF HTTPS Everywhere add-on).
- Set "Do Not Track" everywhere.
- Close your browser(s) immediately after use (e.g., IE/Safari/Firefox/Opera/Webkit/Chrome/Dolphin).
- Do not allow third-party cookies (Ghostery, Better Privacy), location-tracking, "active" scripting, or "XSS".
- Do not save passwords or use automated form filling.
- Clear your caches, cookies, and history frequently (i.e., more often than daily).
- Use anonymizer software (e.g., TOR, Privoxy).

4. Email
- Subscribe to "text only" emails whenever possible.
- Use multiple accounts (i.e., specialized to a persona) and consider throwaway accounts for transient interests.
- Consider whether you really need to use your real identity for a given interaction or whether a virtual persona will be sufficient.

5. Miscellaneous
- Trust organizations and individuals, but not by default.
- Change your passwords irregularly and often.
- Use Internet coffee shops infrequently.
- Do not install Java.

Data security

In the instance of data security (i.e., the ability to control data and related knowledge of it), consider the following properties and examples related to licence numbers:

1. Existence: Do they have a license number? How many?

2. Access: Can you provide the license number? Can you create one?

3. Location: Can you find the license number?

4. Content: What is the license number?

5. Integrity: Is the license number the same?

6. Status: Is the license number current?

7. Manipulation: Can you change the license number?

8. Format: Can you obtain an unencrypted license?

Web Infections and Protections: Theory and Practice

Arnold Kwong

The key lessons learned about data security are:

1. The key threat vector is the individual themselves.

2. Data security cannot be completely assured while the data is useful and used.

3. Threats can occur to data in motion, data at rest, and data in process.

4. Connections expose data to more threats – and the more useful the data, the more connections.

5. If it is on a shared server for others to access, they probably will access it.

6. If it is on the public cloud, the public (and the government) can read it.

7. Encryption is only what you make of it – and its processes. Most organizations have very poorly organized cryptographic controls.

8. Answering a subpoena may be difficult depending on who knows enough to understand the questions.

9. The legal process driving technical process is always very expensive.

10. New infections cannot be guessed ahead of time. The flaws in code may not be obvious even upon inspection.

11. New infection routes may be unknowable when systems and protocols are put in place. Who would have guessed that a flip cam could be infectious?

12. New infection damage is hard to find. Most systems do not maintain enough integrity information to detect damage.

Predictions

Kwong ended the presentation with predictions for the future from the Extratelligence:

1. There will be a $30 million "Chip and PIN" card theft in European Union in the next 18 months (i.e., similar to Target in North America.)

2. There will be a theoretical crypto-analytic attack on transport layer security (TSL) 1.2 before the end on 2014.

3. There will be a real-time (non man-in-the-middle) crack on TSL 1.2 before the end of 2015 using commercially available hardware with key sizes less than 256 bits.

4. The Advanced Encryption Standard (AES) 256 will be cracked by using commercially available hardware before the end of 2016 after a new "Snowden-style" leak.

5. An effort will be made to revise and strengthen certificate authority (CA) processing, which will fail to be accepted before 2017.

6. A distributed denial-of-service (DDoS) attack will exceed 1Tb/sec by mid 2016.

7. Two major email marketers (i.e., spammers) will be caught and blacklisted by mid 2016. Spam levels will drop 50% on the Internet for three weeks and then return to their previous levels.

8. A major infection will break out, affecting systems with more than 1 million web sites before 2016.

Lessons Learned

In the discussions that followed each portion of the presentation, audience members shared the lessons they learned from the presentation and injected their own knowledge and experience into the conversation.

The audience identified the following key takeaways from the presentation:

1. Current approaches are too expensive and do not work. We need a new way of thinking.

2. There is a parallel between the Internet and human biological systems: you can recover from some infections, but others will kill you.

3. Our desire for convenience overcomes our reluctance to give up our data. So, in most cases, people are giving up security and privacy because they choose to; they are weighing the risks and rewards of their economic and emotional interests.

4. Others are making value off your data, so there must be value there for you.

Web Infections and Protections: Theory and Practice

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5. The single largest threat to our security is the lack of education about the nature of current threats and the levels of risk we face.

6. We need to raise the general level of awareness. And, for each of us, it begins at home – recognizing the vulnerabilities of our home computers, for example.

7. Being "off the net" is not enough – you are still vulnerable because others hold data about you.

Next Steps

Finally, the audience was asked to identify practical actions that can be taken at a local level to address the problem presented by the speaker. The audience identified the following next steps:

1. Seek out analogies from other domains; apply tools and frameworks from those domains to the domain of cybersecurity.

2. Develop a multidisciplinary course at Carleton University. (This step is already underway as part of the activities of the VENUS Cybersecurity Corporation: [Bailetti et al., 2013; timreview.ca/article/711], and is scheduled for Summer 2014)

3. Connect successful local entrepreneurs with up-and-coming entrepreneurs in the cybersecurity domain. Include presentations about each participants future vision of a secure Internet.

4. Characterize existing business models for cybersecurity and identify opportunities for new business models.

5. Leverage local pools of relevant security expertise (e.g., data analytics in Ottawa)

About the Speaker

Arnold Kwong has over thirty years experience in management, manufacturing, and technology applications. His operational expertise and cross-disciplinary outlook have been applied in planning, analysis, implementation, and problem-solving settings. A strong operational emphasis on quality and risk management comes from extensive practical work. Ongoing technical expertise, with ongoing research and application publications, focus on telecommunications, security models, mobile financial applications security, complex systems integration and deployment, software modeling of enterprises, real-time data collection, and advancements in computer science. His technical experiences include a core of multivendor complex systems analysis; data base/storage/data communications relationships; software design, development, and evaluation; and hardware/software architectural design and implementation issues. Areas of specific management expertise include complex product development and management, technological risk management, and regulatory compliance for organizations in both the public and private service and manufacturing sectors. Areas of specific technical experience include application architectures; system architectures; applications and Internet security; storage/data base administration, management, and enterprise modeling; networking and data communications; and computer science research.

Citation: Kwong, A. 2014. TIM Lecture Serices – Web Infections and Protections: Theory and Practice. *Technology Innovation Management Review*. March 2014: 35–38.

Keywords: cybersecurity, threats, targets, threat vectors, infections, attack vectors, countermeasures, Internet, privacy, security

TIM Lecture Series
Adventures in Innovation: Inside the Rise and Fall of Nortel

John F. Tyson

> *"The quest is all about relevance and fulfillment. Loving what you do, loving where you do it... within a collaborative community of kindred spirits.*
>
> John F. Tyson
> Industrial designer and senior executive

Overview

The TIM Lecture Series is hosted by the Technology Innovation Management program (carleton.ca/tim) at Carleton University in Ottawa, Canada. The lectures provide a forum to promote the transfer of knowledge between university research to technology company executives and entrepreneurs as well as research and development personnel. Readers are encouraged to share related insights or provide feedback on the presentation or the TIM Lecture Series, including recommendations of future speakers.

The second TIM lecture of 2014 was held at Carleton University on March 18th and was presented by John F. Tyson an industrial designer, inventor, angel investor, and senior executive who spent over 35 years with Bell-Northern Research (BNR; tinyurl.com/6vrpyt3) and Nortel Networks (tinyurl.com/lql2bbw). The lecture was inspired by Tyson's recently published memoir: *Adventures in Innovation: Inside the Rise and Fall of Nortel* (adventuresininnovation.ca) and coincided with the publication of a report on a three-year study into the demise of Nortel Networks (Calof et al., 2014; tinyurl.com/lkk5c3b).

BNR was a telecommunications R&D organization jointly owned by Bell Canada and Nortel Networks until the 1990s, when it was absorbed into Nortel Networks. Nortel operated for more than 100 years and, at its peak, it was the world's largest supplier of telecommunications equipment. In 2000, Nortel earned revenues of $30 billion and employed nearly 100,000 people worldwide (more than 25,000 in Canada, half of whom were in R&D), but went into decline over the following decade before filing for bankruptcy and ceasing operations in 2009 (Wahl, 2009; tinyurl.com/o786wmp).

Summary

As with all TIM lectures, the audience was a diverse mix from academia (both professors and students), industry (especially managers, entrepreneurs, and developers), and the public sector. However, given the topic of the lecture, many of those in attendance were alumni of BNR and Nortel, which provided strong resonance for Tyson's reflective, emotive approach. For those unfamiliar with BNR and Nortel, the lecture – and the subsequent discussions and sharing of experiences it prompted – provided a clear demonstration of the importance of a strong company culture that provides opportunities for its employees to grow, collaborate, and succeed.

Although much attention is paid today to the demise of Nortel, Tyson encouraged the audience to celebrate its achievements and learn from both its failures and successes. With emphasis on his real-time experiences during the rise and fall of BNR and Nortel, Tyson reflected upon the key lessons he learned that still hold relevance for technology companies today:

1. Falling one step behind is the "kiss of death".

2. Vision matters. An organization's vision is not about public relations slogans, but rather it refers to the clarity of the organization's direction and purpose.

3. Pathfinders matter. Competitors will analyze and try to replicate the actions of a true pathfinder, but by definition, they will always be one step behind.

4. Toys are tools, and the workplace is a playground for innovation. Provide talented individuals with the toys they need to innovate.

Adventures in Innovation: Inside the Rise and Fall of Nortel

John F. Tyson

5. Organizations under stress can lose their reason for being.

6. R&D is complex: it is expensive, multidisciplinary, and collaborative... and it is essential. The "R" and the "D" need to be separate, but pulling in the same direction, and neither can be overlooked. Innovation comes from the "R".

7. Innovation means being willing to obsolete or cannibalize your own product.

8. Market leadership cannot be claimed; it can only be assigned by customers, competitors, and industry analysts. Reveling in one's own rhetoric is a deadly sin.

9. Success is a trailing indicator, not a leading indicator. Success is the culmination of past achievements, not a sign you are currently winning the race.

10. Fun matters. If you are not having any fun, stop and ask why. Laughter releases creativity, imagination, and innovation.

11. Corporate culture is the spirit of the organization. It is easy to see and hard to measure, but it is vitally important.

12. Innovation creates new wealth. And, therefore R&D is an investment, not a cost.

In the discussions that followed each portion of the presentation, audience members shared the lessons they learned from the presentation and injected their own knowledge and experience into the conversation. The audience identified the following additional takeaways from the presentation:

1. The largest risk to an organization is insufficient innovation to stay competitive.

2. An organization's most valuable asset is its people, and to succeed, it must encourage a culture of trust that recognizes how valuable this asset is.

3. A lot of innovation does not succeed in the sense of making money for the company. Therefore, companies should bet on many horses, not just one. However, when one horse wins, managers should avoid thinking they are good at picking winners from that point forward.

4. It is tempting to "chase the money", especially applying for external sources of funding, but these activities can become all-consuming. This is time that is better spent getting to know customers and improving the content.

5. The previous generation is the barrier to success for the current generation. If we want to help young entrepreneurs, we need to get out of their way. Let them try, let them fail, and let them succeed.

This report was written by Chris McPhee.

About the Speaker

John F. Tyson is an industrial designer, inventor, angel investor and accomplished senior executive who spent over 35 years with Bell-Northern Research (BNR) and Nortel Networks. During this time he focused on product design, R&D, marketing, and advanced technology. His principles on user-centered design, innovation, and design-based thinking have been detailed in numerous publications and his work has been featured in museums and galleries including the Museum of Modern Art in New York, the National Art Gallery of Canada, the Canadian Museum of Science and Technology, the Canadian Museum of Civilization, and the Toronto Design Exchange (DX). His work has also been featured on two Canadian postage stamps.

Citation: Tyson, J.F. 2014. TIM Lecture Series – Adventures in Innovation: Inside the Rise adn Fall of Nortel. *Technology Innovation Management Review.* March 2014: 39–40.

Keywords: innovation, industrial design, user-centred design, company culture, Nortel, Northern Telecom, BNR, Bell-Northern Research

Author Guidelines

These guidelines should assist in the process of translating your expertise into a focused article that adds to the knowledge resources available through the *Technology Innovation Management Review*. Prior to writing an article, we recommend that you contact the Editor to discuss your article topic, the author guidelines, upcoming editorial themes, and the submission process: timreview.ca/contact

Topic

Start by asking yourself:

- Does my research or experience provide any new insights or perspectives?
- Do I often find myself having to explain this topic when I meet people as they are unaware of its relevance?
- Do I believe that I could have saved myself time, money, and frustration if someone had explained to me the issues surrounding this topic?
- Am I constantly correcting misconceptions regarding this topic?
- Am I considered to be an expert in this field? For example, do I present my research or experience at conferences?

If your answer is "yes" to any of these questions, your topic is likely of interest to readers of the TIM Review.

When writing your article, keep the following points in mind:

- Emphasize the practical application of your insights or research.
- Thoroughly examine the topic; don't leave the reader wishing for more.
- Know your central theme and stick to it.
- Demonstrate your depth of understanding for the topic, and that you have considered its benefits, possible outcomes, and applicability.
- Write in a formal, analytical style. Third-person voice is recommended; first-person voice may also be acceptable depending on the perspective of your article.

Format

1. Use an article template: .doc .odt
2. Indicate if your submission has been previously published elsewhere. This is to ensure that we don't infringe upon another publisher's copyright policy.
3. Do not send articles shorter than 1500 words or longer than 3000 words.
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5. Include a 2-3 paragraph abstract that provides the key messages you will be presenting in the article.
6. Only the essential references should be included. The URL to an online reference is preferred; where no online reference exists, include the name of the person and the full title of the article or book containing the referenced text. If the reference is from a personal communication, ensure that you have permission to use the quote and include a comment to that effect.
7. Provide a 2-3 paragraph conclusion that summarizes the article's main points and leaves the reader with the most important messages.
8. Include a 75-150 word biography.
9. If there are any additional texts that would be of interest to readers, include their full title and location URL.
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