Network Effects: The Promise and Pitfalls of the Internet of Things

December 2016

ppforum.ca

CANADA'S PUBLIC POLICY FORUM
DES POLITIQUES PUBLIQUES DU CANADA

CANADA'S
PUBLIC POLICY
FORUM
DES POLITIQUES PUBLIQUES
DU CANADA

The Public Policy Forum works with all levels of government and the public service, the private sector, labour, post-secondary institutions, NGOs and Indigenous groups to improve policy outcomes for Canadians. As a non-partisan, member-based organization, we work from "inclusion to conclusion," by convening discussions on fundamental policy issues and by identifying new options and paths forward. For 30 years, the Public Policy Forum has broken down barriers among sectors, contributing to meaningful change that builds a better Canada.

Ottawa Office
1400 - 130, rue Albert Street
Ottawa, ON, Canada, K1P 5G4
Tel/Tél: 613.238.7160
Fax: Téléc: 613.238.7990

www.ppforum.ca | @ppforumca

ISBN: 978-1-927009-85-7

Network Effects:
The Promise and Pitfalls of the Internet of Things

> **"Barcelona… measures the dampness of the soil in its parks, and automatically dispatches watering teams to beds that dry out. Amsterdam tracks how many pedestrians are on its streets at night, and dims the lights if nobody's around."**
>
> *– Alexander Starritt on Internet of Things-enabled Smart Cities*

Executive Summary

The Internet of Things (IoT) is the growing network of physical objects that are connected to the Internet, enabling them to collect data, communicate with other networked objects and change their behaviour in real time. Cisco estimated that there were 4.9 billion such machine-to-machine connections in 2015 and that this number will grow to 12.2 billion in 2020[1]. They're not alone; Gartner similarly predicts 25 billion by 2025. The International Data Corporation (IDC) has predicted that in Canada, the number 'of installed autonomous intelligent and embedded systems' would rise from 23 million in 2013 to 114 million in 2018.[2]

[1] "Internet of Everything (IoE) Value Index", Cisco, 2013.
[2] "TELUS/IDC Internet of Things Study 2014", IDC, June 2014.

However, the possibilities from the manufacture and selling of IoT infrastructure – IoT-ready devices, software, sensors and connectivity solutions – will not be as impactful as the possibilities from their use. The game-changer is tech-enabled and -augmented innovation, where it transforms the way we act, interact, live and work, enabling real-time monitoring and optimization of industry, the workplace and the home. This represents both possibilities and challenges for consumers and businesses alike. IoT is third on McKinsey's list of emerging technologies with disruptive economic impact, putting the range at $2.7 - $5.2 trillion dollars by 2025. Which does not necessarily mean potential profit; it may also mean *shifting* profits, and capital investments becoming obsolete.[3] For Canada, IDC has predicted that IoT will be a $21 billion market by 2018[4]; for comparison, a Canadian IT industry association pegs the entire Canadian internet, communications and technology industry at $150 billion annually[5].

To compound the issue, using and generating insights from this firehose of data requires highly specialized talent that is in short supply. A critical and perennial concern for Canadian companies has been attracting and retaining highly skilled information and communications technology talent, including software engineers, information systems analysts and data scientists. The Information and Communications Technology Council (ICTC) estimates that there are 33,600 data analytics specialists in Canada in 2016 and projects 33 percent growth to 43,300 by 2020 while noting that 1 in 5 new Canadian jobs in data will require skills in big data and sophisticated data analytics[6]. Adding to this, a core competency for these data analysts is understanding the business context as well, and the Canadian post-secondary education system is lagging behind the need for these hybrid offerings.

[3] "Disruptive technologies: Advances that will transform life, business, and the global economy," McKinsey, May 2013.
[4] **"**TELUS/IDC Internet of Things Study 2014", IDC, June 2014.
[5] "The Internet of Things: Time for a National Discourse", ITAC, August 2015.
[6] Big Data & The Intelligence Economy", ICTC, 2015.

Understanding the challenges and opportunities

Partnering with Canada's Digital Policy Forum, Loyalty One, Facebook, Shopify and the Government of Canada, the Public Policy Forum launched an exploration of key issues and opportunities of IoT and data analytics in Canada. Participants identified a number of challenges and risks for Canadian business leaders, government and post-secondary institutions. These challenges include executive understanding and acceptance of IoT solutions, availability of skilled labour, privacy and security issues, and a buildout of the connectivity infrastructure necessary to become an IoT leader.

Through roundtable discussions and one-on-one interviews with over 70 leaders across sectors, we identified five recommendations for governments, business and post-secondary institutions that will allow consumers and businesses to take advantage of the opportunities provided by IoT.

Recommendations

1. **Foster a Culture of Knowledge Sharing Across Sectors**
2. **Invest in Developing a Workforce for the Digital Age**
3. **Stay Competitive by Embracing a Disruptive Future**
4. **Prepare for the Inevitability of Security Threats**
5. **Modernize Education Through Industry Partnerships**

These are explored in full at the end of this report.

Introduction

While fitness trackers and autonomous cars have dominated the media and generated buzz about the Internet of Things (IoT), they only provide a hint of the social and economic impact of a thoroughly network-connected physical world. While Cisco calls IoT the "Internet of today," the true impact of IoT will only be revealed over time. However, there are some generally agreed-upon probable futures:

For citizens, the growing prevalence of IoT will deliver real-world improvements to their quality of life, from a reduction in commuting times as artificial intelligence optimizes traffic management to an increase in independence for the chronically ill through continuous remote medical monitoring.

For businesses, IoT offers opportunities for increased operational efficiency through predictive maintenance of hardware and real property, improved customer service through a richer understanding of people's needs and new business models driven by previously hidden insights into markets and products.

How IoT will be used

We can consider IoT's future through multiple frameworks. As in the introduction, there's a difference between the *manufacture and sale* of IoT infrastructure and *the use of IoT capability to improve and optimize business or personal processes,* with the latter being the most powerful use. Within that framework, we can also look at 1) the settings and scenarios in which IoT will play a role, as well as 2) categorizations of how it can help optimize businesses.

Scenarios for IoT Deployment

In their report, "Unlocking the Potential of the Internet of Things", the McKinsey Global Institute divided IoT deployments into nine major settings.[7]

1. **Human**: devices attached to or inside the human body (e.g, wearables, Fitbits, health monitoring)
2. **Home**: home controllers (e.g., smart temperature control), security
3. **Retail**: self-checkouts, in-store offers, inventory optimization, layout design
4. **Offices**: energy management, security
5. **Factories**: operating efficiencies, optimized inventory and equipment use
6. **Worksites** (e.g, mining, oil, gas, construction): operations, predictive maintenance, health and safety
7. **Vehicles**: predictive maintenance, usage-based design
8. **Cities**: adaptive traffic control, resource management, smart meters, environmental monitoring, compliance
9. **Outside**: transit and navigation (particularly for trains, airplanes, ships)

[7] "Unlocking the Potential of the Internet of Things," McKinsey Global Institute, June 2015.

McKinsey predicts that the manufacturing, utilities, resources and energy sectors will gain the most from IoT.[8]

Example: Smart buildings

A building network connects equipment together through machine-to-machine communication. The building's energy usage and internal environment can be optimized through the collection and relay of data by devices throughout the network. For instance, the network 'knows' when a particular room is outside its optimal temperature and makes automatic adjustments. If one side of the building is warmer than the others because the sun is shining on it, this information can be used to unfurl automated blinds and activate air conditioning only in the regions that are currently hot. The thermostat, blinds, and HVAC systems 'talk' with one another, working in concert to maintain a comfortable environment for occupants while optimizing energy utilization, all without human intervention.

Snapshot #1: Miovision – building the Smart City, starting with traffic

Kitchener, Ontario-based Miovision is a 'smart traffic' company supporting efforts to modernize city infrastructure and lay the foundation for the smart cities of the future. Smart cities are driven by data, and Miovision's mission is to develop a data network for smart cities using a grid of Internet-connected traffic signals to link infrastructure wirelessly. The connected network and devices will enable cities and technology developers to access data and build smart city applications to improve the lives of residents. One of Miovision's devices, Spectrum, creates identifiers for different vehicles on the road which can be analyzed in real time to optimize traffic flow. The company's solutions have been adopted by nearly 650 customers in 50 countries.

[8] Ibid.

Miovision's Spectrum hardware integrates with traffic signal infrastructure to establish a secure connection between traffic signal data and operations

Mass sensor deployment and increased real-time information are giving rise to entirely new revenue models for businesses. For instance, industrial manufacturers that have historically sold products such as vehicles or heavy construction equipment now have the opportunity to explore usage-based business models, where instead of selling their product, they can temporarily provide the product to customers and charge by load unit or engine time. Usage can be monitored from their headquarters, much as the ORCAs are centrally monitored by Totally Green in the snapshot below. Using the data they collect, these companies can calibrate usage prices that account for varying rates of equipment wear in different environments.

Snapshot #2: ORCA – an Internet-enabled mechanical stomach

Totally Green is a Toronto-based company that manufactures the ORCA, a machine that sustainably processes large volumes of food waste on site from food service businesses such as hotels, stadiums and grocery stores. ORCA breaks down food waste aerobically with microorganisms that rapidly convert it into an effluent safe for discharge into the municipal wastewater system. Converting up to 2,400 pounds of food waste in 24 hours has a significant positive environmental impact, eliminating the CO2 emissions that would otherwise arise from disposal trucks carrying waste to landfills.

In 2014, Totally Green partnered with Rogers Communications to equip machines with sensors and transmitters. These instruments enable them to remotely monitor machines in the field by tracking waste levels, bacteria populations, temperature and functionality for optimization and predictive maintenance, while also providing clients with sustainability reporting that shows real-time environmental impact reductions. The real-time data can lead to operational savings. Emergency and overtime service calls can be reduced, saving labour costs and the carbon emissions from regular but unnecessary service checkups. For large-scale businesses in jurisdictions with a carbon tax, sustainability reports can also indicate and help manage tax savings.

The OG50 version of Totally Green's ORCA aerobically processes an average of 50 pounds of food waste per hour, depending on the food waste composition

As in the above example, companies can add value for customers by including aggregated data and insights derived from the data as part of their service offerings, creating a data-as-a-service revenue opportunity.

Snapshot #3: blueRover and Rogers team up to offer IoT-as-a-service

Canadian company blueRover enables food safety through their automated temperature monitoring technology

In spring 2016, Rogers Communications partnered with Kitchener-based blueRover to offer IoT-as-a-service, including solutions for farm and food monitoring. Sensors can be installed to monitor equipment found throughout the food production chain - such as refrigerators, ovens, and freezers - in real time from mobile devices. Apart from ensuring continuous compliance with regulations, the real-time information also leads to waste reduction and improved incident management.

IoT's Role In Business Optimization

Point-in-time, batch reporting delivers performance information over a set time period in the past, but companies have room to grow in understanding their operations in real time. Currently, most data flowing from IoT does not contribute to business processes. For instance, McKinsey examined an oil rig with 30,000 sensors and found that only 1 percent of data received was used, generally reviewed on a monthly basis "mostly for anomaly detection and control, not optimization and prediction, which provide greatest value."[9]

It's helpful to layer the above nine settings over how IoT might be used for business optimization. Within Cisco's prediction of $14.4 trillion in value at stake for businesses from 2013-2023[10], they divided the potential into five business drivers with approximately equal potential (Cisco uses the term "Internet of Everything (IoE), particularly when referring to non-consumer applications):

1. **Asset utilization ($2.5 trillion) —** IoE reduces selling, general and administrative (SG&A) expenses and cost of goods sold (CoGS) by improving business process execution and capital efficiency.
2. **Employee productivity ($2.5 trillion)** — IoE creates labor efficiencies that result in fewer or more productive person-hours.
3. **Supply chain and logistics ($2.7 trillion)** — IoE eliminates waste and improves process efficiencies.
4. **Customer experience ($3.7 trillion**) — IoE increases customer lifetime value and grows market share by adding more customers.
5. **Innovation, including reducing time to market ($3.0 trillion)** — IoE increases the return on R&D investments, reduces time to market and creates additional revenue streams from new business models and opportunities.

[9] "Unlocking the Potential of the Internet of Things," McKinsey Global Institute, June 2015.
[10] "Internet of Everything (IoE) Value Index", Cisco, 2013.

The success of IoT depends on many interrelated factors

Interoperability

Forty percent of the value is projected to be dependent on *interoperability*, the process of devices communicating with each other and operating in harmony, as in the former "smart building" example. The thermostat, blinds, and HVAC systems need a common language, and they may be produced and sold by different companies in different countries.[11]

Miniaturization and economies of scale

The miniaturization of processors combined with near-universal connectivity and the falling costs of sensors, bandwidth and cloud storage makes IoT deployment feasible in an increasing number of scenarios. The more data points, the more potential for insights.[12] However, prices still have to fall to generate the growth predicted by Cisco and McKinsey.

Snapshot #4: Sierra Wireless provides the plumbing for IoT

Sierra Wireless' TiGR handheld mobile terminals enable performance for data communications

Headquartered in Richmond, B.C., Sierra Wireless is helping to build the Internet of Things across the full range of settings with intelligent wireless equipment. The company has shipped more than 120 million machine-to-machine communication devices worldwide that are now operating on more than 80 networks globally. Sierra Wireless provides an integrated end-to-end IoT solution for its customers by providing three necessary elements:

- **cellular embedded modules that can be designed into original equipment to enable connectivity;**
- **cellular gateways and routers that can be deployed after-market in mobile, industrial, and enterprise applications; and**
- **connectivity services and an IoT cloud platform to connect and manage the data.**

[11] "Unlocking the Potential of the Internet of Things," McKinsey Global Institute, June 2015.

[12] "Industrializing IoT: From Concept to Reality, IDC.

This Canadian company is positioning itself to lead in the market for equipment that enables devices to connect and 'talk' with each other.

Challenges and risks

Our roundtable participants identified a number of challenges to capitalizing on IoT opportunities. Among them were executive acceptance of IoT and big data solutions, availability of qualified talent, unclear privacy and security implications and legacy connectivity infrastructure. To spur adoption of IoT solutions by business and create an environment more conducive to IoT innovation, stakeholders will have to unite to address these challenges. Governments will also have to assess whether they will wait for the private sector to move forward on infrastructure needs, or take a proactive stance: to accelerate IoT adoption, correct market failures or revisit approaches to public goods like the radio spectrum.

Executive acceptance

The attractiveness of IoT solutions for Canadian executives is primarily the potential for increased productivity and reliability, with tactical deployments such as asset tracking and security monitoring being the most common use cases. IDC surveys have shown that 77 percent of IoT pilot projects in Canada serve such tactical purposes as opposed to broad company transformation objectives.[13] Canadian businesses, surveyed in 2012 by IDC, were "more likely to rate real-time data as 'very important' compared with their global counterparts."

Overall, in 2014, IoT solutions were deployed and budgeted for by 13 percent of Canadian organizations, though 30 percent said they intended to adopt solutions by 2016.[14]

Canada is in an excellent position to capture value from IoT. Canada has a low cost of doing business in the high-tech sector, world-class education institutions and a highly skilled workforce. Canadian companies have led in mobile and cloud adoption.[15, 16] Mark Reuss, the Executive Vice-President of Global Product Development at GM has lauded Canada as a place for high-tech research "because of its clear capacity for innovation, proven talent and strong ecosystem of great universities, startups and innovative suppliers."[17]

However, in spite of assets and tech leadership, Canadian businesses appear to be trailing the United States and Asia Pacific in IoT adoption in many industries, including factory automation.[18]

[13] "TELUS/IDC Internet of Things Study 2014", IDC, June 2014.
[14] Ibid.
[15] "Competitive Alternatives", KPMG, 2016.
[16] "Accenture Mobility Insights Report 2014", Accenture, 2014.
[17] "General Motors to Create 700 Technical Jobs in Ontario", *Toronto Star*, June 10 2016.
[18] "Beyond the smartwatch: Canada finds its place in the Internet of Things," *Globe and Mail,* May 29 2015.

Returning to the reports on economic impact, Cisco put the "value at stake" in Canada for 2013 at approximately $57 billion – but suggested that Canada's firms were only capturing approximately half of that. In their view, Canada is leaving $27 billion "on the table" by not embracing IoT fully.[19]

Canadian executives are having difficulty understanding how to deploy IoT technology in their organizations. In 2015, the *Globe and Mail* reported that only 15 percent of Canadian executives surveyed by the IDC understood the potential of IoT, and 42 percent felt uncertain about adopting the technology because the return on investment is difficult to determine.[20]

Legacy infrastructure

While called the *Internet* of Things, within the entire system several technologies provide connectivity: radio-frequency identification (RFID), near-field communication (NFC), wireless Internet, Bluetooth and other wireless sensors. Not every device requires an Internet Protocol (IP) address – in some cases, large networks of devices will route through one – but IP address availability is still a consideration for IoT.

Canada is trailing other jurisdictions when it comes to the advanced connectivity infrastructure necessary for the coming wave of connected devices. According to The Canadian Internet Registration Authority, adoption in Canada of IPv6, the broadband necessary for billions of IoT devices to connect, is lagging other countries in large part because of a lack of awareness of its importance.[21] The current broadband system, IPv4, provides IP addresses to devices connected to the Internet and has a capacity of approximately 4.3 billion addresses. The forthcoming explosion in the number of connected devices, each requiring an IP address, demands far more IP addresses than IPv4 can provide. In response to this problem, a new broadband system, IPv6, was created with more than 340 undecillion addresses (that's 340 followed by thirty-six zeroes). Currently, the adoption of IPv6-enabled broadband in Canada stands at 9 percent, compared to approximately 29 percent in the United States, 23 percent in Germany and 14 percent in the UK.[22] To ensure that we meet the highest connectivity standards, Canada must increase its IPv6-enabled broadband adoption.

Privacy, security, standards and governance

The world of ubiquitous connected devices will present a considerable departure from conventional engagement with the Internet, shifting from active, self-directed communication and content search to passive participation with connected devices that operate and collect information without intervention.

This presents new challenges for data governance and maintaining the confidence in the Internet that's necessary to maximize Internet-enabled business opportunities and processes. Innovation is likely to outstrip policy, but what about private incentives?

Simply put, IoT can – and inevitably will – lead to privacy and security breaches. Even today, the sheer amount of information that can be collected in various settings causes concerns, as it has been demonstrated that combinations of separate data sets can begin to reveal a picture of users' personal

[19] "Internet of Everything (IoE) Value Index", Cisco, 2013.
[20] "Beyond the smartwatch: Canada finds its place in the Internet of Things," *Globe and Mail,* May 29 2015.
[21] "The internet's IP addresses are running out: Can IPv6 save the day?", *CBC*, May 15 2015.
[22] "IPv6 Adoption", Google.

lives.[23] Even passive scanning for Wi-Fi is enough for sensors to assign your mobile phone a unique ID and track you through a mall or store. IoT will expand the number of settings across which information is collected, and by extension, the amount of information being collected. Data about the locks, lights and appliances in a home setting may not seem particularly revealing while taken alone, but when combined create an image of a person's private life.

MIT demonstrated this ability to 'paint a picture' of an individual's life. Starting with de-identified information about credit card purchases, researchers were able to identify 90 percent of individuals from a sample of over one million by cross-referencing the data with publically available information.[24] In addition to data itself, what data can reveal is paramount when determining how it should be handled to ensure a reasonable expectation of privacy.

Ultimately, the cornerstone supporting business opportunities is consumer confidence that their engagement with the Internet is secure and that their privacy is protected. A balance must be found that meets the expectations of citizens but takes care not to compromise Canadian businesses' competitive position by slowing or removing the opportunity to implement IoT solutions.

Recent years have seen high-profile security vulnerabilities related to connected devices. For example, researchers recently hacked a Jeep Cherokee via its connected entertainment system using a wireless communications system, taking control of the vehicle's brakes, transmission, and steering.[25]

The proliferation of connected devices means a significant rise in complexity, risk and access points for cyber attack. This presents a nightmare scenario in some domains, such as health care, where disruption of health monitoring or machine-to-machine communication can translate into physical danger. Security compromise in other contexts, like vehicles, water treatment plants or utilities also presents a threat to physical security.

Unlike smartphone operating systems, with security teams that find and patch vulnerabilities on an ongoing basis, many IoT devices simply won't have the capacity for software upgrades.

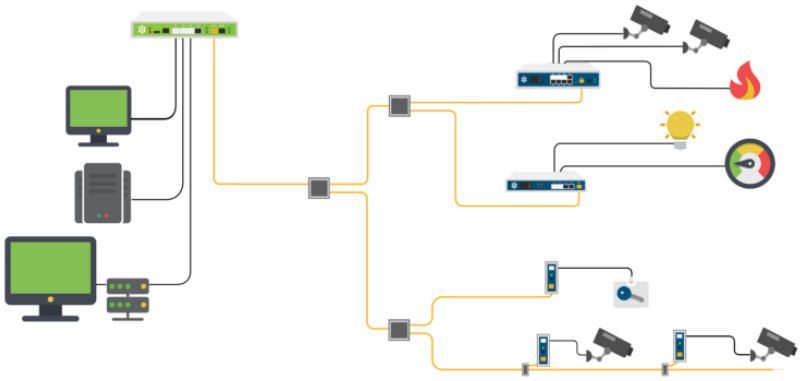
Of course, this is all the same data – and metadata – that likewise creates massive value for businesses and consumers: revealing ways to conserve energy in a home setting, extending the lifecycle of vehicles and equipment, or enabling customized sales and services to customers.

The crucial issue is governance. To date, firms delivering services through the Internet have often downloaded the risks to consumers. For a given consumer, the marginal risk of connecting to one more network (and perhaps being unaware of it) will guarantee that they continue to do so, but it only requires one breach to create significant problems. If users won't demand security (and spend more for it), governments should closely examine whether they should move to fill the void.

[23] "The Internet of Things: An introduction to privacy issues with a focus on the retail and home environments", Office of the Privacy Commissioner of Canada, February 2016.
[24] "Metadata Can Expose Person's Identity Even Without Name." *The Wall Street Journal*, January 29 2015.
[25] "Hackers Remotely Kill a Jeep on the Highway – With Me in It", *Wired*, July 21 2015.

Snapshot #5: Securing the smart building – Optigo Networks

Modern commercial buildings include thousands of smart devices such as heating and security systems that require complex networks of cables, Ethernet and protocols. These networks allow for enhanced security and comfort, but also present new cyber security concerns and problems to troubleshoot. Vancouver-based Optigo Networks offers networking hardware products capable of connecting thousands of smart devices on a property using optical cabling along with a web interface to centrally manage the entire network. Optigo has also developed a web interface that can identify problems in network communications based on protocol standards and help building operators anticipate problems.



Optigo Connect, from Optigo Networks, is a family of hardware products that connects multiple smart devices

Talent

Canada has a talent shortage in IoT- and big data-related positions.[26] A critical and perennial concern for Canadian companies has been attracting and retaining specialized employees in these fields. This is a subset of a wider trend: ICTC predicts that Canadian ICT-driven companies will experience an aggregate shortfall of 182,000 skilled employees by 2019.[27]

The new technologies, business models and insights resulting from IoT and its vast amounts of data require a labour pool with advanced technical education and blended skill sets. IoT adds to the imperative for increased and ongoing collaboration between the private sector, academia, and federal, provincial, and territorial governments to accelerate Canada's adaptation to the country's future high-tech skills needs.

[26] "Big Data & The Intelligence Economy", ICTC, 2015.
[27] "Digital Talent: Road to 2020 and Beyond", Information and Communications Technology Council, March 2016.

Profile of a Data Scientist: Thomas Levi

Thomas Levi is currently Director of Data Science at Unbounce, based in Vancouver, B.C.

With IoT will come the need to intelligently parse through mounds of information in order to gain actionable insights that lead to competitive advantages. Among companies competing in the same industry, their competitive positions will depend in part upon their abilities to find and retain the talent to do this. Thomas Levi is an example of a professional with the skills top companies in IoT and big data will require.

Levi is the Director of Data Science for Vancouver-based Unbounce, a software company providing marketers with customizable website landing pages. He was previously Senior Data Scientist for the online dating site POF.com. Levi has a doctorate in Theoretical Physics and String Theory from the University of Pennsylvania. His post-doctoral studies were in cosmology and string theory, where he wrote 19 papers which collectively received hundreds of citations.

While at POF.com, Levi's work enabled management to make sense of the hundreds of millions of events that occurred on the site each day. Deriving accurate, actionable insight from that volume of data is a significant challenge. Errors and incorrect assumptions can lead to poor decision-making and ultimately an erosion of revenue and market share. Levi employed advanced testing methodologies such as null hypothesis testing, sequential probability ratio testing, multi-armed bandits, and Bayesian sequential test design, balancing the pros and cons of each, in order to give management the best opportunity to make reality-based decisions.

Recommendations

1. Foster knowledge sharing across sectors

Developing best practices, talent initiatives and policies conducive to the development of IoT requires collaboration among citizen and non-profit advocates, post-secondary institutions, investors, IoT product and service suppliers and industry. The government is in a position to convene roundtables on IoT and data governance to bring these stakeholders together.

Topics of investment, talent development, open data initiatives, standards, incentives and regulation should be discussed with two intentions:

- The development of a national roadmap for Canada's tech ecosystem, including cyber security, Internet regulation and IoT technology, including exploring potential partnerships or policies to accelerate standards development and IPv6 adoption
- Collaboration and communication of best practices

For clarity and transparency purposes, the government should report on plans and progress towards an improved tech ecosystem as part of the Innovation Agenda.

2. Invest in developing a workforce for the digital age

Canada's education system will not, in the short term, cover the talent gap for ICT broadly and IoT specifically. Governments and the private sector must pay close attention to both immigration and departures for opportunities in other countries. For the former, this includes annual immigration levels, priorities and the experience of coming to Canada temporarily and permanently across all level of government; everything from the federal application to the municipal system for finding schools for children can impact the decision-making process for top talent. For the latter, there's a perception that Canadian tech graduates must "cut their teeth" in Silicon Valley to maximize their career arc; we must do more to position and celebrate Canada as a tech hub.

In the long-term, Canada should move to improve social mobility, particularly for Indigenous communities. A lack of education opportunities, combined with poor digital infrastructure, means that many Canadians don't have an equal opportunity to pursue specialized skills and contribute fully to the economy and their communities.

Government is in a position to design and execute strategic employment and investment plans related to IoT, including issues of talent and labour mobility, early education programs that emphasize math and science, secondary education programs with a focus on information technology and business and co-op programs for ICT companies and IoT-driven companies. The policy options should be aligned with the aforementioned roadmap, and build on the Digital Canada 150 and Innovation Agenda partnerships, work-to-date and findings.

3. Start IoT discussions in executive boardrooms

IoT-enabled devices, processes and business models will soon become the norm for companies across the globe. Canadian executives will have to discover IoT deployment opportunities for their industries, and begin experimenting with solutions.

Even before adoption of IoT, business leaders must ask the question: "How can we use the information that can be made available through connected devices to unlock value?"

SME leadership should view IoT and big data as an evolution of business analytics. Tactical objectives such as optimization, supply chain management or asset tracking can deliver cost advantages and lead to questions about additional business applications, interoperability opportunities or new revenue possibilities. As a default, business leaders should start with practical use cases, become agile with technology experimentation and continuously assess the transformational potential of IoT for their business and revenue models.

At large companies, Director-level training must include strategic planning for seeking, adopting and defending against IoT-enabled products, services and business models. This capacity-building should, in turn, inform demands on government for granting models and policy reforms that help enable investment and innovation in this area.

4. Prepare for the inevitability of security threats

No one is an island in the connected world, and nobody is safer than the weakest link. Every organization must take an anticipatory stance to security. In order to succeed, it is critical that they follow cybersecurity best practices including the embedding of security discussions in the entire product and service development process, remaining current with security technology, thoroughly understanding all vulnerabilities in the organization and industry, providing continuous security-related education programs and maintaining up-to-date security crisis response plans.

Governments, the private sector and watchdog groups must work together to establish the right balance of regulations, standards, incentives and best practice-sharing for creating a predictable, reliable foundation for IoT investment in Canada. Specifically, the federal government should commit immediately to convening and leading a broad coalition of stakeholders, security agencies, NGOs, experts and industry to identify and correct market failures in the IT security ecosystem.

5. Modernize education through industry partnerships

Industry and higher education institutions need to collaborate directly, on an ongoing basis, to develop programs that meet the needs of companies today and create awareness of lucrative technology- and data-related careers. Post-secondary institutions can create data analytics-related programs that cover the range of required skills related to IoT, including computer science, math, statistics and business. With the rapid evolution of technology and business needs, there needs to be an open channel between these stakeholders to ensure continuous learning and up-to-date university offerings. ICT and data skills should also be a recruitment priority for international students, and it's the path from education to work in government or the high-tech sector that will make Canada competitive here.

This need not reinvent the wheel; governments should evaluate, and, where appropriate, expand existing initiatives. One such initiative is the $73 million dollar Post-Secondary Industry Partnership and Cooperative Placement Initiative unveiled by the federal government in 2016. The initiative "support[s] partnerships between employers and willing post-secondary educational institutions to better align what is taught with the needs of employers. The Initiative will also support new co-op placements and work-integrated learning opportunities for young Canadians, with a focus on high-demand fields, such as science, technology, engineering, mathematics and business."[28]

Conclusion

IoT must not be regarded as simply a new technology. It will rapidly change business models, disrupt industries and become ubiquitous across the world similar to the way mobile capabilities have over the past decade. At this time, Canadian businesses are lagging in IoT awareness and adoption, but there is no opting out if they wish to remain competitive. The IoT wave is coming, and there's a significant opportunity cost to falling behind.

Adoption of IoT must start in the boardrooms and at the senior management level of Canadian companies, addressing real, pressing business needs. Awareness of the transformative potential of IoT must be gained in order to both capitalize on opportunities and defend against would-be disruptors. Government has a role to play in this by convening stakeholders, nurturing the early development of markets for connected devices through procurement, and investing in programs related to IoT that align with innovation agendas. Post-secondary institutions and industry must also come together to fill the talent gap that threatens to limit the adoption, use and development of IoT and data analytics in Canadian companies.

Canada is in a position to be an early mover in the adoption of IoT, but it will require a concentrated effort. The challenges raised in the Public Policy Forum's roundtables must be addressed by all Canadian stakeholders in order to realize the billions of dollars in IoT value-at-stake and maintain the global competitiveness of Canadian businesses.

Areas for further exploration:

- Education programs related to foundational information and communication technology skills in K-12 education
- Awareness and adoption plans of the forthcoming 5G mobile telecommunications standard
- Labour issues arising from the automation of the workforce
- Complexity of data ownership
- Attracting talent from other jurisdictions through incentives and immigration policies

[28] "Growing the Middle Class", Canada Ministry of Finance, March 22, 2016.

Jessie Adcock
Chief Digital Officer
City of Vancouver

Salimah Addetia
Office of the CTO
PHEMI Systems

Gary Agnew
Vice President, Digital
Finning

Rob Annan
Chief Research Officer
Mitacs

Sabrina Anzini
Director, Law and Corporate Affairs
LoyaltyOne

Bill Archer
Vice President
Wavefront

Roxanne Argyle
Senior Vice President
Argyle Public Relationships

Janet Bannister
General Partner
Real Ventures

Kristina Kerr Bergman
CEO
Integris Software Inc.

Chantal Bernier
Counsel
Dentons

Ranjan Bhattacharya
Dean, Faculty of Applied Science and Engineering
Technology
Seneca

Sam Bourgi
Research Associate
Information and Communications Technology Council

Julie Cafley
Vice President
Public Policy Forum

Krista Campbell
Director General
Innovation, Science and Economic Development Canada

Sara Caverley
Project Lead
Public Policy Forum

Kevin Chan
Head, Canadian Public Policy
Facebook

Jason Chang
Director of Foundation and Corporate Partnerships, Faculty of Engineering
University of Toronto

David Climie
VP Investor Relations
Sierra Wireless Inc.

Wendy Cukier
Vice President, Research and Innovation
Ryerson University

Éric Dagenais
Assistant Deputy Minister, Spectrum, Information Technologies and Telecommunications
Innovation, Science and Economic Development Canada

Jennifer Davies
Principal
Earnscliffe Strategy Group

Brian Deck
CEO
SmoothPay

Frank Defalco
Manager, Canada Makes
Canadian Manufacturers & Exporters

Joanne De Laurentiis
President and CEO
Investment Funds Institute of Canada

Jeremy Depow
Executive Director
Canada's Digital Policy Forum

Jan De Silva
President and CEO
Toronto Region Board of Trade

Sara Diamond
President
OCAD University

Eric Dolan
Founder
Neutun Labs

Ryan Eickmeier
Senior Director, Public Affairs
GS1 Canada

David Elder
Counsel
Stikeman Elliott LLP

Steven Fish
Executive Director
Canadian Business for Social Responsibility

Derek Gent
Executive Director
Vancity Community Foundation

Andrew Graham
Co-Founder and CEO
Borrowell

Karen Greve-Young
Vice President, Partnerships
MaRS Discovery District

Kamran Haidari
Director, Cash Management Solutions
CIBC

Karen Harracksingh
Junior Policy Analyst
Innovation, Science and Economic Development Canada

Angela Harvey
Director, Solution Management Big Data and Analytics
SAP Labs Canada

Zoe Hawa
Trade Commissioner – Information and Communications Technologies
Global Affairs Canada

Jas Jaaj
Partner, Consulting
Deloitte

Susan Johnston
Senior Advisor, Business and Regulatory Analysis
Innovation, Science and Economic Development Canada

AJ Khan
CEO
International Institute of Certified Innovators and Entrepreneurs

Henry Kesisyan
Director, Business Management
Scotiabank

Cheryl Kim
VP Corporate Reputation
AMIA

David Lennie
Senior Vice President, Data and Analytics
Shopify

Thomas Levi
Director of Data Science
Unbounce

John Lilleyman
Director, Global Enterprise Architecture
Finning

Dennis Lopes
Legal and Corporate Affairs Director
Microsoft Canada

Rodney MacDonald
Senior Manager, Global Public Policy
Intuit Canada

Mary Lynn Manton
Chair, School of Information & Communications Technology
Seneca

James Maynard
President & CEO
Wavefront

Mitchell Merowitz
Vice President, Corporate Affairs
LoyaltyOne

David Messer
Senior Director, Policy
Information Technology Association of Canada

Michael Mills
Vice President of Investment
PPP Canada

Giovanna Mingarelli
CEO and Co-Founder
Mcrowdsourcing Canada, Inc. (MC2)

Kei Moray
Vice President
Federal Economic Development Agency for Southern Ontario

Sean O'Leary
Director of Corporate Affairs
Information and Communications Technology Council (ICTC)

Caroline Ong
Partner and Analytics Leader, Global Business Services
IBM

Fred Popowich
Professor, Computing Science
Simon Fraser University

Nataliya Rylska
Senior Advisor, Digital Policy and Analysis Coordination Directorate
Innovation, Science and Economic Development

Ajai Sehgal
Chief Technology Officer
Hootsuite

Matt Shalhoub
ORCA General Manager
Totally Green

Raseel Sehmi
Policy & Strategic Initiatives
British Columbia Technology Industry Association

Scott Smith
Director, Innovation Policy
Canadian Chamber of Commerce

Kevin Tuer
Vice President, Strategic Initiatives
Communitech

Lyle Wagner
Vice President
Connected Interactive

Nigel Wallis
Research Director
IDC Canada

Andrew Warfield
Assistant Professor,
Department of Computer
Science
University of British
Columbia

Jim Williams
Senior Practice Manager
McKinsey & Co.

Jason White
Platform Data Lead
Shopify

Ralph Wright
Director, Western Canada
Systems Engineer
Cisco Systems Canada

CANADA'S
PUBLIC POLICY
FORUM
DES POLITIQUES PUBLIQUES
DU CANADA

ppforum.ca | @ppforumca