An InsightaaS/IoT Coalition Canada Best Practice Report: March 2018

IoValue: Intelligence in Community Ecosystems

AN IOTCC BEST PRACTICE REPORT

LEAD ANALYST: MARY ALLEN

CONTRIBUTING COMMUNITY MEMBERS: Don Sheppard, ConCon Management Services; Naeem Khan, City of Stratford; Paul Gragtmans, Display5; John Jung, Intelligent Community Forum; Bill Munson, University of Waterloo; Campbell Patterson, CP Communications; Reza Rajabiun, Ryerson University

Additional expert contributions from: Jennifer Sicilia, RYCOM; Kelly Daize, Invest Ottawa; Prasanna Gunasekera, City of Brampton; Ritesh Kotek, Durham Regional Police Service; Dana Saltern, BusinessOne; Roman Zubarev, 29signals; Ted Longley, ORION

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Definition and context

The 'Smart Cities' concept has graced academic discourse for several decades now, pointing generally and optimistically towards technology's ability to help resolve challenges in urban life. The term has shown remarkable agility and resiliency, a survivor in urban development discussions due to its broad applicability: Smart City can mean the deployment of ICT solutions to improve the efficiency of government operations and administrative response to resource challenges, to manage assets and the built environment, and to optimize the delivery of water, power, transport, and other citizen services. It can also refer to the creation of the collaboration networks needed to inspire a culture of ongoing innovation in both public and private sector[1], sustainability initiatives aimed at improving environmental performance – or all of the above, singly or in combination. It can also mean different things, depending on the specific resources and issues present in a particular jurisdiction. Smart City solutions are likely, for example, to take on a different character in Europe or North America, where much of the foundational infrastructure is already in place, in developing regions, which may lack fundamental services[2], or in greenfield implementations, such as the new cities in Asia[3] that benefit from an ability to plan and deploy state-of-the-art technology from scratch.

Current interest in Smart City is driven by demographic trends, specifically in-migration, which is causing increased densification of the urban landscape and corresponding pressure on city planners to find new ways to address the needs of their growing populations. The UN projects that population growth and urbanization will add up to 2.5 billion people to the world's urban population by 2050[4], and while Asia and Africa are expected to account for a large share of this increase, the impacts of urbanization are likely to be felt in developed regions as well. In Canada, for example, 81 percent of the population already lived in an urban centre in 2011[5]; however, migration to Canadian city centres from other countries, combined with specific

[1] R. Florida, *Who's Your City? How the Creative Economy is making Where You Live the Most Important Decision of Your Life.* 2009.

[2] Ministry of Urban Development. Government of India. What is a Smart City? Smart Cities Mission. http://smartcities.gov.in/writereaddata/What%20is%20Smart%20City.pdf

[3] Songdo in South Korea in an oft cited example.
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[4] UN Department of Economic and Social Affairs. World Urbanization Prospects. The 2014 Revision. New York, 2014. https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf

[5] According to Statistics Canada's most recent Census. Urbanization. The Canadian Encyclopedia. http://www.thecanadianencyclopedia.ca/en/article/urbanization/

policy aimed at intensification in urban areas[6] is putting strain on municipal resources and structures – as it inspires a search for new solutions.

Another factor that is catalyzing interest in Smart Cities is technology advance, the articulation of purpose built urban solutions by the technology industry, and the growing deployment of pilot projects that serve as models for other jurisdictions considering similar implementations[7]. Typically, ICT solutions aimed at developing new levels of efficiency in the delivery of government services, transport, energy, health care, water, urban agriculture and/or waste management, have been built around one or more technology frameworks, such as digital city, intelligent city, ubiquitous city or even knowledge city, that differ in their emphasis on features such as connectivity, knowledge workforce or information access, but which share a focus on the deployment of ICT platforms aimed at urban innovation within definable geographic boundaries.[8] But tech advance, in telecommunications in particular, has inspired a re-evaluation of the relevance of defined physical space to concepts of ICT-driven urban innovation.[9] Internet-enabled trade and commerce, the broad distribution of operations and market reach, and remote work styles have inspired the evolution of intelligent community concepts that extend beyond a city's geographical borders to encompass global tech deployment, exploitation of global markets, and collaboration across city or state boundaries. Cities today operate within global frameworks.

Since the 1990s, emphasis on top down innovation executed at the government level has begun to shift as the "smart community movement" identified a broader base of participants as being critical to the successful implementation of advanced technology solutions and as the benefits of deployment extended from strictly economic outcomes to encompass socio political revitalization. For example, the concept of 'Intelligent Community', a more inclusive construct defined by groups like the Intelligent Communities Forum (ICF), incorporates the connection of actors in the private sector who develop innovative products, services and applications to drive a virtuous circle of economic productivity. In the ICF schema, Intelligent Communities are not circumscribed by geographic limits; rather they are defined by relative measures of broadband

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6 For example, Ontario's 2006 Places to Grow legislation, aimed at densification in Southern Ontario. Dakshana Bascaramurty. Places to Grow: Ten years later, is this progressive act a success or failure? The Globe and Mail. April 2015. http://www.theglobeandmail.com/news/toronto/places-to-grow-ten-years-later-is-this-progressive-act-a-success-or-failure/article23886492/

7 See, for example, IBM's Smarter Cities Challenge, a philanthropic initiative in which IBM experts assigns company experts to work on specific urban issues, and develop repeatable solutions that may be deployed in other cities. The program is now in its fifth year.
https://smartercitieschallenge.org/

8 Smart city. Wikipedia. https://en.wikipedia.org/wiki/Smart_city

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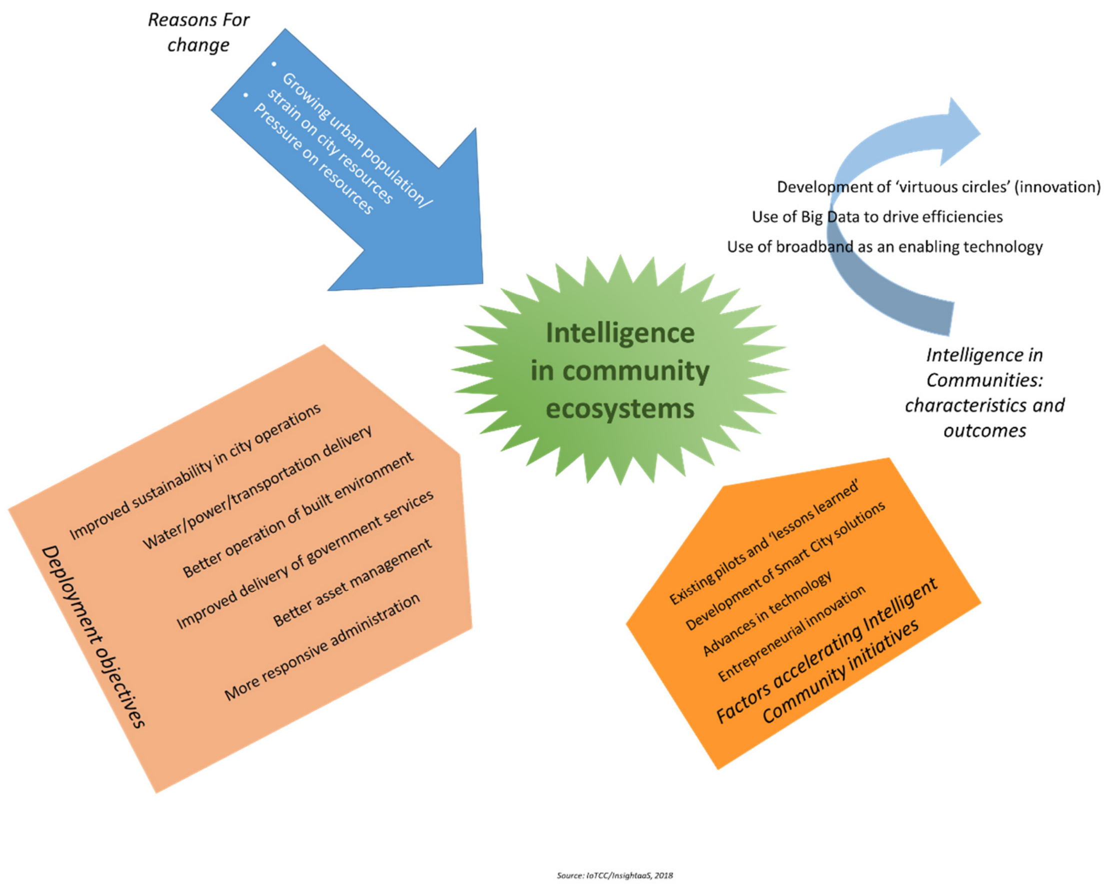
accessibility, knowledge workforce, innovation, digital equality, sustainability and advocacy in a region.[10]

Figure 1. Intelligence in community ecosystems drivers, objectives, accelerators and outcomes



Today, the technology that is animating a rebound of interest in urban solutions is the Internet of Things, or the interconnection of sensors and devices in the physical world with systems of analysis supported by advanced ICT, which can deliver new levels of monitoring, intelligence and control in urban planning, operation and innovation. IoT potential has become a focal point in urban development for a number of organizations, ranging from groups like the Smart Cities Council,[11] which has sidestepped definitions to focus instead on the practical explorations of digital technology implementation, to the World Economic Forum, which believes the future progress of cities lies in the deployment of IoT-based intelligent assets that will support

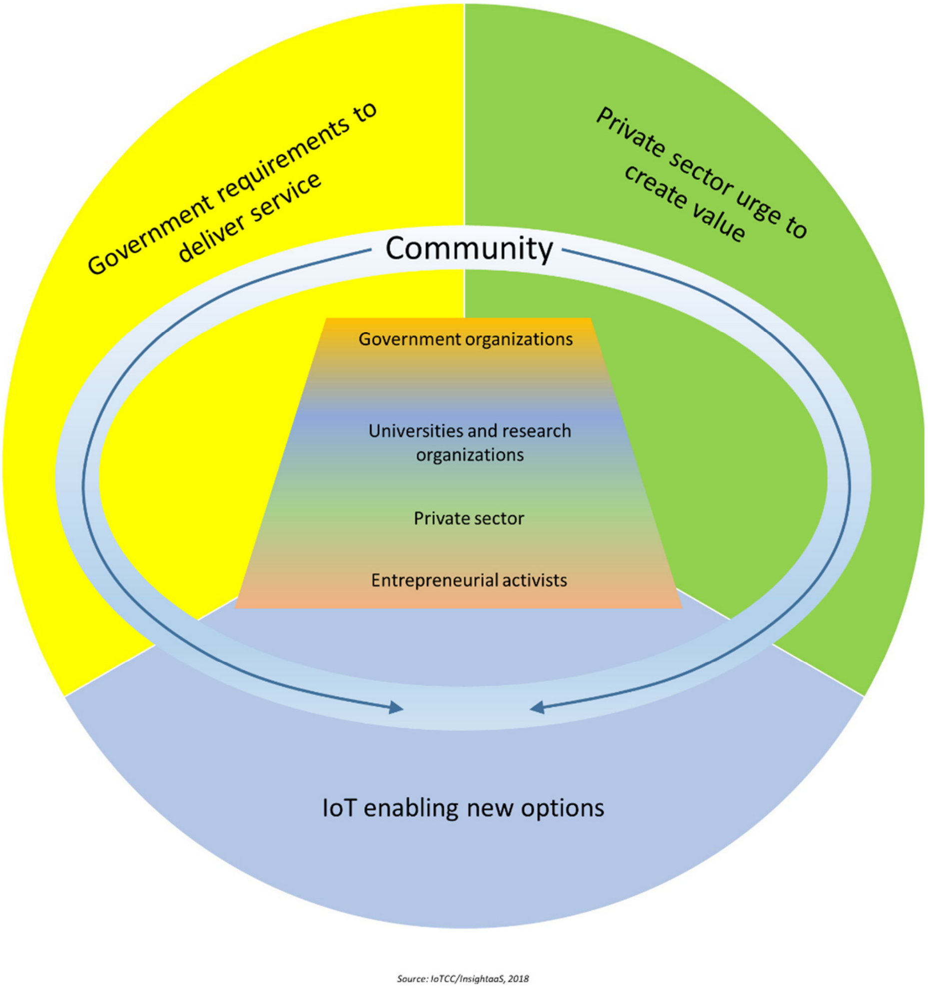
[10] ICF. Intelligent Community Indicators. http://www.intelligentcommunity.org/intelligent_community_indicators
[11] Definitions and Overviews. SmartCitiesCouncil. http://smartcitiescouncil.com/smart-cities-information-center/definitions-and-overviews

creation of the "circular economy," a new approach to resource management that focuses on regenerative production and sustainable consumption.[12]

According to the Intelligence in Community Ecosystems working group, a better understanding of ICT potential to improve social, economic and sustainable outcomes can be achieved by combining key elements of these various visions into an IoValue concept that aligns the technology capabilities and characteristics of IoT with the broader, more inclusive notions of city/community. While IoT innovation acts as the key driver of IoValue, befitting the distributed nature of IoT, the working group has outlined best practices around its implementation in terms that encompass more actors in the adoption of advance technology than may appear in other definitions. As the explosion of data generated by instrumentation of the physical world and the surge of creativity unleashed in the development of new applications are features of IoT that are common to both public sector and entrepreneurial initiatives, through enhanced sharing of data-driven intelligence, a connected 'community' will be empowered to create new value in an ever-expanding number of use cases that involve the delivery of virtual goods/services beyond geographic borders. And as the consumerization of technology has enabled localized, grass-roots innovation that speaks to broad ownership and stewardship of IoT, Machine2Machine (M2M) communications are enabling the development of autonomous, internetworked systems – initiating a 'bottom up' approach to urban transformation that is scalable from the smallest group of stakeholders to the global cluster.

[12] World Economic Forum. Intelligent Assets. Unlocking the Circular Economy Potential. December 2015. http://www3.weforum.org/docs/WEF_Intelligent_Assets_Unlocking_the_Cricular_Economy.pdf

Figure 2. IoT enablement of Intelligent Community



Parsing 'community' to identify participants in urban/regional IoT initiatives, the working group has singled out: government organizations that initiate projects or provide support for other agency initiatives, university and research organizations, the private sector, on its own or in public partnerships, and entrepreneurial activists. As guidance to these groups, the IoValue: Intelligence in Community Ecosystems working group has defined best practice positions in the following areas:

- Infrastructure foundations: Levels of connectedness, including broadband or edge technologies that are critical in many IoT applications.
- Public/private partnerships: IoT deployments can entail considerable investment in infrastructure. Can public/private partnerships help address this challenge, and what structures/principles can encourage effective cooperation?
- Strategic program direction: A lack of strategic direction on technology implementation at the government level can have significant impact on community innovation. Beyond

limited investment in infrastructure or funding of incubator programs, the lack of communication from government on strategic technology direction can create a climate of uncertainty amongst other groups. In this atmosphere, how does the private sector proceed on IoT projects, whose value outcomes may change with changes in government position?

- Balance top down and bottom up approaches: IoT unleashes new levels of local activity. A sensor may be deployed on a WiFi network, for example, and run via M2M to deliver insight on a local system. How might this potential for distributed IoT applications collide with regulatory or other requirements imposed by governments that are typically animated by top down, control approaches, and how do local applications fit into a broader ecosystem?
- Architectural reference: Is it possible to develop an architectural frame of reference for IoT in municipalities? What would an IoT roadmap that simultaneously supports cities' need to deliver citizen services and an intelligent communities' innovation agenda look like?

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Business objectives

"Because we can" is a justification for IoT that may be tempting but not adequate to support deployment at scale. Commenting on the City of Stratford's experience as testbed for connected cars,[13] a spokesperson for the city noted that while the WiFi and fibre optics communications infrastructure is in place to support testing, questions around how the platform can be used to the city's advantage remain. While the pilot project offers exciting opportunity for certain groups – the local provider of a popular connected car OS (BlackBerry's QNX), an industry association (the Automotive Parts Manufacturers' Association of Canada) partner that is looking to better understand issues in this space, researchers at a local university (the Waterloo Centre for Automotive Research testing), and citizens and local politicians who are keen to showcase Stratford's smart capabilities – the full benefit of connected car implementation will depend on the ability of all members of the community to articulate the project's business objectives. What type of related city services can be provided to support the deployment, when and how can integration with other city systems take place, and does a small city actually need this type of technology are key questions that city administration needs to answer before it engages with vendors, throwing full financial support behind the initiative.

Ultimately, government involvement would be contingent on development of a use case for the data collected through IoT, on identifying how data can be used to support better decision making and optimal use of critical assets. "We are approached by a lot of manufactures with door sensors to help with headcount," the spokesperson explained. "It may be a good idea – a mall or a very large city centre might do that, but do we need it? Probably not." In situations where private stakeholders who could use this data to advantage might go ahead and deploy with funding support from government – the owner of the shopping mall, for example, or a group of retailers might opt for sensors – an ROI estimate for the city must be established: "We still have to think like a business. At the end, it comes down to the citizens, and we have to make sure tax dollars stay low."

At the same time, return on investment for government is a proposition that is informed by broader responsibility to various citizen interests. If the overall goals of private and public sector may diverge, this imperative to think like a business, is a common requirement across IoT stakeholder groups. But with creative thinking on how data can be used to solve problems, IoT offers unique potential to deliver on business goals, while providing new opportunity to each constituency. In the door sensor case, for example, occupancy sensing may help reduce costs through better energy management and improved building security, while the harvesting of sensor data may provide new means to monetize contextual information; within the mall, there would be several commercial interest groups who could benefit from time stamped demographic analysis – who enters the building, when. This data-driven IoT intelligence would be available to the building owner, to a third-party solution specialist or broker who might develop an application based on data analysis, to retailers, to municipal government who might

[13] Mike Beitz. Waterloo Centre for Automotive Research testing highly automated vehicles in Stratford. The Beacon Herald. November 2016.

reduce policing cost and benefit from support for economic development in the region, or even generate incremental revenue through sale of the data. In these kinds of scenarios, who has the right to collect sensor data, what kinds of permissions are required, who has the right to sell it, and what open formats the data is distributed in, will emerge as critical questions that shape IoT project planning, business outcomes and stakeholder roles. Many intelligent community initiatives are likely to take the form of public/private partnerships in which government functions as facilitator rather than a fundamental gate keeper, developing provider neutral infrastructure support, guidance on standards-based architectures and scalability, and open access to open data in an IoT design model that encourages a productive mix of private and public-sector talent and industry effort.

While IoT business objectives will vary according to regional requirements and resources, by industry and key stakeholder interests, the working group has outlined five broad goals in IoT community deployment. How these can be achieved is illustrated through a vertical or sectoral exploration. In transportation, for example, IoT can deliver the following benefits to multiple stakeholders.

Productivity improvements: Smart traffic lights and smart parking are two of the most pervasive IoT solutions, which have been deployed to improve vehicular traffic flow within metropolitan regions. Sensors in traffic lights can monitor for system failure and associated maintenance requirements, and for traffic abnormalities that need correction. For drivers, better traffic flow means less time spent in the vehicle and with access to information on parking availability, less time spent searching for vacant parking spaces. Enhancing the efficiency of traffic systems can also deliver environmental benefits, in terms of both reduced carbon emissions from vehicles that are no longer caught in traffic congestion and reduced energy consumption to operate systems, which in turn can have a positive impact on public health.

Cost reduction for administrators: The connection of mass transit vehicles with operational control centres can improve asset management for transportation operators; better routing, based on occupancy and traffic data, will serve to optimize operations, reduce cost and improve service to drivers. The connection and integration of various transit services can introduce additional efficiencies: a shared service approach can eliminate duplication of investment in ICT infrastructure if emergency services, city administration, police services rely on a single ICT ecosystem, while riders benefit from opportunities for multi-modal, regional transit.

Safety improvements: While the insurance industry continues to work on developing appropriate risk models and fee structures for autonomous vehicles, self-driving cars with full on sensing capability to monitor road obstruction are widely touted for their ability to improve safety in vehicle operation. Telemetry data collected from connected vehicles can also provide important input on component wear and update requirements to improve maintenance services for individual cars, private sector fleets or mass transit vehicles to further improve safety and reliability.

New citizen services: Service delivery and customer satisfaction in transit systems are greatly enhanced with data-driven applications that use real time information on fleet location to provide riders with up-to-date scheduling intelligence. Intermodal transportation service is a growing requirement in many areas as urban innovators work to connect people, place of employment and residence across regions, and as the individual's need to combine inter-urban rail with public transit systems, car and ride sharing systems, and cycle rental to complete a commute or other journey, becomes an increasing phenomenon. Open data on routing, arrival/departure times, and the availability of different modes of transport services is being combined in integrated ticketing and new third-party applications that provide citizens with information on the best travel options.

Support for innovation and entrepreneurial activity: IoT infrastructure and systems in the transport sector deployed to support new levels of efficiency in service delivery may also inspire the creation of a range of new products and services. When data that is generated from the sensing of multiple transport systems is made available to citizen/entrepreneurs, it can be used in the development of new applications that were not thought possible before the advent of IoT. Location-based data collected from an individual riding on the subway system, for example, has been used in connected environments in Montreal to push marketing messages appropriate to the app user and the physical location of the specific car, creating a new real time, location-based advertising channel that is tailored to the individual user.

Figure 3. Intelligent community business objectives: transportation

Source: IoTCC/InsightaaS, 2018

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Best practices

Infrastructure foundations

The foundational element in the "Internet of Things," connectivity is a key enabler – or inhibitor – of IoT innovation. Levels of connectivity, including the technical capacity and distribution of broadband and access network services, can impact both the delivery and consumption of IoT applications, and ultimately determine the success or failure of an IoT venture. Historically, service providers have argued that Canadian-specific challenges associated with geography (extensive territory that is sparsely populated) have translated to higher broadband costs, for high speed services in particular,[14] relative to many other regions of the developed world, resulting in a poor showing for Canada in key metrics designed to assess a country's level of connectedness. Service provider coverage maps often reflect maximum advertised speeds for fixed broadband services, though mobile broadband is likely to offer more flexibility for the support of evolving IoT applications. But in mobile coverage surveys, Canadian performance is less than ideal.[15] The most recent OECD broadband update (based on data for 2016) has shown, for example, that while mobile broadband penetration for the 35 country OECD region is 99 percent (subscriptions per 100 inhabitants), Canada ranked 29th , outperforming only Belgium, Turkey, Portugal, Slovenia, Mexico, Greece, Hungary and Colombia in this important measure of next generation coverage.[16] Compounding this issue is the gap between reporting and reality: as the working group observed, while service provider maps may make blanket statements on mobile coverage across an area, when tested in the field, actual signals may be found wanting. Third-party companies contracted to confirm coverage and actual capacity have found differences between what is delivered and what is advertised, especially in rural regions of the country, while the coverage map for Canada as a whole notes variation in actual availability, along with service delivery clustered along the country's more densely populated southern border[17]. And in an ITU assessment of IoT readiness, based on rates of M2M penetration, Canada does not appear in the top 20 list.[18]

New community initiatives

In several Canadian regions, "community" extends beyond the physical borders of the city proper, so ensuring the extension of high speed broadband services out into the rural regions is

[14] Empirica and TÜV Rheinland. Fixed Broadband Prices in Europe 2016. A study prepared by the European Commission. https://ec.europa.eu/digital-single-market/en/news/fixed-broadband-prices-europe-2016

[15] Even in areas with advanced spectrum assets, gaps in mobile coverage exist and are expected to increase due to growing demand for mobile data services. See notes on The Eastern Ontario Regional Cell Gap Analysis in: Reza Rajabiun. Intervention regarding the CRTC *Review of Basic Telecommunications Services*. Submission delivered under the direction of the Eastern Ontario Wardens' Caucus/Eastern Ontario Regional Network (EOWC/EORN). July 2015. https://www.eorn.ca/en/resources/CRTC/EOWC_EORN_CRTC2015_final.pdf

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[18] ITU. ICT Facts and Figures 2016.

critical to the advance of IoT adoption, especially in those areas that Canada aspires to lead in, such as precision agriculture, or smart resource management. Many Canadian cities are sprawling. For example, approximately 90 percent of Ottawa residents are classified as rural, and there are 1,600 farms within the 'city' that need to be connected to support smart agriculture. The Edmonton and Calgary experiences are similar, but connecting far flung properties as well as community residents represents a physical and financial challenge for the service providers. Currently, a CRTC sub-committee is debating establishment of minimum quality of service for rural areas; however, even if there is agreement on standardization in service delivery, operators have traditionally argued, and may continue to assert that the financial incentive for infrastructure investment in sparsely populated regions remains elusive. Currently, there are multiple dead zones even within major urban areas such as Toronto where neither WiFi nor broadband are available. To ensure that individuals in rural or remote communities have the same access as those living in the best connected urban neighbourhoods, and are not systemically disadvantaged when it comes to access to healthcare, education, government services and online marketplaces, all citizens must enjoy the same price and performance to access the Internet. From an IoT perspective, this translates into ubiquitous and equitable access to fibre optic, LTE and WiFi/WiMAX connectivity.

To achieve the capacity, reliability and quality connectivity needed to support participation in IoT innovation by all community stakeholders, new approaches are in order. Growing IoT activity and demand has potential to influence the traditional cost/delivery equation, and the increasing role of IoT in driving new efficiencies in services delivery and in regional economic development is leading several Canadian jurisdictions to consider addressing underserviced community requirements with their own infrastructure. In regions across Canada, municipalities have invested in the development of their own broadband and Smart City infrastructure to ensure adequate coverage in underserviced areas, and to maintain the transparency and access to open data needed to stimulate entrepreneurial application innovation, and ultimately, competition between third-party service providers leading to better connectivity services.

To support its "Smart Community" vision, Kingston has built its own Community Broadband Network, a 1,000-kilometer fibre optic network with additional fixed wireless which interconnects to global links to connect institutions, businesses and residents throughout the region. Deployed initially to support the delivery of municipal services, CBN services are now sold to commercial clients and residents at a competitive rate. In Ottawa, ownership of city broadband is a topic that is generating interest, and a re-creation of Telecom Ottawa (which was sold to Rogers) is gaining momentum with city commissioned research into Smart City potential. Ottawa efforts to balance the benefits of local delivery (better uplink speeds) against cost, now encompass consideration of the innovation and international recognition that municipally-owned, Software Defined Network controlled, next generation infrastructure can bring. Communities are also looking to build out WiFi connectivity, and the delivery of WiFi services in public spaces is becoming standard practice across the country. Stratford, for example, has offered WiFi to residents at no charge for some time, though the city may need additional capacity and new devices, and potentially invest in LTE or 5G networks to support advanced applications such as connected car.

Efforts spanning multiple municipal regions which are aimed at improving connectivity are also now underway. For example, CENGN, the Centre of Excellence in Next Generation Networks research centre in Ottawa, which is funded by the federal government and industry, just received additional funding from the Government of Ontario for its mandate to connect the province. Created as a platform for the testbed of advanced applications, CENGN supports research into interoperability, software defined networking and network virtualization by members, which include government, academia, the large Canadian service providers, and mobility and network vendors. In the IoT space, CENGN will support research into application requirements and the development of PoCs aimed at identifying the devices needed to support the feasibility of IoT solutions. Another example can be found in the South Western Ontario Integrated Fiber Technology Network, which has a financially sustainable plan to leverage funding from the governments of Canada and Ontario, and reinvest some portion of the revenue that will come from public financing into the extension of high speed broadband to connect people and businesses in 350 smaller, rural communities where private sector funding for broadband is less likely to go. Lying outside city budgets, this funding can help smaller communities build the connectivity foundation needed to participate in IoT innovation, which the Ontario government and others have recognized as key to a region's social and economic health[19].

Is all broadband created equal?

In addition to issues with access and availability, IoT connectivity challenges include the requirement for reliability and symmetry. While there may be some coverage across populated regions of Canada, "connectivity" needs will be defined differently for various IoT use cases. Broadband upload speeds can be bursty, and while lack of symmetry or two-way communication may be suitable for some applications, for others that require continuous connectivity back and forth to cloud or between machines, this asymmetry can become problematic as it slows communication. IoT applications are highly varied in terms of the capacity they demand: low power devices out in the field may not generate a lot of information, if data can be cached for transmission at a later time, high speed access would not be needed; however, applications based on real time information are dependent on adequate transmission speeds.

To ensure the stability of IoT applications that sit on top of the network, the working group advises that agreements on service levels be established – for each piece of the network continuum. In smart parking or street light solutions, there would likely be low power, mobile

[19] Ministry of Infrastructure, Government of Ontario. Building better lives: Ontario's Long-Term Infrastructure Plan 2017. https://www.ontario.ca/document/building-better-lives-ontarios-long-term-infrastructure-plan-2017

connections between sensors and a gateway, and then high quality broadband service between gateway and a cloud or enterprise data centre, which each feature different QoS requirements. Within IoT enabled buildings, connectivity is often provided through a wired cable system or WiFi, for which a guaranteed service model should be in place to ensure adequate signal reception.

A widespread opinion held today by service providers and other groups is that the full unfolding of IoT is contingent on the pervasive deployment of 5G networks, which is anticipated for 2020. Currently, CENGN researchers are engaged in test beds for 5G, and the CRTC has been tasked by the federal government to decide on how 5G spectrum should be allocated, how it will be prioritized, and if public safety spectrum will be included – key questions that may also impact roll out of IoT. In March 2018, ENCQOR, a joint initiative undertaken by five digital technology leaders and provincial coordinators Prompt, CEFRIO, and Ontario Centres of Excellence (OCE) with additional funding from the federal government to establish the first Canadian pre-commercial corridor of 5G wireless was announced, with a goal of supporting IoT and other advanced applications.[20] Other private sector innovation is also in place to support IoT deployment: for example, eleven-x has built a low power WAN network based on LoRaWAN technology which is purpose-built for IoT applications that require long range, low power consumption and low-cost connectivity. This summer, the provider announced a cross-Canada expansion of its next gen network to enable Smart City and IoT initiatives beyond its southern Ontario roots.

Standards

If IoT solutions are composed of a mix of broadband and access technologies, they are built with proprietary components that typically rely on different networking protocols. At the communication layer, for example, there are close to 20 different protocols with competing standards in the low – to medium data transfer rate, which hinders the growth of IoT applications, and additional incompatibilities in higher communications layers (LoWPAN vs ZigBee, for example).[21] Different standards also appear at the device discovery, data, application, cloud and security layers of the IoT stack. And while the use of some protocols may be optimal for specific applications, the existence of multiple standards and consortia that promote them pose an especial challenge for the connected community; problems with interoperability may impede the development of an individual IoT solution, but these issues are compounded for the intelligent community that aspires to integrate systems for smarter management, to collaborate, to share information among different administrative bodies, with various city operations and with the community at large. A holistic view of IoT connectivity is about more than the technical and scientific nature of the Internet, it is about connecting

20 CNW Group. Historic ENCQOR partnership will launch Canada's 5G communication highway. March 2018. http://insightaas.com/historic-encqor-partnership-will-launch-canadas-5g-communication-highway/

[21] IoT Standards and Protocols. Postscapes. https://www.postscapes.com/internet-of-things-protocols/

people with information that informs and enables better management of the physical world; however, interoperability, technical compatibility are fundamental enablers that need to be in place. Siloed systems can stymie the creation of open solutions; a lack of agreement on standards can serve as the source of an IoT application's inability to communicate. This is an issue that is even more problematic on a global scale, where movement towards standardization may occur on a country by country, and on an industry to industry basis.

According to the working group, standardization is one of the most important means to drive IoT adoption because uncertainty around multiple competing standards introduces material cost. In the adoption of advanced technology, if the community opts for the standard that fails, redeployment costs can impose significant burdens on budgets. Today, several standards bodies, such as the NIST, the ISO, the ITU or the IEEE, are working to understand how particular applications travel over networks and what general rules should be in place to allow IoT developers to build on those applications according to a common set of rules, and several have developed standards and reference models[22] that they hope will gain global recognition. For the most part, Canadian implementers of IoT would have few unique needs that can't be met through reference to these international standards, due to the universality of technology need and because many of these global bodies include Canadian member bodies. A local Canadian committee, for example, is reviewing ISO work on IoT standards[23]. However, Canada does feature long distances, and a rural/urban population mix across many regions (such as Ottawa), which may dictate unique scale needs and a focus on specialized applications in IoT, such as precision agriculture and related applications, space-based (drone) sensing from farm to fork, autonomous tractors and farm equipment, robotics to replace humans in dangerous or monotonous work and mobile applications.

Public-private partnerships

In Canada, new approaches to intelligent community deployment are beginning to take shape, largely in response to financial and administrative challenges associated with funding IoT infrastructure and platforms through more traditional means. In a joint venture or more formal procurement arrangement, for example, where the private firm manages the implementation with public support, procurement processes can consume a lot of work and time as the specific project moves to the top of the priority queue. Involving multiple components, vendors and implementers, IoT may also present a complex puzzle for government procurement officers who may find that fine tuning tendering to encompass engineering detail in IoT solutions is an unwelcome proposition. And while procurement fills an important role in supporting

[22] Don Sheppard. An ICT framework for everything. InsightaaS. July 7, 2017. http://insightaas.com/an-ict-Sframework-for-everything/

[23] For example, the Canadian Mirror Committee is reviewing the ISO's SC41 standard for IoT.
The ISO/IEC has published a first Technical Report on Internet of Things (IoT) use cases. ISO/IEC 22417. November 2017. https://www.iso.org/obp/ui/#iso:std:iso-iec:tr:22417:ed-1:v1:en

government's need to support transparency and competitive practices, in some circumstances, a lack of technology understanding may introduce its own roadblocks.

Initially designed to fund mega projects such as the building of hospitals and bridges, P3 (public, private partnership) arrangements were intended to deliver concrete physical evidence of assets with recognizable benefit. Layered on top of other physical infrastructure, IoT implementations, on the other hand, typically represent a much more modest investment with a longer-term value proposition that might be more difficult to envision. While ROI is calculated in city budgets in financial terms, the return on IoT technology may be more closely aligned with the delivery of citizen-based services that are more difficult to prioritize. As a result, funding for IoT may fall through the cracks between traditional procurement and established 3P processes.

However, new kinds of structures are evolving to create access to the talent and funds needed to enable cities/regions to modernize existing infrastructure, to keep pace with the rapid advance of IoT solution development, and to support innovation in public and private sectors. In March, 2017, for example, The City of Toronto, announced the creation of the Civic Innovation Office, funded by Bloomberg Philanthropies, which will serve as a coordinating centre for financing innovation initiatives that bridge the work of city divisions and the technology community in solving municipal service delivery challenges. With a mandate to apply technology, data analysis and design thinking to urban issues, the Innovation Office will enable the city to work with external partners who will develop and test real solutions, including IoT, that can be procured by the City. Another good example of special purpose funding can be found in the South Western Ontario Integrated Fiber Technology Network referenced above, which relies on funding from the governments of Canada and Ontario to invest in connectivity infrastructure for smaller communities.

Through relationships with external partners, several communities across the country have engaged in forward thinking projects that have laid strong foundations for IoT advance. Established in 2013 through funding by the Governments of Canada, Ontario and Toronto to lead revitalization of the city's waterfront district, Waterfront Toronto was designed as a leading example of how to build a Smart City. Built on IBM cloud computing services, its Intelligent Operations Center technology and social business software, Element Blue implementation services, and Cisco WiFi for connectivity, Waterfront Toronto's Smart City deployment aimed at integration of city data for better insight into operations, the creation of an information delivery portal for the ongoing launch of new information services for residents and a platform for social collaboration. Currently, the agency is working with Alphabet's Sidewalk Labs to create a plan that will expand development, but which is contingent for approval on appropriate provisions for the protection of privacy, citizen engagement and digital inclusiveness.

The early engagement of external vendor partners in pilot projects may offer the advantages of rapid ramp and ongoing work with public administers to complete a technology project, and to support this kind of arrangement, some metropolitan regions have eschewed formal RFP process in favour of participation in competitions or philanthropic activity designed to support smart deployments. The working group cautions, however, that once large vendors become involved in a community, the project may become more exclusive and it may be difficult to include other participants due to the use of proprietary protocols and capture of project data that is not open access.

Ideally, the application of IoT solutions to challenges in urban life involves the creation of partnerships between multiple stakeholders. As in the nascent stages of any technology, collaboration between research bodies, public institutions and corporate entities provides the technical expertise that forms the foundation for creation of municipal solutions; in Canada, as elsewhere, this cooperation has taken the form of corporate support for new academic chairs in IoT research and related R&D. However, with IoT, a shift from ICT-based innovation focused on the deployment of broadband infrastructure to the creation of ICT applications that enhance quality of life is beginning to take shape – and with it, the emergence of a new role for urban and regional areas as innovation engines in their own right. Across the globe, there are initiatives aimed at mobilizing cities and rural regions as the agents of change, as environments supporting "democratic innovation" that function not only as objects/recipients of infrastructure modernization, but also as ecosystems that power the co-creation capabilities of user/citizen communities as they design for innovation in life, work and play solutions. AMS (Amsterdam Institute for Advanced Metropolitan Solutions) design and engineering researchers, for example, work on the development of multidisciplinary metropolitan solutions, but in tandem with key technology vendors and with "social partners" such as the City of Amsterdam which shares city data, acts as a pilot location for AMS solutions, and provides access to city talent, networks and organizations in addition to financial support. Similarly, the MIT Senseable Lab in Singapore is a SMART innovation hub supported by Singapore's National Research Foundation that hosts multiple international and local researchers who rely on city data in their investigations into the impact of digital technologies on city/country transit. This kind of experimentation is also beginning to take shape in Canada; while a Smart Cities Challenge has been introduced by the federal government, UPPlift (urban pilot program), a virtual technology accelerator that aims to resolve city challenges and increase the city's livability through IoT and other smart technologies, launched recently in Toronto with the support of a key technology vendor, a realty company and the City of Toronto, and has plans to expand to other regions across the country. Extensive pilots, such as the Stratford connected car example cited above or the recently announced Ottawa Research and Engineering Centre, which is focused on developing autonomous vehicle technology with the help of university researchers, commercial businesses, industry associations, city administrators, federal/provincial governments and citizens, constitute "living labs" – 4P ecosystems that engage public sector, private sector and people in partnerships for IoT-enabled change.

Figure 4. Examples of regional and global community initiatives

Source: IoTCC/InsightaaS, 2018

Strategic program direction

If the participation of multiple stakeholders across the community in IoT innovation is an aspirational goal, in many real-world examples, creating the environment needed to catalyze this engagement is typically led by one or other group, and often by government at the local level. This leadership is needed to ensure appropriate investments in the people and technology infrastructure that will create a foundation for change; and to ensure ongoing leadership that can weather the vicissitudes of pollical process and priority, strategic program direction on technology implementation is called for. In the absence of this kind of statement of commitment from government, a climate of uncertainty can dampen private sector activity.

From a planning perspective generally, a first step for city/regional administrators involves identifying the stakeholders – the 'five W's: who, what, where, when, why, as one working group member put it – and combining this with an assessment of sectoral strengths, weaknesses, opportunities and threats associated with a particular planning initiative. A solid understanding of the secondary literature and research that is available on a project may help define the need for specific activities and/or communities of interest. Another important requirement is to specify time horizon, as planners tend to look at the longer-term vision, as well as more tactical operational issues. For example, as a project moves closer to approval, definition around how it will operate, how will it be funded, and how will it continue to deliver on execution challenges, including long term funding and response to community input to ensure continued relevance and support for the project, become increasingly critical. Ideally, these questions can be answered through a business case/feasibility assessment that is used to approve pilot project funding.

In IoT, answer to the ‘who’ question can be diverse: from the government’s point of view, the audience may be constituents, voters, partners in public-private sector collaboration, or stakeholders in specific deployments, who are also diverse. In smart real estate, for example, there will be unique drivers, different pressure points and different stakeholders at the table within individual communities, different tenant profiles, and different appetites for services and amenities in smart buildings, depending on the region and location. Real estate also offers a good example of multi-level government engagement, as many city and provincial governments have instituted educational incentive programs aimed at incenting the adoption of smart solutions to improve efficiency and drive savings. In programs that relate to upgrades, building or implementing smart building systems, or that cover the use of data to generate energy savings or reduce carbon footprint, building operators and owners are compensated for a certain percentage of the cost of their project. While these programs may contribute to a government’s environmental agenda and ultimately to the well being of citizens, they also highlight the need for greater coordination in IoT program delivery. Today, there is considerable variation in how education programs are delivered and in educational content, and a lack of consistency in the incentives themselves – how saving outcomes are quantified, the type of rebate and how these are applied. Different programs in different jurisdictions can be confusing to the multi-site building owner, and to value-added services providers who are looking to develop and market a consistent Smart City vision. On the other hand, these and other suppliers would benefit from a clear statement of government’s smart infrastructure strategy and implementation design, so they can help drive innovation in the planning agenda.

Beyond differences in community and sectoral requirements, the specific IoT application will also shape planning and infrastructure needs. Smart parking and lights represent a different use case than occupancy sensing for optimization of HVAC and security systems: different technologies are deployed in different contexts, with diverse incentives and stakeholders. And though everyone could benefit from smart parking, problems arise during implementation around issues, such as the inability to account for this technology investment in municipal budgets. However, to avoid ‘coordination failure’, or the failure to benefit from the efficiencies that can be created by coordinating multiple deployments, the working group advises maximum effort to encourage broad stakeholder engagement. Coordination failure may occur at top levels of the administration, but also at the next layer down due to competing priorities, a problem that is compounded by a failure of language, which contributes to an inability to communicate across departments and agencies that may each benefit from a deployment. In the absence of a strategic plan, “How do you herd cats?” the working group asked.

To address this challenge, administrators should think in terms of the critical infrastructure needed to improve improved efficiency and return business benefits, coalescing enough groups at a programmatic level to support the articulation of a common vision. In some jurisdictions, this will be easier than in others: in Markham, Ontario, for example, the local utility Alectra is owned by the municipality, an arrangement that has helped government ‘partners’ work together on the implementation of smart grid projects[24]. In smaller communities where there can be more potential for misalignment, it may be helpful to map out an IoT project as part of meeting citizen needs, but it may also be possible to align the initiative with provincial requirements that the community must meet in order to abide by provincial law, and to communicate this process to the public.

Sketching out economic benefits is also helpful; in Toronto, the CIO's office conducted a study that found $40 million worth of potential value that could be won from the greater productivity, operational efficiency, and cost avoidance that could be achieved through IoT, and the city is now collaborating with the Toronto Regional Board of Trade to build a plan that will prioritize smart city goals and programs based on a cost/benefit analysis that ensures adequate ROI. Due to the sheer number of modernization opportunities, Toronto's CIO has reframed language around technology initiatives to talk of "portfolios" not "projects." And in Vancouver, a digital strategy initiative (that involved the integration of 13 city departments that depend on central IT delivery) built in the CTO's office is viewed as a key achievement and the foundation for technology-enabled change.[25] While overall strategic vision is critical to this process, the Toronto and Vancouver experiences speak to the difficulty in implementing IoT "in one shot": immediate needs – traffic congestion, in Toronto's case, for example – often trigger the community's journey down a smart path, and to avoid loss of focus or recognition of ROI, the working group suggests planning encompass both long and short term vision – a staged execution that can match dollars spent with dollars saved to create validation along the IoT journey, and hence improve prospects for achieving eventual goals.

In many Canadian examples, leadership at the top such as the mayor, CIO, or chief planner has proved instrumental to establishing technology modernization as a priority. In IoT deployments, there are other constituencies that will also be involved, including IT groups, data management groups, engineering teams who develop the infrastructure budgets and timetables, the economic development team, building planning team, budget leaders and procurement groups. Historically, urban planners not been part of economic development and technology awareness discussions; however, in the last five years, these have become more cognizant of the importance of technology in developing response to community interests. Citizens, and the younger generation in particular, as well as business groups are demanding that their jurisdiction be part of the Internet economy, and connected community is increasingly viewed as a way for a region to differentiate itself, to prove 'shovel ready' and able to attract companies that will invest in the creation of jobs of the future. Successful government leaders

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[24] Alectra Utilities and City of Markham to support Ontario's EV goals with innovative charging station program. Alectra. https://news.alectrautilities.com/alectra-utilities-markham-support-ontarios-ev-goals-innovative-charging-station-program/

[25] Mary Allen. Vitamin Y: new 3P approach to city building at Wavefront 2017. June 2017. http://insightaas.com/vitamin-y-new-3p-approach-to-city-building-at-wavefront-2017/

will be those who have managed to overcome 'coordination failure', who have taken advantage of best practice sharing across communities to share use cases, and potentially even infrastructure to support the innovation and new opportunities that communities look to their leaders for.

Bottoms up

Throughout planning process around technology implementation, engagement with the broader community is a key contributor to project success, as it works to ensure the deployment meets community needs and hence enjoys ongoing support. In IoT, broad contribution from multiple constituencies is especially important; composed of multiple ICT hardware and software components from a range of established service providers and app startups, the development of IoT solutions relies on an ecosystem of partners, which in the community context also includes domain and policy experts along with municipal planners/operators. A "triple helix model" of innovation[26] that features interactions between public, private, institutional, and non-governmental sectors is well suited to the articulation and implementation of IoT in a community context. The constellation of IoT players is profuse, and may include vendors, who work with communities to develop vision and solution, as well as industry associations, tech associations, government, academia, incubators and the startup ecology, which operate on both global and local scales. The GSMA, for example, is a global association representing the mobile telecommunications industry that is now looking to IoT to help fulfill its mandate to ensure the growth of mobile services. To support the development of this opportunity, the GSMA has developed an extensive collection of educational resources aimed at training regulators on technology advance, which are designed to encourage standardization in the deployment of IoT solutions, such as Smart City, and promote device interoperability to accelerate IoT roll out. GSMA connects with other institutions and presents at international forums to spread awareness of IoT opportunities, and advocates with government for policy and regulation that can enable key initiatives, specifically IoT.[27]

In Canada, input on issues such as standardization or broadband pricing (Canada has some of the highest prices in the world for fixed and mobile broadband[28]) can be critical as these will impact the shape and vigour of municipal IoT innovation; however, competing interests increase the complexity of these discussions. Groups in the US and Canada, for example, who are opposed to network neutrality, or equal access to Internet services, are now citing IoT as a justification for discriminatory traffic management practices, a position for which the working group believes there is no technical basis. And if advocates for net neutrality may have other,

[26] Henry Etzkowitz and Loet Leydesdorff, "The Triple Helix -- University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development". January 1995.

[27] IoT is a discrete program area for the GSMA, which encompasses Mobile IoT, IoT Security and Connection, Smart Cities, Drones, IoT Big Data, IoT Knowledgebase for Policy and Regulation, Connected Vehicles and Remote SIM Provisioning. https://www.gsma.com/iot/

[28] Ibid. European Commission. Fixed Broadband Prices in Europe 2016.

political interests, the working group suggests that differentiated pricing need not be incompatible with adequate access; while the Internet is becoming more differentiated in terms of service quality levels, many IoT applications depend more on reliability of the connection than on a lot of capacity. From a technical, network management perspective, movement towards more differentiated services is ongoing and desirable, but with minimum service quality guarantees from service providers, potential negative impact on IoT service delivery can be mitigated, an outcome that solution developers and implementers will look to ensure in project research, as they assess the cost and benefits of connectivity services that may be required. Each use case will have its own characteristics; lightbulbs do not need 100 percent gigabit speed to connect with a controller at all times, and packet loss requirements may be in real time or cached, affecting the connectivity needs of the application.

As part of awareness building, another goal of industry/municipal partnerships such the Smart City Alliance, or contests such as the ICF's annual Intelligent Community competition or the Government of Canada's Smart Cities Challenge is to build use cases that may serve as models for other regions. For example, every city has parking and traffic problems, but if communities could exchange information on how to build a solution, it would be possible for individual implementers – from smaller communities especially that may not have the resources to develop unique methodologies or templates – to benefit from pioneering research and pilot work that has been completed by larger municipalities without having to reinvent the wheel. According to the working group, this approach could be supported through sharing the intellectual property that evolves out of the projects or through the use of standards – a standard way of sharing data or even sharing of a common data platform. Similarly, data exchange would help one government agency make use of common assets to build its own services – data collected from parking or traffic monitoring could be used in predictive modelling by fire services do real time route planning in real time or by transportation services in planning bus routes, the number of lanes a roadway should have, and other matters.

Pilots can offer good insight into the kind of triple helix collaboration that is now in play at a local level. Stratford, Ontario, for example, is working on an IoT parking pilot that is partially funded by the Open Data Exchange, which includes support from the federal government, the University of Waterloo and the Communitech accelerator, and partially by the city's parking reserve, which will pay for the sensor hardware. The goal is to collect usage data on individual spots, analyze trends, and build dashboards that city administrators can use as they make decisions on parking needs and fees at different times of the year. For the city, collaboration between government specialists who had knowledge of parking issues and what data views would be needed internally with innovators within the Waterloo community was critical to project viability. Without extra DBA, programmer and networking resources, the city was happy to look for expertise in a technology hub populated by companies that have done similar application work, who could develop a solution at low cost. For the city's perspective, the pilot was not intended to test the technology, which was tested by partners; but rather if the technology would deliver value in a community context. According to Stratford, the solution was in the field within three months from project launch without the use of dedicated city staff; if developed internally, the pilot would not be off the ground before technology advance had outstripped the initial project plan.

Technology accelerators and innovation hubs can play a large role in expediting the roll out of IoT solutions, and these may be government or vendor sponsored research hubs – or purpose built facilities, such as the Waterloo-based Catalyst that supports next generation IoT companies. These entities are especially effective in localized environments, such as the Waterloo region, when the right companies work together. In some instances, however, centralized hubs can suffer from what one working group member called the "insider and an outsider approach," an insular model in which information is not readily shared outside the tech hub. In vendor centres, information may be 'privatized' – a model of information production that is important, but which can compete with the entrepreneurial spirit needed to connect a community or generate applications that are relevant to a region. In contrast are 'hubs' for practitioners – meetings of planners from various municipalities that may not be focused on IoT specifically but who share information and are in a position to act upon this knowledge.

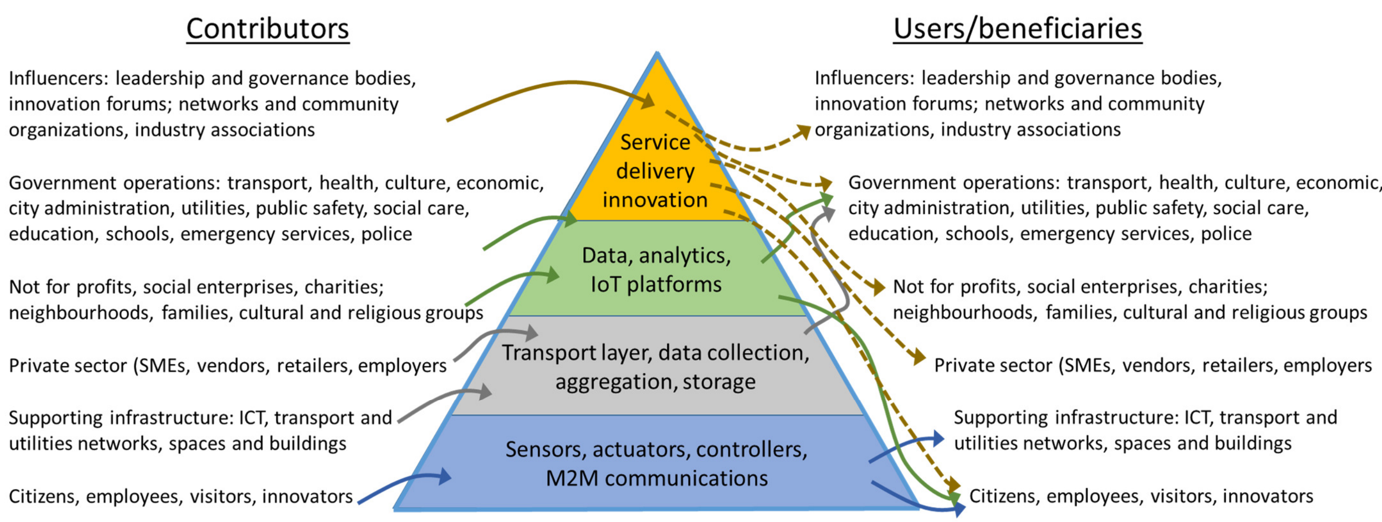
To ensure that the organic nature of innovation is not stymied, the working group advises broad sharing of information collected from IoT deployments. In the Stratford parking pilot, a final stage will involve making data (both historical and real time) available to citizens so entrepreneurs, or potentially local university students, can innovate, building a mobile app on top of the data that will allow drivers to locate available spaces. In Toronto, several transportation apps have already been developed by interested individuals with access to data: "IoT innovation comes from smart people who have some technical chops," as one working group member put it, the app that tells users when the next bus is coming was developed not by the TTC, but by a user working outside an innovation hub. Ultimately, the aim is to distribute information as broadly as possible, recognizing that there are 'softer hubs' where people will get together to share use cases and experience with IoT deployment.

Information sharing can be a complex issue. Governments, or private sector, for that matter, that contribute open data must invest in data cleansing and access and management. In addition, business models must be created that incent sharing; currently, the first person/organization who wants the data must finance its collection, and there is little precedent for contracts that can parse out costs and incremental value that the data can generate. In the Stratford example, who ever builds the parking app will own that IP; however, rights are not so clear in all cases. The biggest challenge, though, lies in concerns for privacy protection in open, shared data. On this point, the working group advises the application of standards (ex. for anonymization) that conform to regulation, to privacy legislation on the use of personal data, such the Ontario Municipal Freedom of Information and Protection of Privacy Act, which regulates the collection, retention, use, disclosure and disposal of personal information in government's custody or control.[29] The Privacy Commission of Ontario also has requirements, contained in PIPEDA legislation that can inform governance around data sharing. Innovation in IoT technology may offer some additional answers to this conundrum. For example, while legacy video monitoring in public spaces may capture personal information such as a face or license plate, creating the need for additional process to manage privacy issues, new IoT sensor devices that detect metal or movement can generate the data needed to answer questions on traffic movement which can be shared without adding new risk.

Architectural framework

In intelligent communities, there is a complex mix of "contributors" and "beneficiaries" that operate at each layer of the IoT stack. The relative benefits of IoT deployment to the community as a whole are highlighted in the figure below, which shows multiple lines from each layer of the stack to several user groups – a confluence of benefits that demonstrates the value and interconnection of the IoT community ecosystem.

Figure 5. The people – technology stack in IoT Community



Source: IoTCC/InsightaaS, 2018

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Metrics and milestones

Maturity

At the macro level, intelligent communities aim to realize a range of broad outcomes – improved environmental sustainability, economic development, enriched citizen services and enhanced utilization and enjoyment of public space and other resources. Achieving these with the help of IoT involves a range of other success indicators that align with mature use of the technology. Milestones in the evolution of mature practices around the adoption of IoT solutions in community environments fall into two camps: top down process and behaviour that metropolitan leaders develop to improve services and operations; and activities that characterize outreach to engage citizens and business groups outside the administration.

In the first, administrative category, IoT maturity milestones would include progress beyond "skunk works" projects and pilots towards a more strategic approach that encompasses increased levels of coordination between different projects and groups (ex. different departments and city services), better integration of work that formerly might would take place in silos, and greater commonality of infrastructure – or use of existing technology underpinnings to support more than one IoT project – and the deployment of more cohesive platforms as part of the overall IoT blueprint and design, which are device agnostic and can support the integration of multiple sensors, software and data feeds. This coordination and integration often entails the allocation of funds to bring a full time dedicated resource on board who can focus on digital strategy, promote innovation and a shift away from the legacy way of thinking to change the mindset of service administrators/operators, developing in them the capacity to work with multiple partners with specialized technology capabilities.

Beyond more efficient use of technology assets, this "coordinator" approach enables a more mature approach to issues that are key to development of the intelligent community. IoT enables unprecedented collection of data in public spaces, and unbridled use of sensors can introduce privacy risk. As they move towards the data-driven management, municipalities will need to understand who collects the data, and who provides the right to use it in what way, and if collection infrastructure impedes people's use and enjoyment of the physical space, in order to establish responsible frameworks for IoT deployment. Privacy by Design is the right starting point, but the municipality will also need Security by Design, an upfront cyber security strategy that protects the privacy of personal information as well as public infrastructure. While cyber threats are continuously evolving – Quantum computing, which is expected to introduce unprecedented risk of attack, is 8-10 years away from broad use – public infrastructure is built to last several decades and sensor devices will be in the field for several years, without the tech pattern of refresh in three-year cycles. As a result, a cyber security strategy that plans for known threats, and is flexible enough to react to future demands is critical.

In the second category, the mature municipality will have evolved processes for community involvement. This may take the form of direct engagement – a survey that can gage citizens' attitudes and priorities with respect to IoT – or a more indirect engagement, such as a social media program designed to capture information on how the city should invest in IoT. Information on citizen concerns and concerns may also be gathered in public forums, complaint or suggestion feedback via website or phone or Big Data social channels. Or the municipality may collaborate with a private sector partner to introduce new information gathering solutions: a telco, for example, that installs an interactive kiosk in a public space to monitor interest, and build knowledge around what activities the government is engaged in. Ultimately, the level of community involvement will depend on the type of project that is proposed: while technology to monitor water infrastructure for proactive maintenance may be of unique interest to service operators, smart parking will impact council and administrators who benefit from better traffic/parking management, citizens will use the solution. To improve prospects for top down/bottoms up collaboration in a community project, the intelligent municipality will first identify the type of IoT project, and next determine the level of involvement in outreach needed based on stakeholder interests.

The mature IoT adopter will also have allocated funds for the creation of partnerships, established process around pilot funding (Council approval and the involvement of procurement as the pilot extends), and established terms for partner relationships. For example, the ownership of assets, the technology platform in a pilot and the intellectual property that comes out of the project is a strategic decision that needs to be made as part of planning. This question is especially challenging when government funds are used to subsidize pilot research and execution, and provisions should be made for the municipality to also benefit from intellectual property that may emerge from the project so that the pilot not only delivers industrial property, but also functions as smart urban development. Several models operate here: on a global basis, the EU has established the World Cities project to support the free exchange of pilot experiences; while in Europe, the Intel ICRI group has built middleware that some communities are sharing and some licensing to recoup investments; in the US, winners of the Smart City Challenge in Ohio built a consortium that would own project IP; and in the upcoming Canadian Smart City Challenge, winners will decide if they want to retain ownership around a particular idea, if they want to commercialize the IP, or if they want to share technology and processes with other municipalities. If a sound approach to supporting the advance of IoT deployment in the community context, the working group notes that the benefits of pilot information exchange may be limited by unique community profiles. For example, local needs and size of the community will demand different approaches to IoT evolution – the larger city will achieve different milestones than a smaller one, and the urban/rural composition of the community will impact priorities.

Metrics

As with any organization, the intelligent community will require metrics that validate the logic of technology deployment, including assessment of the success of implementation from a tech perspective, and a measure of the return on investment that the project will create. IoT is uniquely positioned to deliver on both these scores: while heavy instrumentation in IoT can provide real time information on operation of the system itself, the massive data collected from urban infrastructure works as an enabler of planning process. The more data that is available, the better the assessment of specific needs and local resources can be, so the more IoT technology that is in the field, the more complete is the foundation for building strategy and plan. Planners are using IoT information today, and organizations, including engineers and planners, or startups looking to develop commercial products, are coming to recognize the need for even more Big or open data detail.

With IoT rollout, data and analytics platforms are helping organizations understand the value in generating new efficiency gains, won through monitoring and measurement of municipal systems, and this analysis is surfacing many benefits, such as cost savings, or operating in a more coordinated fashion. They are beginning to understand how an opportunity in one area may uncover opportunities/benefits in other areas and are increasingly able to reallocate savings to areas where budgets are low, to take limited resources and reprioritize in order to address issues that they were unable to fund before.

The working group has identified two kinds of metrics: one is to help the business user/city operator measure success in meeting end user goals (improved traffic safety), and a second kind of metric measures the technology deployment itself. In the technology evaluation, key metrics will determine if the technologies are experimental, if newer ones will be more effective, if the solution can scale for broad deployment, if the vendor trying out the market or if the technology more mature, are multiple vendors offering the technology, can it be bought off the shelf or is it custom made? These questions may be asked of any technology, but are especially critical in the immature, and fragmented IoT landscape, where innovation and experimentation are the market norms. Other tech-related metrics will include technology resilience, privacy protection and security, which measured through adherence to standards that can be certified.

The benefits of specific IoT deployments will be measured using individual KPIs. With smart street lights, for example, the impact on traffic congestion can be measured, and benchmarks on traffic through particular centres established to inform rerouting decisions. Ultimate metrics may include time savings for drivers or a decrease in the number of traffic accidents. In establishing KPI's, the working group notes the importance of having the right data for the right question – and beginning with a problem statement, without which there is no justification for the IoT project. KPIs will fall from the problem statement, though these may change and develop as a pilot extends to broader implementation.

A key metric for community-based initiatives is engagement – the number of people engaged through digital signage, through their mobile phones, who are using hot spots, WiFi in certain areas – feedback from the general population based on interaction with the IoT technology. As noted above, feedback may also be provided through social media, through numbers of complaints, frequently asked questions and suggestions and proactive surveys. But with IoT, consensus that develops through these channels can be verified by information collected from cameras or other sensors that surveil public spaces; corroboration of data gathered via direct and the indirect means will produce more reliable results.

Some metrics are relatively easy to identify and implement. With broadband coverage and use, it is possible to simply collect network data. But the working group cautions implementers to be aware – and avoid – a tendency to use input variables, in which organizations are invested, as measurement outcomes. In broadband, for example, norms around measurement evolved out of older, regulatory models and have been reinforced over time: rather than focus on quality of service levels and prices as outcome variables, focus has been placed on how much the service provider is investing, which may not necessarily translate into outcomes. While there may be more investment in DSL and cable infrastructure, the intelligent community looking to engage city operators, business users and entrepreneurial actors in IoT innovation may reap greater reward through investment in one superfast fibre optic service that multiple providers can share, delivering better outcomes at a lower cost.

Resource Materials

Blockchain/Distributed Ledger Working Group. Using Blockchain Technology to Secure the Internet of Things. CSA. February 2018. www.cloudsecurityalliance.org

ITAC Whitepaper – Seizing the Internet of Things Opportunity. Recommendations to Government. May 2016. http://itac.ca/wp-content/uploads/2012/09/ITAC-Seizing-the-IoT-Opportunity-June-2016.pdf

KPIs on Smart Sustainable Cities. ITU. https://www.itu.int/en/ITU-T/ssc/Pages/KPIs-on-SSC.aspx

Sponsoring members and contributors

We would like to acknowledge and thank the sponsors and contributors who supported the *IoValue: Intelligence in Community Ecosystems* working group.

Sponsoring members

The Toronto Cloud Business Coalition gratefully thanks our corporate members for their support:

Contributors to this document

We would like to acknowledge the following contributing community members, whose input shaped this document.

Reza Rajabiun

Competition policy and telecom strategy researcher/consultant

A researcher on competition policy and broadband infrastructure, Reza has advised many public and private organizations on the development of Internet services, for rural Canada in particular. He is now research fellow at Ryerson University.

Don Sheppard

Emerging technology consultant, standards advisor, author/writer

Don has worked to help de-mystify ICT as an engineer, a manager, and a consultant for more than twenty-five years. He is best known for his involvement in ISO standards for open systems interconnection and, more recently, for cloud computing.

Naeem Khan

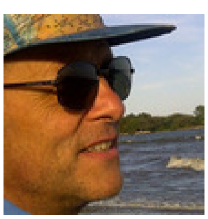
Manager of IT and Business Systems, City of Stratford

Naeem has over 15 years of experience designing, implementing and integrating government enterprise and GIS systems. He is interested in exploring ideas discussion around IoT and Big Data in day to day operations of a city government.

Paul Gragtmans

Principal, Display5

Paul describes himself as a technology generalist with substantial experience in a wide spectrum of technologies - hardware, software, services, wireless, internet, etc. His current venture, Display5, is a digital media communications software platform.



Bill Munson

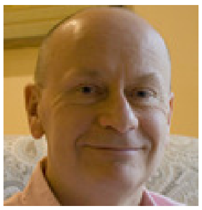
University of Waterloo

Bill is a policy professional with a multidisciplinary background. He now works with Quantum-Safe Canada, to help drive response to the grave threat posted by quantum computing to the cryptography that currently underpins much of our cyber security.

John Jung

Chairman and Co-founder, Intelligent Community Forum (ICF)

An award-winning urban planner, urban designer, economic developer, author, global urban navigator and speaker on planning, development, urban design and economic development issues, especially related to smart cities and intelligent communities.



Campbell Patterson

Founder, CP Communications; Technical Committee Chair, ICF Canada

Campbell is actively engaged helping regions, counties, municipalities, utilities, school boards, hospitals and user-based consortiums in Canada by designing, procuring, building, deploying, and project managing community broadband operations.

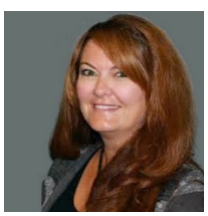
Additional expert contributors

In addition to the contributing members listed above, the following experts participated in the co-creation of this document:

Jennifer Sicilia

VP and GM, RYCOM Corporation

Jennifer leads the design, deployment and management of technology solutions for businesses across North America. She works with property owners and managers to drive business results through innovative smart building solutions.



Kelly Daize

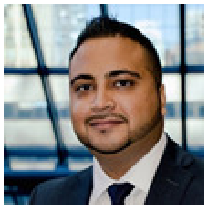
Director, Americas, Invest Ottawa

Kelly has successfully won and managed large government programs, and has a proven track record working with all levels of government. Prior to joining Invest Ottawa, Kelly held senior roles at QNX, Corel, Nortel spinoff NetActive and CENGN.

Prasanna Gunasekara

Senior Manager, Business Services, City of Brampton

Prasanna is a leader in business transformation through automation and innovation. He leads a team that helps business leaders solve problems using automation, and is a promoter of business process innovation through process re-engineering.



Ritesh Kotak

Advisor, Durham Regional Police Service

Ritesh advises and assists police services, government bodies, judiciary, major financial institutions, community partners and private sector organizations with understanding social/cyber/digital technology opportunities and challenges.

Dana Saltern

Director, BusinessOne Corporation

Dana is an executive advisor to all levels of government on Smart City/Digital Government initiatives. Her focus is driving innovation through co-creation, agile practices and cloud technologies to enable value and enhance experiences.

Roman Zubarev

Partner, 29signals Consulting

An entrepreneur with experience in telco, IT consulting and automation, Roman has led several SMEs and large-scale IT projects. Currently a Master of Management Analytics candidate and an analytics consultant.

Ted Longley

Director, Engineering and Network Operations, ORION

A network engineering specialist and architect, Ted now leads the operations team at Ontario Research and Innovation Optical Network, an advanced network connecting Ontario researchers, educators and innovators.

Lead analyst: Mary Allen, Chief Content Officer, InsightaaS

Co-founder of InsightaaS and the IoT Coalition Canada, Mary has devoted two decades to understanding and communicating key trends shaping Canadian and global IT markets. She has authored hundreds of reports, articles and analyses on advanced technologies, including *Building Cloud Value: A Guide to Best Practice, 2016* (with InsightaaS partner Michael O'Neil). She still likes green IT.

About InsightaaS

Dedicated to exploring "the 'why' in enterprise technology," InsightaaS was founded by Mary Allen and Michael O'Neil in 2013. The company operates Canada's deepest IT content website and provides strategic consulting and channel management guidance to leading firms in Canada, the US and abroad.

In 2015, InsightaaS launched the Toronto Cloud Business Coalition, a community dedicated to the co-creation of Best Practice guidance designed to accelerate adoption and use of cloud in Canada. The tremendous success of the group has spawned three additional communities – IoT Coalition Canada, Canadian Analytics Business Community and V2V: The Economics of Data, plus the CIA-Plus meetup community. These groups continue to help Canadian businesses to capture value from advanced technology.