CONNECTED CITY
Advisory Board

WIRELESS
BROADBAND ALLIANCE
DRIVING NEXT WIRELESS EXPERIENCE

Connected City Blueprint

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Executive Summary

Under the umbrella of the Connected City Advisory Board (CCAB) and the Wireless Broadband Alliance (WBA), the Connected City Blueprint is intended to work as a guideline to support cities and government authorities to develop their connected city plans, and for the broader wireless industry, including citizens, entrepreneurs, operators, regulators, equipment manufacturers and service developers to better understand the challenges and opportunities of the Connected City and Smart City ecosystem.

Overall connectivity is important to a city on many layers:

Citizens: Providing greater convenience and better quality of life;

Businesses: Create new economic opportunities for companies in all sectors including tech, media, healthcare, logistics and more;

Government: Efficiently manage and run the city by anticipating needs and providing improved services to its people.

This initial Connected City Blueprint report is a starting point to aggregate and identify Cities and Local Authorities views and perspectives on how to structure connectivity plans, their benefits and the value propositions around a horizon that various stakeholders can understand.

The structure of the Report is divided into three major parts:

Part I (Chapters 2 – 5): Identifying the importance of the Smart City Vision and the role of connectivity. What cities need to be thinking about to begin the process of developing a smarter and more connected City Ecosystem.

Part II (Chapters 6 – 8): The necessary technologies to help cities develop their Connected City Plan and identifying a set of case studies in terms of verticals implemented in cities around the world, acting as a benchmark for future deployments.

Part III (Chapters 9 - 11): Examining the opportunities and services that can be explored by cities, including Big Data, Roaming and Public-Private Partnerships.

Throughout the report, references are made to examples of deployments and processes implemented in different cities. This aims to bring realistic and real-world examples to the discussion in order to facilitate the understanding of the opportunities and challenges for the cities in the various aspects addressed in this report.

Overall, Smart Cities represent an evolutionary step in urban development, which is based on the combination of technologies and human resources with a common goal of achieving economic growth, sustainable development and optimal quality of life for the citizens. Connectivity in general plays a central role in the Smart City development, since they provide the means for interconnecting infrastructures (i.e. networks, sensors, devices) and collaboration between the different stakeholders, including the Citizens, City Authorities, Private Sector Companies, Innovators and Entrepreneurs and the Academia, the key for success.

The CCAB and the WBA will continue the development of this Connected City Blueprint, both in terms of additional content as well as making it available to the industry in different channels, including an online eBook version. This is an Industry-collaborative effort and the CCAB would like to invite the different stakeholders to get involved in this initiative. The Connected City Blueprint can be considered a living document and updated versions will be released throughout 2017 and beyond.

1 Introduction

1.1 Background

While developing connectivity plans, cities have the responsibility to ensure that it is equitable, accessible, consumable and useful to the diverse constituent groups that cities represent. Cities must structure connectivity plans, their benefits and value propositions around a horizon that various stakeholders can understand.

Cities face several constraints (including land availability, population growth, revenues and resources) but must also look at ways to facilitate improvements in the citizens' and visitors' standard of living. Therefore, it is not just about technology, but also about the management framework supporting the connectivity technologies.

For cities that are just beginning to embark on their citywide connectivity deployments, the key challenges are based on understanding how to handle inevitable technology changes and the viable revenue models for public-private partnership. Even for cities that have done some deployments in the past, there is a need to validate technology roadmaps and business models.

The cities must cater to different scenarios – the backup plan for data versus managing security and high definition video streaming for police and transport, requires different capabilities. All these different cases require different levels of connectivity. Therefore, cities need to figure out how all of this ties together.

It is also important to recognize that various cities are at the different ends of the development spectrum and there are differences in social, economic and political frameworks.

The Connected City Advisory Board (CCAB) was created to tackle the challenges previously described, and to develop, share and promote thought-leadership and practical framework for the social and economic development and sustainable operation of the Connected City Ecosystem.

It's a unique platform for city managers and CIOs to knowledge-share challenges and opportunities in the development and execution of the Smart City, establish best practices and determine a strategy to leverage public-private partnerships.

The membership of the CCAB consists of a group of city CIOs and senior city and government officials along with industry experts and members of the Wireless Broadband Alliance (WBA).

The guiding principles of the group are to address and reduce the digital division and ensure digital equality through accessible and universal Internet connectivity, improve the quality of life of residents through hyper-connectivity and establish and grow Smart City's partnerships to increase shared knowledge and informed decision making.

Internet connectivity, at its core, is a civilization changer on the same level as roadways, water systems and electric grids. It is redefining the way people interact with the world, access and share information, and improving the way we live work and play.

It's a universal, global need that supersedes economic status, language and location. Having a global connectivity infrastructure provides the real potential to transform civilization forever

Build awareness, advocacy and global availability of Connectivity guided by the leadership of Connected Cities. These Cities will guide and mobilize the industry through the adoption of standards and best practices as defined by the shared knowledge of the Connected Cities Advisory Board (CCAB).

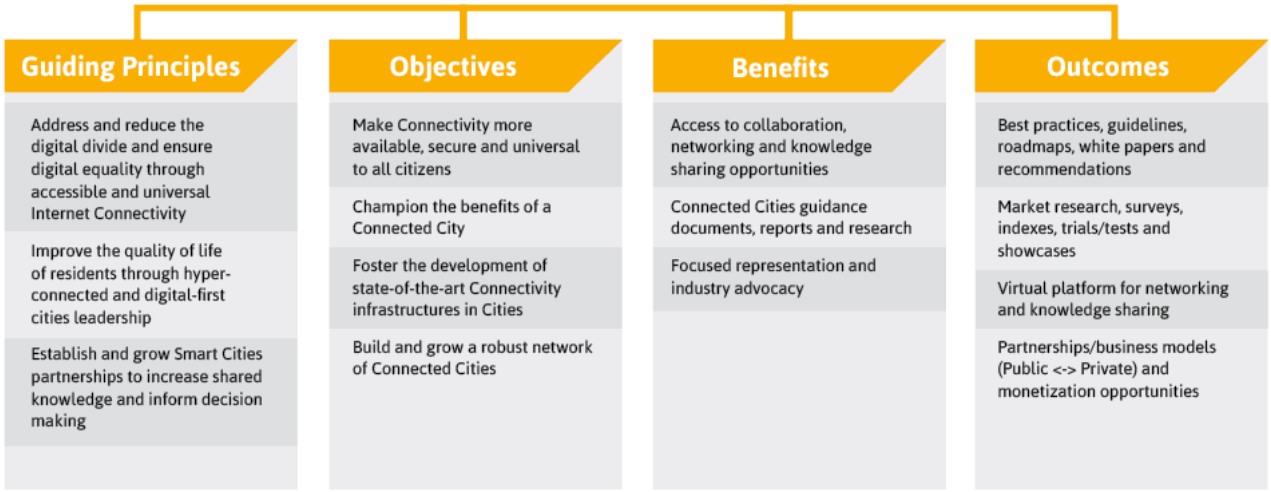


Figure 1. Connected City Advisory Board Charter

The Connected City Blueprint is intended to work as a guideline to support cities and government authorities to develop their connected city plans and for the broader wireless industry, including operators, regulators, equipment manufacturers and service developers to better understand the challenges and opportunities of the Connected City and Smart City ecosystem.

1.2 Smart City Definition

Smart City involves an ecosystem platform of multi-stakeholders and utilizes integrated information and communication technology systems, ICT, and data analytics, to transform its culture, structure, operations, economic development, and citizens' engagement to manage complexity and dynamically improve and enhance quality of life.

According to this definition Smart City is using technology to connect people, processes and assets in order to improve efficiencies for the cities, improve sustainability and improve the lives of citizens, businesses and city agencies, while creating a safer, more sustainable and civilized city for the citizens. The thread that's weaved through all of the solutions that adds this value is a secure scalable communications platform. It's all about improving the lives of the citizens, businesses and governments to create a safer and more sustainable and efficient environment for them to live, to work and to operate.

The goal for any city municipality is to improve the quality of life for citizens and ensure that they are safe. This could be through new economic development opportunities, job creation, and/or making sure that they have the right infrastructure in place in order to leverage learning opportunities. Furthermore, from an economic development

perspective, cities need to have the right infrastructure in place so that they can recruit companies which would add to the investment in the region and aid in job creation.

It's also important to promote start-ups and innovation in cities to leverage the Smart City technology and create open data platforms. This will also help to grow the innovation ecosystem and the start-up ecosystem that are currently in those cities. It is important to show clear differences between social/economical connectivity and technical connectivity.

In looking at the technical connectivity conception, International Telecommunications Union (ITU) defined a model that considers connections mainly in collection systems (transducers, sensors, actuators and communication networks), conceptual data warehouse and service applications for all normalized city devices and/or applications. There are standard interconnectivity interfaces for devices and/or applications from third parties who have interactions with cities. Consequently, we have connectivity or interconnectivity with devices, users and third parties at the network telecommunications level (i.e. Wi-Fi), data warehouse level (data or metadata) and at the application level (i.e. web services, open data, etc.), creating the concept and framework for the development of a smart city within all of these elements.

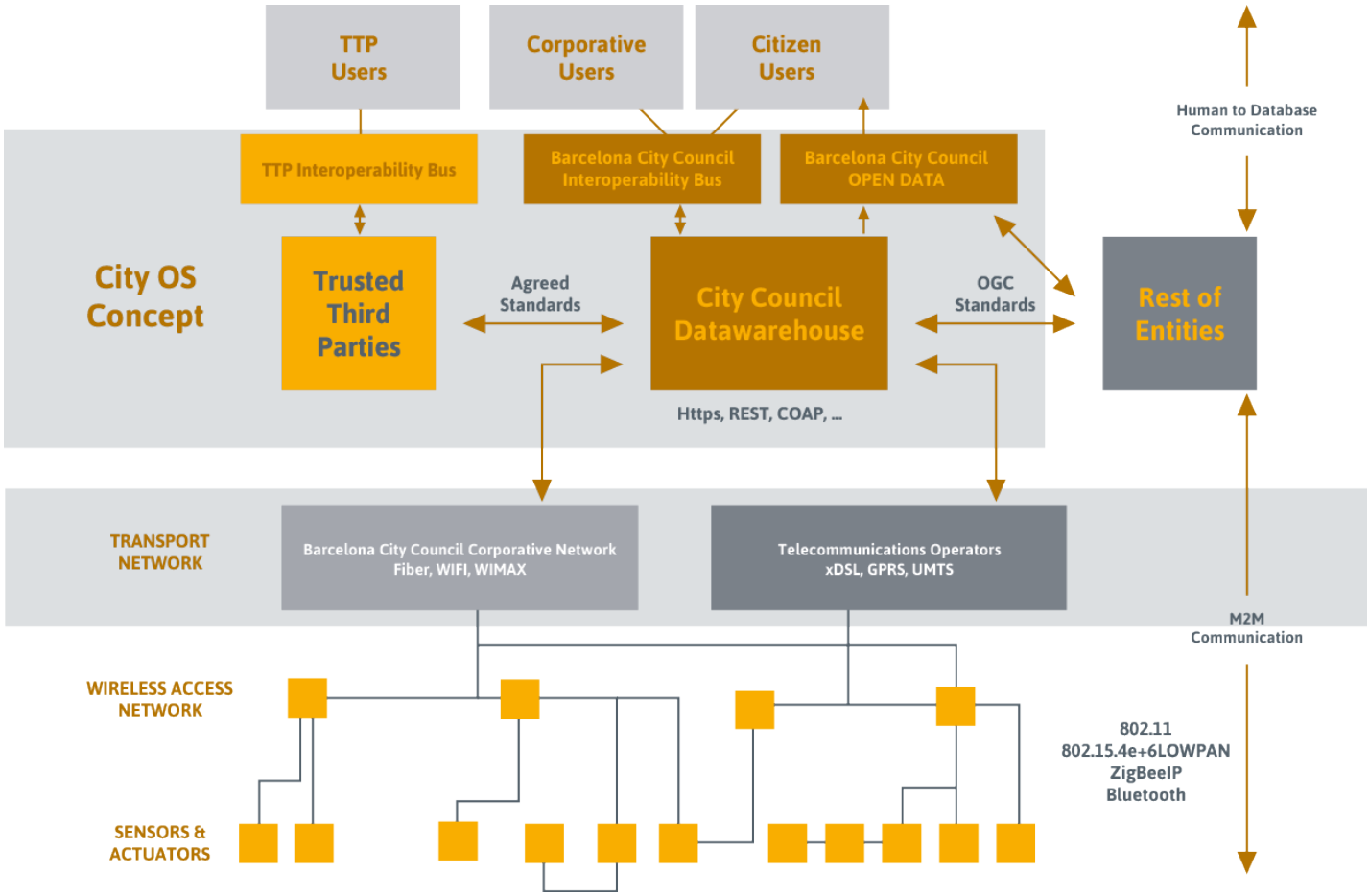


Figure 2. ITU City Connectivity framework model

1.3 The importance of the Smart City and its Challenges

Smart Cities are more than just the implementation of various technologies. "Smart" does not only refer to technology or sensors - it is a concept and new kind of culture for how cities and its agencies can work more effectively internally, with partner agencies and organizations and, of course, with their citizens. "Smart" is a way of transforming from the way things have always been done because that's the way we did them, to thoughtfully considering what should be done based on analytics, metrics and adjusting the goals/mission of the city and various agencies based on that analysis, while continuing to update those goals as new and more relevant data is captured and analyzed. Smart Cities are not a destination to arrive at, but a new process for managing how cities and agencies work.

Smart Cities can be a tool to positively affect policy changes at the municipal level in terms of everything a city does such as energy conservation, air quality/pollution, transportation, connectivity, data collection and sharing, etc.

- Smart Cities think of how their departments can better coordinate all of their activities and data.
- Smart Cities think about the data they collect and how to make it easily available to the general public to better understand it, to use that data in new and interesting ways such as apps, etc. allowing constituents to contribute to improved services.
- Smart Cities think about how to collect additional data that can be easily shared across departments to help each unit make smart, more cost effective decisions.
- Smart Cities think of how technology and data can help them provide a better service to constituents, how they can make this service equally effective, but more importantly, cost effective.
- Smart Cities think about how constituents can contribute data and information to more quickly alert the municipality of problems such as malfunctioning lines, transportation issues, road work and construction, etc. Smart Cities can make an urban environment easier for people to navigate, live, work, play and to experience more out of the cities with various technologies than other cities. Examples include:
- If a city understands more about vehicular traffic flow, they can better implement changes to the existing road infrastructure and right-of-way as well as parking issues. They can make decisions based on collected data that can change how cars are used in a city.
- If a city understands how pedestrians and bicyclists move around the city, the data can be used to create newer and safer pathways for them to move around. They can combine that data with vehicular data to create a more cohesive system of movement within the city.
- If a city knows when and where their public transportation buses and trains are at all times, they can significantly improve the quality of the experience for their constituents, reduce delays, and improve maintenance.
- If a city knows how much trash is being generated, they can adjust their collection routes based on need versus routine, saving money, improving efficiency and freeing sanitations services to do more general cleaning to improve the overall cleanliness of the city.

But the real benefits of a Smart City come from the data that is subsequently collected. At the start of the process, most cities won't fully grasp the benefits of pooling all of their data together; but by combining as much city data as possible, agencies will be able to answer questions that before seemed un-answerable. In addition, they will begin transforming from a reactive city to a proactive city, and work towards predicting the issues affecting constituents before they become major problems. Such as:

- How are people moving around the city related to trash collection and does it depend on the mode of transportation that they are using? If more cars produce less trash, but more pollution, can those effects be analyzed?
- If constituents are empowered to report potholes, does that lead to quicker repairs and reduced bus transportation delays, making movement through the city faster and improving transit ridership?
- When different agencies share data, can they combine resources to get projects done faster and more cheaply? Can they more quickly complete construction projects because information is more easily accessible?

Smart Cities can be an extraordinary economic development tool, but can also create their own transformation because the culture of collecting and sharing data within agencies will most likely affect how employees work and even potentially create new types of jobs to analyze and respond to the new information. This is another component of the culture shift that happens from becoming "smarter" because internal and field employees may need to be educated about the changes in their job and the roles they play and the new opportunities available to them with new and valuable information.

The smart nature of a city becomes a strong foundation for continually improving the collective intelligence of the organization, the ability to collect more specialized data based on what they have learned that they need, the type of experiments that they are willing to take, the coordination between agencies and the incorporation of participation and feedback from constituents.

But this concept of a Smart City is essentially a front-end concept - the back-end is also an extremely crucial component. This involves the network for communicating data back to the servers to how data is collected either by sensors or employees out in the field by using handheld devices, as well as how the data is stored and shared throughout city agencies and the public. This will be discussed later in this document. We will also cover several cases of Smart City pilot projects in this blueprint in order to help show how cities can take steps to become smarter themselves.

Unfortunately, right now most cities face many different obstacles towards becoming Smarter:

- Infighting or lack of cooperation between agencies
- Fear of sharing data
- Inability to analyze any new data collected
- Insufficient funding for Smart City initiatives
- Cultural resistance throughout the city and various agencies

The concept of Smart Cities is very broad and different people will have different views; if you ask a dozen city officials what it means to be a 'smart city', you'll probably get 20 or 30 different answers, because people are still trying to figure out the intricacies of the term. It is important to define a framework that would be the platform by which cities would become smarter. The identification of different programs in a city that have all been worked on and prioritized to help put a city on a path to becoming smarter. It's also important to note that the smart city concept is not necessarily new, with several cities around the world already offering excellent smart services.

Becoming smarter is about using the new wave of technology to become more responsive and more data-driven. Populations and constituencies need more and more services from their cities - they have higher and higher expectations of politicians and city officials, because they have built higher expectations in their everyday life with other service providers that they engage with.

City governments are now trying to find ways to live up to that expectation, in a world that also has more and more pressure on the resources that they have. Cities are just recognizing the opportunity to leverage technology to help solve these calls for a more responsive and in-tuned government for its constituency.

1.4 Connected City Ecosystem and Stakeholders

City agencies usually work in silos, with a need to collaborate more internally, but there's also a larger ecosystem that needs to be brought into the discussion. Cities must look outside their own ecosystem to develop and implement a path towards a smarter city. These stakeholders may include non-profit organizations that specialize in specific services such as homelessness, housing, education, etc., but also includes universities (particularly those with strong research departments) as well as larger companies based in their city and including start-ups who are innovating new smart city ideas. In addition, cities have the influence to bring in major utility (water, energy and telecommunications) providers as partners on their smart city path. For example, the electric utilities in a city may own 90 percent of the poles that lighting is attached. Partnering with them would make using a smart lighting system that much easier as well as the flexibility to attach other sensors to light poles.

By partnering with various utility partners, cities not only will have more data available to them, but will also have the capability to combine these disparate data sets together to provide new insights and understandings of the needs of their constituents. Once that data has been aggregated, cities may want to do be more transparent and allow citizens access to the data so they can understand the value of having a smarter city.

New York City:

New York City has a much larger urban ecosystem than other cities across the nation and the globe. They view broadband in New York as a mission-critical utility service for the citizens of the five boroughs, much like electricity and water. The stakeholders in this ecosystem include: all types of businesses, government agencies, commercial entities, healthcare institutions, public safety providers, incumbent wireless agencies that already provide services to the City, and LTE incumbents who provide millimeter wave and fixed wireless services. Bringing universal, affordable, broadband services to the public at large is deeply embedded in the mission of the New York City government. The initiative in New York comes from the mayor and his unique approach to being able to proliferate broadband by making large capital investments. His goal is to bring universal broadband services to everyone, everywhere by 2025.

New York City approaches broadband proliferation by bringing together a host of city agencies, including the New York City Housing Authority, the New York City Economic Development Corporation, the Mayor's Office of Data Analytics, the Mayor's Office of Technology and Innovation and the Telecommunications Planning Unit of the New York City Department of Information Technology and Telecommunications. This last unit is deputized by the mayor to make real his vision of bridging the digital division in New York City.

Being able to create a truly connected city is the result of how the city governs its broadband proliferation and the quality with which it works with those stakeholders who have an influence on the marketplace. In order to appropriately develop the broadband ecosystem in New York, they would have to put together a variety of different agencies who have, in the past, had independent telecommunication assets. They are now trying to take these independent assets, independent budgets, and independent acquisitions of telecommunications assets and pool them into one place so that they can better leverage what they have and figure out where they want to go. The city's initiative is to standardize and make their approach uniformed to deployment so that they can capitalize on what they have.

In New York they also have a broadband task force made up of citizens from a variety of different industry sectors, including the financial sector, public safety, waste management, etc.

There are no operators who might influence in a biased way the work of this broadband task force. Its mission is to take a hard look at how the city is approaching the proliferation of broadband and get input directly in terms of strategy, policy, and in terms of what they think might be the best fit.

Do we need more services in the subways? Do we need more services in our railways? Do we need to have more capacity at congested transportation corridors? Do we need more services in our job centers or in our homeless shelters? Or in other locations that are mission critical to the city? These are the kinds of questions the broadband task force addresses.

It's motivating and incentivizing to be able to do business with the city of New York, but to the extent that it's not, they are putting a lot of franchise agreements on the surgery table today in order to lower the cost of doing business in under-served areas. They are also introducing methods that can be used to support incumbents and new entrants by allowing them to provision services from a surplus amount of fiber that they already have in the ground and extend it beyond their existing franchise agreement, which they may not have been able to do in the past. For example, some are restricted in providing services beyond the subway corridors. They have a surplus of fiber which New York City can allow to take out of the subways and go above ground in order to serve the railway passages, transportation corridors, schools, libraries, and other areas.

In New York City, local community boards are critical stakeholders in the telecommunications ecosystem. They consistently talk with the community boards about important localized neighborhood issues that come up around telecommunication services. NYC is installing Wi- Fi kiosks across the city, and every step of the planning is coordinated with political leaders, the borough presidents, and the community boards where citizens come out and talk about how they feel that their specific communities can benefit from the deployment.

At the end of the day, the proliferation of broadband exists for the public at large. New York City's goal is to provide equitable, universal services. The idea is to proliferate broadband to help the community, schools, libraries, healthcare services, job searches, and even children with doing their homework.

2 Connected City Value Proposition

2.1 Importance of Connectivity to Cities

Connectivity is important to a city on many layers – for individuals, it means greater convenience and better quality of life; for businesses, connectivity helps to create new economic opportunities for companies in all sectors such as tech, media, healthcare, logistics and more; and finally connectivity also allows the Government to better manage and run the city by anticipating needs and providing improved services to its people.

Cities today are facing challenges arising from increasing urban density, aging population, healthcare needs, transport mobility, and energy sustainability. Cities around the world are experimenting with 'smart city' technologies to tackle such issues, and connectivity plays a key enabler role.

For example, in Singapore, public hospitals are currently trialing a tele-health rehabilitation system. With robust wireless connectivity, data is collected and transmitted from sensors attached to patients' limbs as they carry out therapy sessions within the comfort of their homes. This eliminates the need for patients to travel and wait for their appointments in hospitals. At the same time, the approach frees up Singapore's pool of therapists to render more dedicated care to a larger group of patients.

Connectivity powering big data and analytics technologies, and next-generation sensor networks help country's leaders to develop insights and share data more effectively, to improve operations and policies and build services to make life for residents better.

By digitizing the government process, it's not just about adding conveniences to people, businesses and government officials who have smart devices and conveniences already. This will certainly be an outcome and it's a worthwhile one. However, the greater benefit is making government services more readily available to people who have less flexibility and less convenience available to them. One of the primary tools for making this happen is expanding connectivity for all areas of a city and for all members of it.

Developing connectivity throughout a city varies from city to city. Many of them do include determining how to best use city-owned real estate assets for the deployment of telecommunications service. One of the most important questions in Connected City planning is to determine whether a particular city wants to manage its destiny and the time to market for broadband proliferation by utilizing its governance system and its real estate. An example of this is the approach that New York City is using.

This allows cities to broker relationships with third-party operators, whether by cellular, Wi-Fi, or otherwise. Telecommunications Planning uses the city's real property assets to support the growth of not only those incumbents, but all of those new entrants that are looking to provide services.

Whether it's trenching new conduit to provision fiber across the city or whether it's locating fifty to five hundred to thousands of new small cells on buildings, street light poles, other types of city street furniture, such as kiosks, park benches, bus stops, etc., it is critical to determine where broadband needs to grow equitably across the city. This is the importance of the Connected City plan.

One of the things that cities have to decide is: who is going to manage the operations of these networks? Does the city have an interest in investing and managing networks itself?

If a city decides to become a network operator/communication site manager/lead agency for all telecommunications operations, then it is going to go through a massive culture shift. The interest of the government in terms of proliferating broadband is much different than that of a third-party consultant. The consultant's interests may have higher margins or they may have an ability to oversee technical operations. However, they don't have the leverage that a City government has, subject to the use of infrastructure or the interest in proliferating broadband into mission critical locations. Nor does a third-party consultant typically care about equity.

Creating a lead agency for all communication operations is very important, because it leads to leveraging all telecommunication services to all city agencies and the use of all real estate in that city. The city now becomes a very powerful broker subject to bringing in telecommunications services. To an extent, it owns some of these assets, whether its fiber optic or common antenna across the city resulting in it being in a great leverage position.

Looking again at the example of New York, their plan is to proliferate broadband to everyone, everywhere, by 2025. By doing this in a way that is universal and equitable, they hope to be able to close their digital division. They have chosen some small scale pilots to begin with by investing in the proliferation of Wi-Fi services in public housing authority complexes, where they can directly those who don't have connectivity and hopefully more quickly bridge that digital division. They anticipate being able to take those lessons learned and scale that across the entire city.

Connectivity is important to cities because, in many ways, municipal government functions like a large conglomerate. Cities provide community services, utilities, public safety, engineering, human resources, finance, technology, regulatory functions and many other services. Much of what a lead agency in telecommunications does revolves around how they communicate and collaborate— and this means having an open dialogue with elected representatives and constituents, staffs operating an expansive infrastructure, and ultimately making the machinery behind our municipal services run.

Cities now have a new view on how to support that infrastructure that's more holistic for the same reasons. They see how things are connected and how rendering exceptional municipal services requires a new level of communication. When they talk about the benefits of connectivity for cities today and in the future, the reality is that we're at a leap

phase of what we call "smart cities;" meaning, using technologies to transform how governments run. Rather than just rendering a good singular municipal service, coordinated municipal services are more effective at helping our families and businesses to thrive. The modern organization that runs in an optimized way can communicate across its infrastructure and staff and measure its achievement in the success of the community.

This means that Cities have an opportunity to use this new constellation of connected and networked processing—with analytics on top of that—to improve what to do in insightful ways. This includes everything from the safety of our city, to being more inclusive and friendlier to interact with citizens and businesses than cities have ever been. Cities are going to be more sustainable because of how they manage things and how they can see across municipal functions.

Some specific examples include dynamic traffic, predictive policing, water management, waste water and other utility systems, (see more examples of these type of cases in section 7). In regards to family services, we can now render what helps to produce the best results for families. Never before in the history of local governments have cities had this many tools that potentially can work together for great outcomes.

In the 21st century, connectivity is one of the essential pieces of infrastructure that a city needs in order to be economically competitive and a good place for people to live in. Connectivity underlies so many of the things that are needed for modern society. It can be examined in a few different ways: from a city's perspective, the city government itself requires connectivity increasingly in order to be able to achieve the operational goals that it sets for itself, like managing fleets, managing the built environment, smarter traffic flow, and better provision of public services. It has a role to play in that.

For the residents of the city that connectivity is something that is equally if not more important than what the landline phone was in the previous century. A city that doesn't have a reliable, affordable, and high speed connectivity available throughout its infrastructure is going to fail to provide opportunities to citizens they need to succeed.

In addition to those categories of the city itself and the residents, businesses are a key driver of the need for connectivity. In New York City, for example, it can be a challenge if a business is looking at renting some space that looks like a good place to headquarter their business, but then they realize that there is not a good variety of choices of connectivity at that address, in terms of pricing, reliability, redundancy of speed, etc. This can be seen by commercial tenants as a major driver of whether a building or a neighborhood is attractive to locate.

It's getting more difficult for the city itself to have the capabilities to manage their telecommunications infrastructure. It can be challenging to compete with the private sector in terms of the salaries and job opportunities that are available outside of the city. Making sure that a city has the talent internally to be able to not only develop great systems, but also to be able to manage and maintain them is something that should be a priority for cities.

2.2 Smart Cities role on the economic and social development

There are lots of opportunities in cities and many programs being developed around the role of smart cities to accelerate economic and social development. For years, the 'catchphrase' has been "bridging the digital divide", based on smart cities and broadband proliferation.

It is important to make sure that cities are addressing the connectivity need from the inner city and the urban setting all the way to the rural areas of the municipality. There's sufficient fiber available and a great opportunity to leverage the 5G vision and incorporate the right programs, such as tablets, for underserved or under privileged communities.

Smart Cities have their main role in economic and social development using PPP (Public Private Partnership) as a tool to collaborate between stakeholders and this topic will be address in more detail in section 9.

Looking into the specific example of the city of Barcelona the figure below shows this concept applied to a set of services. The starting point will be the city requirements or conclusions from research centers or RFI Processes. It usually starts with someone (often a startup) proposing a project. This project evolves into a pilot with the city supporting it. If the pilot is successful, the project can be expanded to a larger area or constituency and if that is successful the city has created a new normal that inspires and creates new pilots in other areas or services.

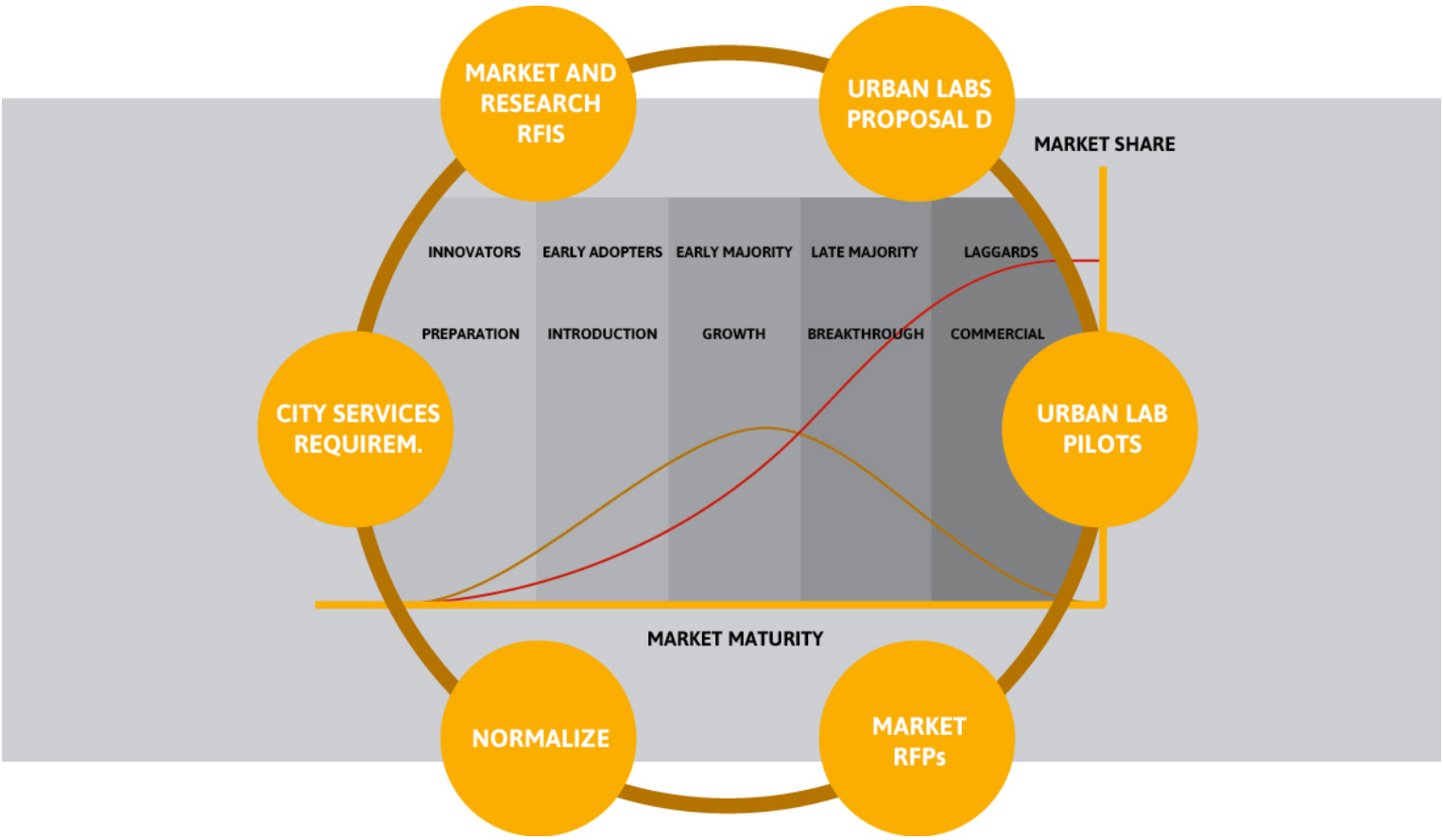


Figure 3. Barcelona Urban Labs

How Urban Labs Proposals work:

- Once the proposal is accepted, the municipality assigns a project manager from the municipality, who will:

1) Study and agree on the feasibility of the proposed project.
2) Facilitate the access to the infrastructure
3) Negotiate with local contractor's installation and maintenance of equipment for the proposed living lab.
4) Participate in results analysis

- Costs associated with the project (management, installation and maintenance) are not covered by the municipality.
- However, if the project has interest for the municipality the city can provide sources of funding programs in order to collaborate on grants/proposals with proposal entity.

Benefits:

- Involvement of city-knowledge in the development of new products and research actions.
- Possibility of generating patents on state-of-the-art products already tested in a city.
- Creation of economic activity based on these actions

This example shows how cities can mobilize their citizens and entrepreneurs to accelerate innovation, economic growth and social inclusion by generating more employment and attracting more businesses.

3 Governance

The figure below summarizes the major assets for a proper governance in a city.

CITIZENS	CITY AUTHORITIES	PRIVATE SECTOR	INNOVATORS	ACADEMIA
Create more participatory citizenry, where citizens are empowered to share and participate in governance and reshaping city life	Address innovative socio-technical and socio-economic aspects of growth by formulating proper policies and strategies to assist in planning initiatives and projects	Partner with the private sector to better deliver services to the citizens	Adopt and include technological, organizational and policy innovations	Partner with Academia sector to leverage on research to identify city trends and technological evolution

Table 3-1: Major assets for a proper governance in a city

3.1 Citizens' Engagement

The goal for any city or municipality is to improve the quality of life for citizens and to make sure that they are living in a safe and sustainable environment. Across many cities and countries, there is growing evidence of collaborating with citizens to get them to participate and help shape this environment.

Some cities are making a more concerted effort to increase citizen engagement, whether by directly soliciting their input or by collecting additional data about the habits and needs of constituents. To do this effectively, cities need to have a clear idea of what their own goals are and what they are trying to achieve. One of the core promises of big data and connected cities is to have an increased understanding of your constituency in order to better understand their needs, while simultaneously effectively soliciting their input and ideas. This engagement will also help citizens understand the potential benefits of smart cities and all smart city efforts, which can lead to support of investment and increased participation.

This is a challenge for fast moving, nimble companies that are motivated by increasing efficiency and customer satisfaction to make more money. However, it can be even more difficult for cities and is a break from the way many people perceive government. While encouraging input from citizens it is also important to understand the difference between what they are asking for and what they really need.

Citizen engagement generally happens in one of two primary ways: passive engagement and active engagement. The passive feedback loop is becoming stronger with the development of Internet of Things (IoT) and smart cities. Cities now have the ability to put sensors on streets or have other smart systems. Cities could have other smart systems that are paying attention to how people interact with their municipality services, so cities could be generating feedback from customers in a passive format, just by the nature of them walking up and down the sidewalk. If cities collect footfall patterns or traffic patterns, then they can take that information and consider adjusting the way cities are

designed, particularly things like bike paths or pedestrian walkways, without any direct action from customers, other than them just going about their business. This passive feedback loop is what has become very interesting and much more informative, in this new era, just because cities have the ability to collect data in these different ways.

Active Engagement	Public meetings that people can come to, where they can voice their opinions or their desires or requests or grievances in an open forum. That's an official gateway to receiving that kind of feedback.
Passive Loop Engagement	Maybe less formal but similarly traditional and intentional active methods. Use citizens' indirect information in order to understand what they're asking for services and then aggregate those into information
Passive Engagement	Citizens only interact with cities authorities if they are somehow pushed to do that, either throw surveys or voting processes for a specific decision

Table 3-2: Types of engagement with Citizens

3.2 The Role of the CIO

What is the present role of a CIO in a city's development?

Cities regularly face several challenges and opportunities, which is one reason why we are seeing more and more cities with more typically corporate roles such as Chief Information Officer, Chief Technology Officer, Chief Innovation Officer, Chief Digital Officer, Chief Infrastructure Officer, Chief Marketing Officer, and/or Chief Customer Officer. These new roles in government are focusing more on understanding, communicating with and working across the silos of departments and organizational lines than it has in the past. As discussed earlier in this blueprint, smart cities are more about changing a culture. If this new Chief role isn't given the proper authority and oversight to reach across all departments and agencies, the chances of success are limited.

Where CIOs and CTOs can really help is by giving government workers in all agencies a better understanding of how all of their work connects together. They can see where departments are duplicating efforts or providing similar services or using technologies and applications that don't work well together and much more. The key for them is to show the various agencies the potential of combining their resources, their technology and their data together to create something that is bigger and more effective than they can be on their own.

The CCAB architecture allows city leaders to say, "Here's how I perceive and approach the problem" in a way that's consistent with others. Cities can have a community of practice, a common dialogue and vernacular, an understanding, and shared insights. There's amazing value in what CIOs, CTOs and other CXO's can do together by rising to the challenge.

The goal of these new Chiefs should be to not just think about technology, but how collaboration can improve services, but also create new innovations the city has never before been able to provide.

4 Develop effective city plans

City planning is the main reason for the CCAB and the development of Smart Cities. Many cities are working on it and there's a lot of qualified, competent energetic people in different areas in different cities. Each city is planning from its own perspective and the value is to broaden that perspective. To be more specific, there are some cities that are focused on specific applications of the Smart City, but a city with a smart lighting project is not a smart city - it's just a city with a smart lighting project.

A city that has a smart lighting project and is investing in the framework to accelerate smarter infrastructure projects, is a city on the path of becoming smarter. There are cities that have, for whatever reason, their local politics or their local needs, focused in certain areas. You have some cities that have been thinking for a long time about the internet of things. There are some cities that have really been focused on the data programs. There are other cities that have really focused on connectivity. All of these things are the core elements.

The beauty is, bringing these cities together builds a more robust planning framework. The essence of a smart city is a city who has a plan that is comprehensive. Even if they are not yet investing in particular areas, but that their plan recognizes that all of those areas are important. One city may be putting a lot of money into connectivity, but it may not be focused on data yet. If their smart city plan acknowledges the need for data, then I think that city is better poised to execute.

The framework that we're working on in CCAB will hopefully become the structure for how the cities develop their smart city plans. Cities are in a very early stage with this type of technology and are still at the very beginning of this conversation on a global level. Many are still at a point where they're trying to construct what the plan elements should be and then putting a plan together.

Some cities are further ahead than others. For example, Singapore and Dubai are two places doing fantastic work. CCAB is creating a platform to learn from them and other smart cities/nations to accelerate the smart city planning and implementation process to allow cities to increase the pace and outcomes and cut costs associated with their smart city projects and planning. This is the value of sharing nest practices and lesson learned, because our problems are very common and similar, even across geographies.

When it comes to planning a "Smart City", it becomes clear how multidisciplinary a connected community and a smart city is. Cities are running into the barriers of functional silos and learning how they need to work better together. As an example, let's consider the typical process of building a house; the different trades work very independently. Plumbers, foundation layers, framers, etc., each do their various tasks without communicating with each other. That used to be how cities often functioned. Public Works only thought of IT staff for PC support and the police rarely talked with Engineers. In contrast, many cities are now requiring agencies to coordinate more today. Cooperation and collaboration between agencies is vital to the success of every major city.

Cities must work differently for better planning changes with the size of each city. In terms of the scope, when large cities implement a smart city plan at a large scale, there are more exceptions and variables than in a smaller city: housing clusters in communities, types of topology, streets and traffic design, codes and comprehensive plans, and age of infrastructure. You might have newer infrastructure in one place, and older ones in another. It's more likely that you have the state, counties, and other cities to work with, as well.

In terms of how you plan Smart Cities, larger cities have a larger portfolio of things that can go wrong that they must work through. However, success is still rooted in having a superior vision, with all of the best minds working towards a shared outcome, an understanding of newer technologies and methods, developing good vendor relationships, and piloting things to test concepts.

How do you make the city deal with the planning, in a more holistic manner, rather than the silo approach that has happened in the past? What we have seen from small cities to medium sized cities to large cities and at the state level, is that the ones that are going to be successful are the ones that are collaborative. Communities that lead have executive clarity that there are no fiefdoms, that all will work together towards a clear outcome. Otherwise, cities will not be able to solve the problems.

Looking into the example of San Jose in the US, they improved themselves when working on the Facebook project for their Terragraph technology in downtown, and they worked with Silver Springs Networks to put IoT in the city. They also worked with the Eastside Union High School District to bring underserved/disadvantaged students into the fold of a connected community through faster internet connections. These projects are mentioned because it expands what cities have to offer: the way it permits, the way it partners, and the services a city should offer.

Another good example are light poles. It's clear that cities will have to manage those pole attachments differently in that there's limited space and power. Cities will also need to be strategic in what they connect to the network; whether or not it wants to be an ISP; how to manage support and service requests; and how it will contract. All these things that really help you get a clearer vision of what the problems are, once you understand what the vision is based on the outcome that you want. The mark of a great organization is that they are a demonstration organization. They pilot things. Their staffs prove things and learn from their experiences. Then, they can build what others cannot because they have learned more effectively. It is about who solves more problems rather than who owns what.

For better planning there is a need for things that push us to be a different organization on the other end of that pipeline, and how people work together with that. Where executives are involved, and city managers and councils, where they can push the limit to say, "We're weighing how you get to the other side of the vision. We don't really care who owns what." Then you get other questions that come out of that; for instance, based on transportation, you have to coordinate with the federal government and say, "We need you to broaden how those usage policies are for the federally funded fiber networks that are out there to safeguard the transportation usage, but with that extra capacity allowing other uses. Wireless frequency should have public uses reserved and they get how itis prioritized."

In the New York City example, they have the Department of Design and Construction and have the Department of City Planning and the Economic Development Corporation, and the Mayor's Office and its broadband expert. All must understand together where the city's growth is going economically, where the city is planning to build new affordable housing and new transportation corridors, such as bus routes, shipping lanes, and ferry crossings. City economic and civic growth has an impact on how you size, scale, deploy, order, and prioritize where your broadband will grow. You have to have a collaboration with other agencies in order to make sense of the telecommunications growth in your city.

It is a challenge in big cities to get that kind of collaboration; to agree on what the telecommunications growth should look like and where it should take place. Sometimes, because the streets are being opened for one reason in a neighborhood, it also makes sense to lay down fiber there at the same time. Cities need to have an equitably-based, comprehensive plan.

Once cities have a plan, we can get to more schools, libraries, and multiple dwelling units. They need to be able to get to housing authority locations or lower-income neighborhoods that would be devoid of having this broadband path. The Economic Development Corporation's knowledge and foresight subject to how the city is economically growing based on demographics, traffic patterns, and where current broadband already exists and where it does not, leads to quite a few decisions in terms of what is going to make the greatest impact.

City Planning also contributes, in terms of knowing where new commercial and new transportation corridors will be built and/or modified over time. Rezoning activities are going on in New York City, much like many cities around the world, and they look at those to determine whether or not to replace or modify street light poles, for example. While

removing and repaving streets, why not build new infrastructure like more street light poles that can accommodate both Wi-Fi as well as 4G and 5G deployments?

Because of the size of New York City they cannot tackle everything at one time. There are a variety of small pilot projects that they are working on and once they are successful, they will proliferate those across the city in a broad way. For example, NYC is bringing affordable public Wi-Fi to the city's housing projects, but the City's Housing Authority covers thousands of residences. So they are starting out with five projects, one in each borough, and then they will branch out from there.

By the same token, they are modifying small areas as they rezone them, like East New York, to invest in creating the city's own conduit while the streets are open. In both of these instances, NYC is able to provide fiber services to a variety of new commercial and residential neighborhoods that were traditionally devoid of broadband.

New York City is developing the connected city by going from the heart of Manhattan all the way out to the outer boroughs. They have the core fiber hubs in the urban area. In order to reach the outer boroughs or the outer perimeters of our marketplace, they really have to start from the core and then grow out.

They are also taking a look at areas outside of Manhattan—what they call the Outer Boroughs of Brooklyn, Queens, the Bronx, and Staten Island. These places may not have fiber infrastructure in the ground. Trying to determine whether the city would like to connect them through millimeter wave fiber backhaul solutions that could then be used as hub locations to provide wireless, high speed services much faster and at a lower cost than provisioning fiber all the way out to these locations.

The New York City broadband initiative is continuing to grow. They continue to attract new talent and new leadership that brings new ideas to the table, new creativity and new innovation. This cycle of generating revenue from the city's own real estate will make it possible to finance more and better broadband ideas and their plan is for New York City to continue to lead in innovating telecommunications services.

5 Assessing the role of different technologies

Cities are facing a wide spectrum of different wireless connectivity technologies both for broadband and the Internet of Things (IoT) applications, special with all recent evolutions in terms of unlicensed technologies both for IoT and broadband proliferation.

This chapter identifies the most relevant wireless technologies and their main applications in the industry, in order to facilitate the understanding and roadmap that cities should pursuit.

This analysis is divided into wireless broadband technologies and IoT and Smart City technologies both from a perspective of unlicensed and licensed spectrums.

5.1 Technology Landscape

The map below shows an overall positioning of the different wireless technologies divided into wireless broadband technologies and IoT and Smart City technologies both from a perspective of unlicensed and licensed spectrums.

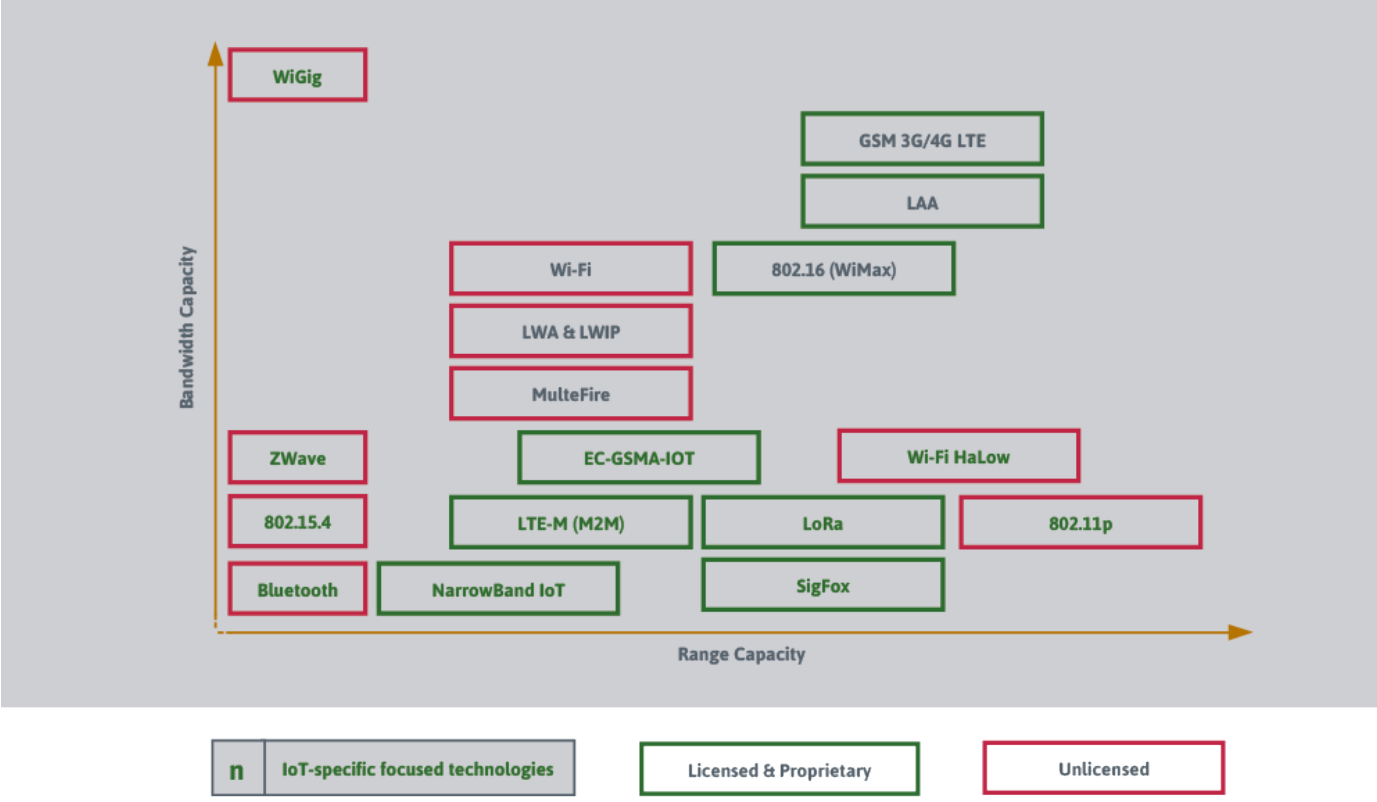


Figure 4. Wireless Broadband and IoT Access Technologies

5.2 Wireless Broadband Technologies

5.2.1 Wireless Broadband Technologies

Wi-Fi

The traditional Wi-Fi operates in 2.4GHz and 5GHz ISM bands and comes in two flavors of Infrastructure Wi-Fi where devices connect to the Access Points (APs) primarily for accessing the Internet and Wi-Fi Direct which enables peer-to-peer communication among devices without need of an AP.

LWA/LWIP

LTE-WLAN Aggregation (LWA) and LTE WLAN Radio Level Integration with IPsec Tunnel (LWIP) were developed in Release 13 from 3GPP. These solutions use the 3GPP E-UTRAN as an anchor point where the WLAN is connected to the eNB, thereby also eliminating any impacts on the Mobile Core Network. Furthermore, making the offloading decisions at the access network can reduce signaling. It is assumed that an eNB is connected to WLANs that are under its coverage as LTE connectivity is required for these solutions.

LWIP was designed to minimize the impact to legacy WLAN while LWA is based on Dual Connectivity split-bearer solution for proven substantial performance gains compared to other LTE/WLAN integration solutions.

MulteFire

LTE can also be deployed in unlicensed spectrum (e.g., 3.5 GHz, 5 GHz) without being anchored with a licensed carrier. With this option, unlike LAA or LWA/LWIP, all the signaling and data are carried over the unlicensed carrier. The primary motivation for this is to combine the enhanced performance of LTE (capacity, range, and mobility) with the deployment simplicity (similar to Wi-Fi) of unlicensed spectrum. This can broaden the LTE ecosystem to more entities such as ISPs, cable operators, and enterprise/venue owners and enable both offloading and neutral host deployments.

One initiative to enable standalone unlicensed operation of LTE is the MulteFire Alliance (www.multefire.org) which announced its formation in December 2015. The Alliance is currently working on developing the MulteFire technical specifications as well as establishing a product certification program. A key principle for this design will be fair co-existence with Wi-Fi which will be based on methods used by LAA.

5.2.2 Licensed Wireless Technologies

GSM (3G/4G-LTE)

GSM (Global System for Mobile Communications) is the world's most popular licensed wireless phone technology. It's used by billions of people around the world, in more than 220 countries, and normally delivers nationwide coverage. GSM offers unparalleled global roaming capabilities, as well as the truest voice quality in wireless. Its easy-to-use data capabilities offers fast wireless data broadband connectivity.

There are several technologies and levels of services within the GSM “family”, including LTE, HSPA+, HSPA, UMTS, EDGE, GPRS.

IEEE 802.16 (WiMAX)

The IEEE working group IEEE 802.16 have standardized the family of 802.16 technologies, widely known as WiMAX. Originally focused to provide Fixed Broadband Wireless Access Services this technology has been evolving and standards like 802.16p/1b focus on the Support to Machine-to-Machine Applications.

LTE (U)

Long Term Evolution (LTE-U) is a radio access technology that has been proposed by the members of the LTE-U Forum for providing carrier-grade wireless service in the 5GHz unlicensed band.

LTE-U operates using unlicensed spectrum as a Supplemental Downlink to primary LTE technology operations that use licensed spectrum. LTE-U has some modifications to the normal LTE radio signal, but is predominantly a shift of the LTE signaling and protocol to the 5GHz band. As such, the primary use for LTE-U is the quick time to market, as a “pre-standard” technology, leading toward LAA, but with minimal changes needed to traditional LTE deployments and equipment to enable quick adoption.

LAA

Licensed Assisted Access (LAA) is a technology that enables operators that have access to licensed spectrum to complement it with unlicensed spectrum while leveraging the existing and planned investments in LTE/EPC, i.e., hardware and software in the radio and core network. The access to unlicensed spectrum is done via a Secondary Component Carrier (SCell) which is assisted by a Primary Component Carrier (Pcell) on licensed spectrum using the Carrier Aggregation Framework of LTE.

LAA is part of 3GPP Release-13 and the main objective is to deliver enhancements to LTE for operation in the 5 GHz band. Fair co-existence with other technologies operating in unlicensed spectrum is a fundamental design

principle for LAA. Based on the principle of carrier aggregation, the LAA designs aim to combine the best of the licensed and unlicensed band opportunities while reducing operators' operating costs

5.3 IoT and Smart Cities Technologies

5.3.1 Alternative Unlicensed Access Technologies

The unlicensed access technologies addressing IoT are divided here based on their typical transmission range, from short range to medium range and long range technologies.

1) **Short Range**

The wireless access technologies in this category have traditionally been used for Personal Area Networks (PANs). However, mesh capability has enabled them to expand their coverage area significantly by multi-hopping. Growth in this category is reported as being driven by consumer electronics, home automation, smart city and smart buildings.

IEEE 802.15.4

IEEE 802.15.4 is the MAC and PHY standard operating primarily in 2.4.GHz ISM band, targeted for low power and low rate PAN applications. It is the basis for ZigBee, and hhread specifications, among others; these specifications specify the upper layer functionalities.

Bluetooth

Another low rate PAN technology operating in 2.4GHz ISM band is Bluetooth. While traditionally it has been used for audio applications, Bluetooth Low Energy (BLE) has been introduced to expand into IOT applications including healthcare and home entertainment. To further improve the applicability and use of Bluetooth technology, the Bluetooth SIG is in process of definition of a long range version of Bluetooth as well as enabling Bluetooth mesh.

Zwave

Designed to provide reliable, low latency, and low data rate communication, Zwave's target application is home automation. It operates in sub 1GHz ISM band. Similar to the previously listed PAN technologies, Zwave can also be used to cover a larger area by use of mesh.

IEEE 802.11ad (WiGig)

Operating in 60GHz ISM band WiGig enables communication at very high data rates. Given that the 60GHz signal typically cannot penetrate through walls, the WiGig network is confined to a room. The large channel bandwidth of WiGig enables delivery of signals at a very low latency, making it a good candidate for mission critical industrial applications.

2) **Medium Range**

Wi-Fi is the only medium range wireless technology capable of providing single hop connectivity in a local Area Network (LAN). Other technologies like Wi-Fi HaLow and 802.11p provides narrowband connectivity to IoT applications based on 802.11 spectrum bands.

Wi-Fi

The traditional Wi-Fi operates in 2.4GHz and 5GHz ISM bands and comes in two flavours of Infrastructure Wi-Fi where devices connect to the Access Points (APs) primarily for accessing the internet and Wi-Fi Direct which enables peer-to-peer communication among devices without need of an AP.

Wi-Fi HaLow

Wi-Fi HaLow, which is currently under development in the Wi-Fi Alliance, operates in sub 1GHz ISM band. Wi-Fi HaLow is based on IEEE 802.11ah which provides longer range, lower power operation, and lower throughput compared to other Wi-Fi technologies and hence is suitable for sensors and IOT devices distributed in larger areas. Non harmonized spectrum is globally identified as a contributing factor for slow adoption of Wi-Fi HaLow in the industry.

IEEE 802.11p

IEEE 802.11p defines enhancements to Wi-Fi required to support Intelligent Transportation Systems (ITS). IEEE 802.11p operates in 5.9GHz band. IEEE 802.11p enables delivery of high throughput data with low latency which is required for ITS safety applications.

3) **Long Range**

The Wide Area Networks (WAN) operating in unlicensed bands primarily target IOT applications. These technologies are also managed and are in direct competition with their licensed counterparts, i.e., Cellular IOT solutions.

LP-WAN provides a detailed comparison of the following unlicensed Low Power Wide Area Networks (LP-WAN) technologies:

LoRa:

The LoRa Alliance is driving the adoption of the LoRAWAN protocol that has been optimized for low cost, low power, battery powered IoT devices that leverage a Chirp Spread Spectrum based physical layer.

SigFox:

Using an Ultra Narrow Band physical layer, the SIGFOX system is designed for infrequent sending of small messages that characterizes many IoT use cases.

Wi-SUN:

The Wi-SUN Alliance promotes open interoperable standards for Smart Utility Networks based on peer-to-peer and wireless mesh based IEEE 802.15.4g networks.

5.3.2 Alternative Licensed Access Technologies

The licensed access technologies addressing IOT are identified here. These technologies operate by sharing spectrum with LTE and GSM networks that provide other data and voice services.

LTE-M

Standardized by 3GPP is an evolution of LTE optimized for IoT, focusing on M2M applications. Looks for applications of large volumes of transactions with low data rate, with low cost devices and long battery life.

Narrowband IoT (NB-IoT)

Standardized by 3GPP can be deployed over an existing infrastructure, with minor updates, of a normal 3G/LTE carrier and can also be used “standalone” to enable deployments in dedicated spectrum. Focus of this technology are an indoor coverage, low cost, long battery life and large number of devices.

EC-GSM-IoT

Standardization in place by 3GPP, expected to be concluded by the end of 2016. It is an evolution of GSM (eGPRS/EDGE) optimized for IoT, designed as a high capacity, long range, low energy and low complexity cellular system for IoT.

It's important to mention the 5G solution for cellular, IoT is expected to be part of the new 5G framework by 2020. Standardization has just started in 3GPP but based on NGMN and ITU/ETSI initial assessment uses cases for IoT are a key element of the 5G technologies.

5.3.3 Mapping of alternative access technologies to IoT Requirements

The applicability of different access technologies to different applications is determined by the application's requirements and the ability of the access technologies in addressing those. The following are the main requirements of IoT applications.

- **Coverage**

Some IOT applications, e.g., Industrial applications, require a wide coverage area, whereas home applications, for example, require a small coverage area. A large coverage can be provided by use of multi-hopping, a technique ZigBee utilizes to extend its coverage area; or can be achieved by longer range transmissions, as provided by Wi-Fi for medium range coverage or LP-WAN technologies for wide area coverage.

- **Scalability**

The ability of an access technology to scale to a large number of nodes with high efficiency is another determining factor for its applicability for a particular application. Bluetooth for example, is capable of supporting small-sized networks, whereas ZigBee easily scales to very large networks.

- **Power**

A major requirement for IoT sensors is low power operation and a multi-year-long battery life. There are other IoT devices, for example in Industrial applications, which are ac-powered. And there are different devices with different battery life expectancies in between. A related parameter to power is the form factor; the form factor of a battery powered device determines the type and size of battery it contains and hence how low power the operation of the device needs to be. Other related parameters impacting power requirements are required throughput and traffic patterns as well as the determinism of access.

- **Throughput and traffic patterns**

While sensors typically require very low throughput to transmit collected data at low frequencies, e.g., reporting measured temperature every hour, other IoT devices, for example surveillance cameras, require higher throughput for long durations of time. There are actuators that typically only receive data and there are sensors which only report data, and there are many different types of devices that both transmit and receive on a regular basis.

- **Reliability**

Some applications require high reliability communications. All wireless access technologies that operate within a fading environment provide probabilistic reliability, i.e., there will typically always be a finite possibility that the wireless channel is suffering from an extreme fade. Furthermore, wireless access technologies that operate in unlicensed spectrum needs to operate in an environment with un-coordinated and

un-controlled sources of interference and hence inherently cannot provide guaranteed reliability; however, higher levels of reliability is achievable with implementing efficient medium access mechanisms and operation in low interference environment.

- **Determinism**

Mission critical applications require determinism to be provided by the access technologies. While unlicensed technologies in general do not provide guaranteed timely access to the wireless medium, in special scenarios, for example in an isolated industrial field, determinism can be achieved especially for short-range and high-bandwidth communication technologies like WiGig.

- **Cost**

Unlicensed communication technologies enjoy lower cost in general compared to cellular communications. Among unlicensed technologies the cost the complexity of the technology and the size of the existing ecosystem impacts the cost.

- **Security**

Secure communication is required for many IOT applications and becomes more critical for longer range access technologies.

ACCESS TECHNOLOGIES	REQUIREMENTS							
	COVERAGE	SCALABILITY	POWER	THROUGHPUT	RELIABILITY	DETERMINISM	COST	SECURITY
IEEE 802.15.4	✓ (mesh)	✓	✓	✗	✓	✓	✓	
BT & BLE	✗	✗	✓	✗	✓	✓	✓	
ZWave	✓ (mesh)	✓	✓	✗	✓	✓	✓	
WiGig	✓	✓	✗	✓✓	✓	✓	✗	✓
Wi-Fi	✓	✓	✓	✓	✓	✓	✓	✓
Wi-Fi HaLow	✓	✓	✓	✗	✓	✓	✓	
LP-WAN	✓✓	✓	✓	✗	✓	✓	✓	
LTE-M	✓	✓	✓	✗	✓	✓	✗	✓
Narrowband IoT (NB-IoT)	✓	✓	✓	✗	✓	✓	✗	✓
EC-GSM-IoT	✓	✓	✓	✗	✓	✓	✗	✓

Table 5-1: Mapping of Access Technologies to IoT Requirements

6 Use Cases identification and description

A city consists of a combination of cases spread across several vertical service categories.

The table below gives an overview of the different smart city cases that can be rolled out. A city does not have to adopt every service to be considered smart, but normally are linked by a common infrastructure, platform and technology.

Service Category	Use Cases
Transportation	• Public transportation • Traffic management • Parking
Safety	• Street lighting • People counting & control • CCTV
Environment	• Air quality • Weather sensing • Flood control
Healthcare	• Disease control • Emergency response • Patient identification
Utilities	• Smart metering • Waste management • Sewerage
Government	• Citizen engagement • Public Wi-Fi • Civil work monitoring & control • Infrastructure monitoring
Commerce	• Delivery logistics • Advertising
Entertainment & Tourism	• Events management • Recreation facilities

Table 6-1: Smart City Cases that can be rolled out

1) Civil Works Control and Monitoring

Project on Civil Works Control and Monitoring, in the City of Barcelona, in order to implement good practices to minimize civil works impacts in terms of noise, dust, vibration and gas to guarantee security and wellbeing to the citizens.

Implementation in the civil works in the Estatut Avenue, between 2011 and 20133 and in the Glories Square since 2014.

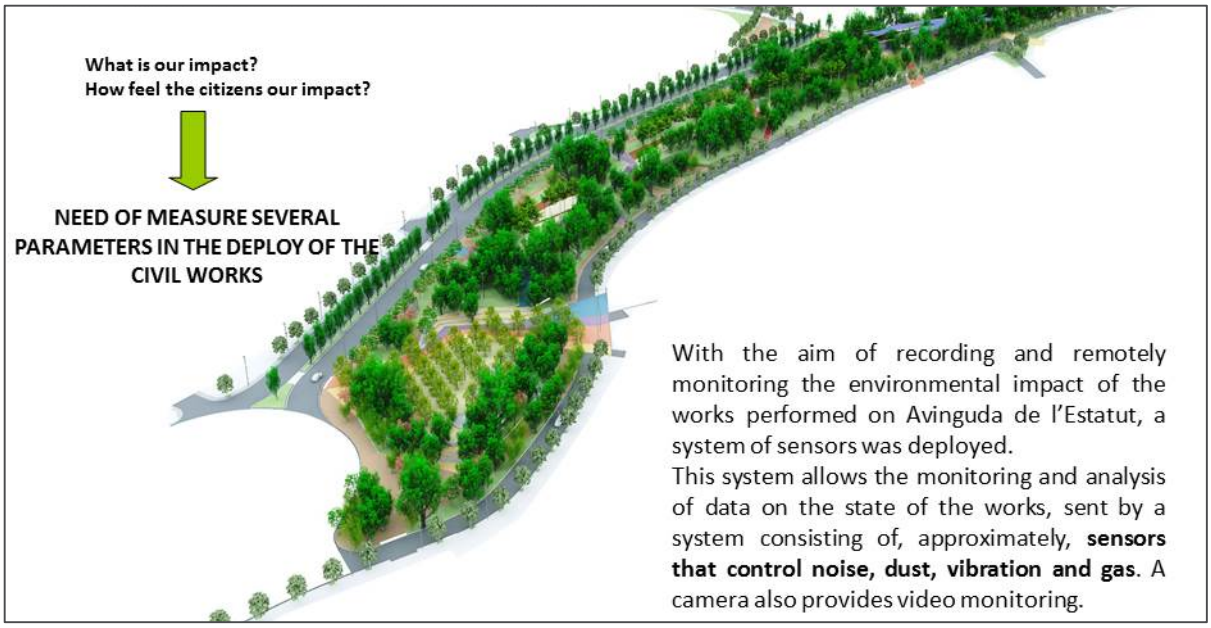


Figure 5. Implementation in the Civil Works

2) Trash Containers Sensors

Pilot project on trash containers sensors since 2010 for the City of Barcelona.

Test ultrasonic sensors to provide the load information for each trash container. Smell sensors tested as well. Data collected helps to optimize the collections routes and plan for future services.

This project involved citizens and local businesses trash containers.

Citizens	Stores and Businesses
27.000 RFID tagged trash containers Amount of rubbish per day and container Geocoded information Cleaning trash-containers control	12.000 RFID tagged trash containers For stores and offices trash containers Data protection standards (ENECSTI) compliant Future service "Pay as you through"

Table 6-2: Table to show pilot project scope

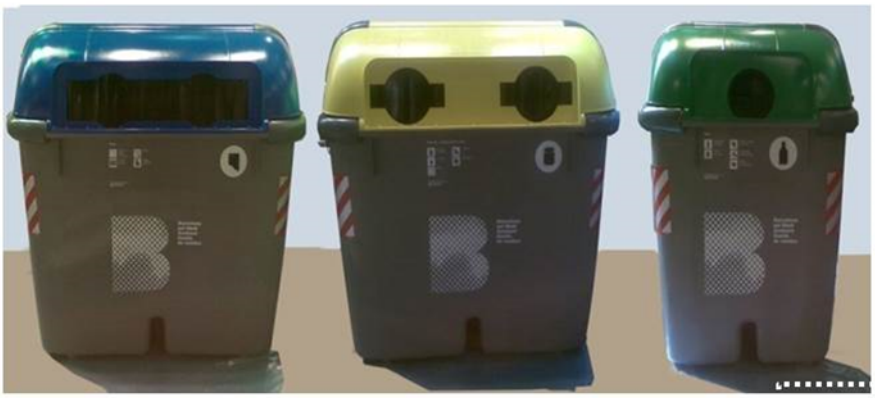


Figure 6. Photographs of Smart Trash Containers

3) People Counting

People counting pilot project in the City of Barcelona from 2013 till 2015.

Test a system for people counting was tested in several areas of the City of Barcelona, including Born, Av. Statute and Glories Square.

There are several systems for people counting. City of Barcelona tested different technologies in terms of count users, preferred displacements, error evaluation and data identity protection:

- IR photodetectors
- Cameras with integrated process
- Radar techniques
- MAC based techniques, including Bluetooth and Wi-Fi
- IMEI based techniques

Figure 7. People Counting

4) Harlem Free Public Wi-Fi Network

Following the deployment of the Harlem Free Public Wi-Fi Network, which provides Wi-Fi access to approximately 80,000 residents across 95 city blocks, New York City Department of Information Technology and Telecommunications (DoITT) solicited proposals from various industry experts to conduct a comprehensive network assessment. Project scope:

- A physical site survey to measure the true coverage area and equipment performance.
- Assessment of existing bandwidth and opportunities for expansion.
- Recommendations for improving service and identification of new locations on which to mount additional access points.
- Review and analysis of network hardware and software, including the network management tool.
- Recommendations to upgrade the network to increase user speeds to at least 25 Mbps.

DoITT set out to conduct a comprehensive network assessment to ensure that a significant public/private investment in Wi-Fi is fully and efficiently implemented to deliver the best possible service to the public and to make recommendations as to how it can be improved. Recommendations made pursuant to the assessment will help inform decisions that DoITT will make with regards to potentially upgrading the network to improve speeds and/or expand the coverage area. DoITT also analyzed the results of the "pilot" assessment to help determine if it should conduct similar network assessments on existing incumbent Wi-Fi networks and their providers.

The entities involved in these projects were Silicon Harlem & Kalpesh Wireless.

Silicon Harlem is a technology and advocacy group focused on advancing broadband services in Harlem. With their technical experience and close relationship to the community, Silicon Harlem is uniquely qualified to perform an assessment evaluating the efficacy of the network and its community impact.

Kalpesh Wireless is a market leader in municipal and private Wi-Fi networks and assisted Silicon Harlem in conducting the assessment.

To test the propagation of the Wi-Fi signal and coverage area, Silicon Harlem measured the Signal to Noise Ratio (SNR) and Received Signal Strength Indicator (RSSI).

The network assessment provides insight into the performance of the Wi-Fi network (and vendor) to ensure that the public receives a quality Wi-Fi experience. Results of the assessment can identify network deficiencies and credibility issues which may necessitate a plan to mitigate the issues. The findings and conclusions from the comprehensive network assessment will help the city to make informed decisions with respect to the allocation of resources for future wireless deployments.

No major challenges were encountered. The solicitation of vendors to perform the assessment and the project itself was performed professionally and expeditiously and yielded good results.

DoITT distributed a clearly defined solicitation stating the project's goals and scope of work to a host of highly qualified vendors. The responses received were very impressive and demonstrated a wealth of skilled vendors capable of performing the services. The selection of the "right" vendor for the particular project is essential to deliver the desired result.

The Harlem Free Public Wi-Fi network assessment identified shortcomings in the network such as in many locations the throughput fell below the minimum 2 Mbps threshold. Recommendations to achieve user speeds of at least 2 Mbps included adding additional strategically-placed gateways and access points as well as upgrading from a 35/5 backhaul connection to a 300/20 connection. Further recommendations to achieve significantly higher user speeds of at least 25

Mbps include deploying a hybrid fiber-fed point-to-point network and upgrading access points using the 802.11n standard to 802.11ac Wave 2 technology. The backbone of the hybrid network would leverage 1+ Gbps fiber lines installed to support the City's LinkNYC kiosks.

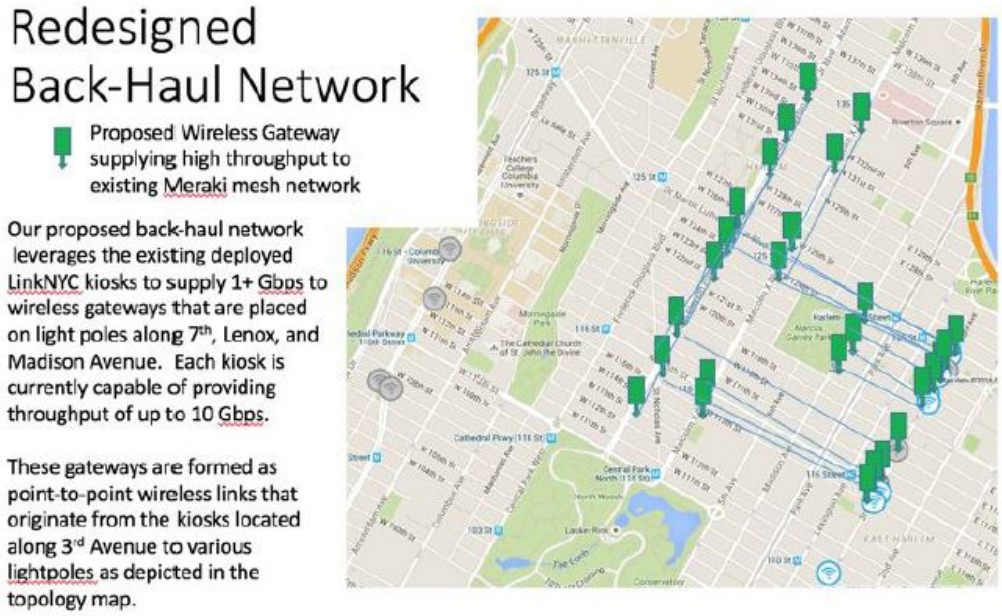


Figure 8. Redesigned Back-Haul Network

The final assessment report detailed a number of shortcomings in the network's design and operation and offered specific recommendations to remediate those issues. Taking into serious consideration the suggested recommendations, DoITT has initiated the process to identify a plan to immediately resolve the short-term issues affecting the network's reliability and performance while also formulating a plan to significantly expand and future-proof the network. The report's findings also provided insight into whether or not the city will conduct future business with the network provider as well as the inclusion of added City oversight measures in future network deployments.

DoITT is committed to expanding access to broadband services throughout the city, particularly in underserved communities. To ensure that those services adequately meet the needs of its citizens, and after reviewing the results of the Harlem Wi-Fi network assessment, DoITT intends to increase standards for future network deployments requiring providers to install robust, future-proof networks and institute more stringent monitoring and maintenance protocols.

Municipalities may be deterred by the cost associated with conducting the network assessment, however the report's findings provide tremendous vision into the network's true performance that would otherwise not have been visible to the city.

DoITT anticipates conducting similar network assessments for other existing and future Wi-Fi projects that are funded by the city and/or utilize city-owned property.

With the increase in city-sponsored public Wi-Fi networks, DoITT is motivated to continue to find new ways to make certain that the city's residents and visitors have access to quality wireless networks. Future network assessments will likely include an even broader range of potential vendors and an enhanced scope of work. Potential projects include network assessments of the city's LinkNYC kiosks and Transit Wireless subway Wi-Fi network.

5) Municipal Data Network for CCTV

Limerick Digital Strategy - Limerick Municipal Data Network, launched in May 2012 but is still expanding.

The scope of this project was to assess the viability of using city assets (ducting, street cabinets, access chambers) in developing and expanding a city owned high-speed, high-capacity fiber network to connect any council buildings, operational depots and any other city-owned data sources.

- To expand the existing CCTV fiber network and connect City Hall and the Emergency Services Campus (Munster Regional Control Centre and Limerick City Fire Station)
- To upgrade older analogue CCTV to IP CCTV to create additional capacity in the existing fiber networks. To transfer traffic controllers to this network and reduce communication costs
- To enable the roll-out of additional CCTV (e.g. the Limerick Canal walkway as part of Smarter Travel Limerick, Regeneration CCTV)
- To develop a dedicate infrastructure for Wi-Fi and IoT pilots as part of the Howleys Quay re-development
- To provide a live connection to An Garda Síochána (Police) to 2 major CCTV centers

Figure 9. Creating High-Speed, High-Capacity Municipal Data Network

Limerick City & County Council wanted to use existing city infrastructure assets to create a high-speed, high-capacity municipal data network, a backbone for connecting any council buildings, city data sources (CCTV, Traffic controllers, Wi-Fi, etc.) and support the future roll-out of IoT.

The following entities are involved on this initiative: Limerick Regeneration, An Garda Síochána, Munster Regional Communications Centre, and Bandwidth Telecommunications

Limerick Regeneration is responsible for the Framework Implementation Plan one of the largest capital programs in the State. The Plan includes a €253m investment on physical, €30m on social and €10m on economic programs.

Munster Regional Communications Centre is responsible for the efficient and effective mobilisation of fire appliances and other agencies with the Munster region.

Bandwidth Telecommunications are system integrators with over 20 years' experience in design, installation and maintaining a wide range of technology solutions.

The following benefits are the result of the project:

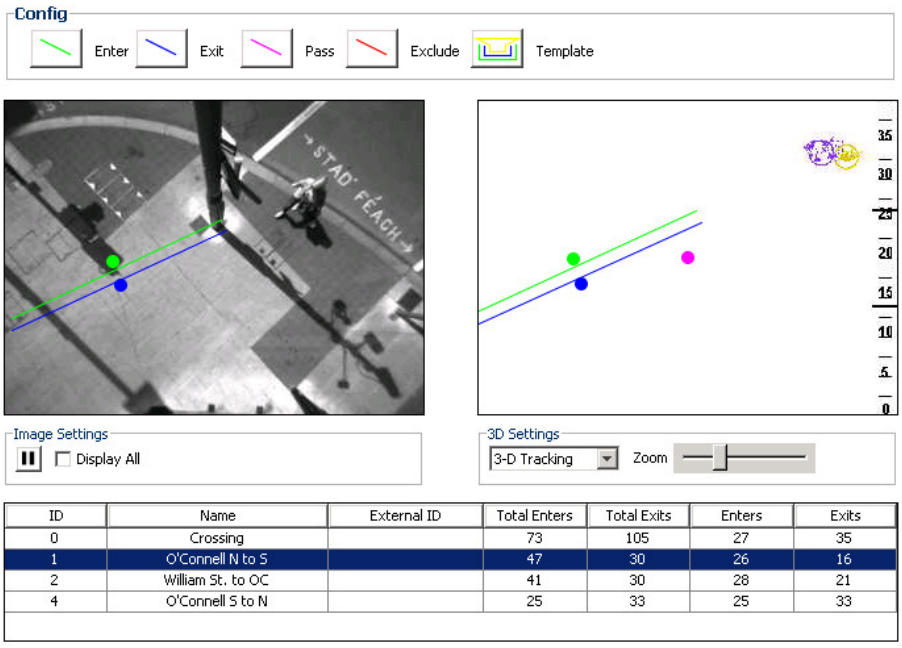
- Improved public safety by connecting a community based monitoring centre and the police force to previously isolated CCTV
- Increased speed and reliability of city communications infrastructure
- Creating opportunities for IoT deployments: footfall sensors, CCTV and traffic monitoring sensors have already been added to this network;
- Creating opportunities for cost sharing of communications costs therefore connecting more devices and locations
- Improved DR and backup capacity to any location in the network
- Demonstrates how to maximize the untapped potential of the city's infrastructure assets in order to create new data communications capabilities for Limerick

No major challenges were encountered. However, identifying and maintaining a register of city assets (ducting available in footpaths and roads) can be problematic. In the discovery phase, interviews with engineers, technicians and contractors helped us identify information about city assets from previous project plans and aggregate this information in a GIS system.

The Digital Strategy Department worked across the Council in close co-operation with ICT, Traffic Management, Community Support Services departments to put forward a proposal to other agencies for co-creating this network and sharing costs. The proposal was very well received and the benefits of the project increased as more agencies joined the project.

Future areas of improvement:

- Further expanding the use of the network
- Development of a self-monitoring and alert system on the network
- Development of a network loop across the city in order to increase resiliency
- Mature the governance and operational processes



ID	Name	External ID	Total Enters	Total Exits	Enters	Exits
0	Crossing		73	105	27	35
1	O'Connell N to S		47	30	26	16
2	William St. to OC		41	30	28	21
4	O'Connell S to N		25	33	25	33

Figure 10. Identifying and Maintaining City Assets

To evaluate the success of this project LCCC uses

- The number and type of devices connected in this network as an indicator of the service uptake; and also the number of devices and locations that are still unconnected;
- The communications costs vs. using point solutions (3G, dedicated lines, radio, etc.)
- The impact on the local community in relation to safety and reduced antisocial behavior

LCCC are committed to implement the Limerick 2030 Economic and Spatial plan and take full advantage of Digital and ICT technologies in the development of Smart Limerick in order to:

- Create smart communities and safer communities
- Create new social and economic opportunities for all, through the use of technology
- Create a better citizen, visitor and customer experience

Municipalities should keep an updated infrastructure assets register (besides the financial asset management register) and if one does not exist, start its development by capturing the knowledge of their staff and contractors.

Develop internal processes that will facilitate keeping the infrastructure assets register up to date and engage with other agencies: the business case for shared development increases in value created as more agencies take part.

LCCC anticipates that this network will be further expanded as the city streets are upgraded, for example the €8 million O'Connell Street (main thoroughfare) upgrade will see an expansion of the network and the use of different types of IoT devices.

As the municipal, data network expands and new data is being captured while we are developing "Insight Limerick", a data aggregation, visualization and analytics service that will allow us to make better decisions based on insights from this new data.

We are currently working on Limerick Enterprise Architecture for Smart Cities with LERO across universities research groups based in the University of Limerick

6) Smart Traffic Management System

Development of a Smart Traffic Management Systems for the city of Cyberjaya in Malaysia.

This project includes the following blocks: Traffic lights, Traffic sensors, CCTV with traffic counting analytics and Adaptive controller systems.

With the objective to implement a system that:

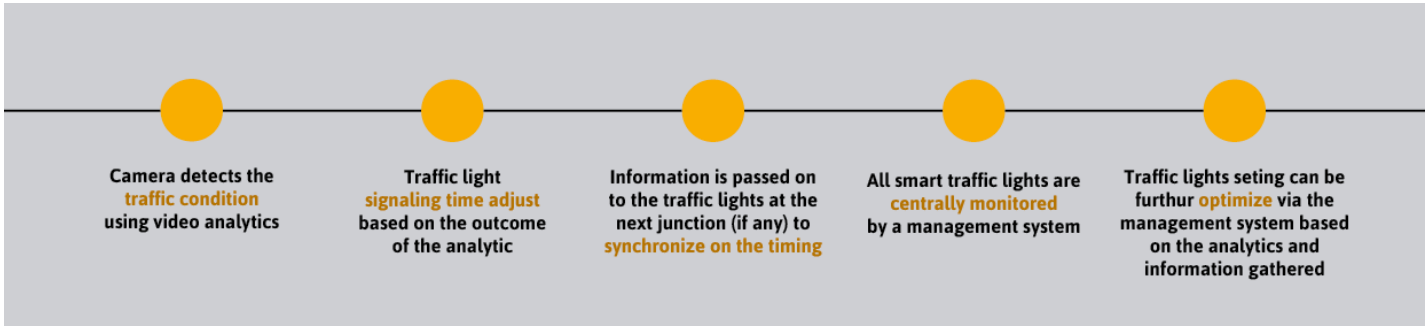
- Auto-adapts and auto-optimizes traffic lights to reduce traffic congestion,
- Reduce waiting time at traffic intersection
- Savings on petrol and CO2 emission affecting everyone
- Remote management

Through understanding the traffic condition and behaviour via traffic sensors and CCTV analytics, the smart traffic signal control system can automatically distribute green time to all traffic lanes and adaptive to fluctuating traffic volume to enhance rapid traffic movements. This would result in reduced travel time, waiting time and directly addresses traffic congestions while accommodating to multiple variable/unpredictable traffic demands.

The objective was to address the following issues:

- Long queue due to inefficient traffic light signaling
- Cars stop at every traffic junction because the traffic lights are not in sync
- Traffic light signals are set to a fix timing rather than automatically adjust according to traffic condition

The project is summarized in the following chart that describe the main blocks of the smart traffic management system:



The implementation of this system brought the following benefits:

- Less time spent on waiting at the junction
- Smooth journey from one junction to the other
- Reduce traffic congestion in the city
- Able to remotely monitor and control traffic light signal to accommodate multiple variable/unpredictable traffic demands

The following figure identifies the flows of activity of the Smart Traffic Management Systems of Cyberjaya.

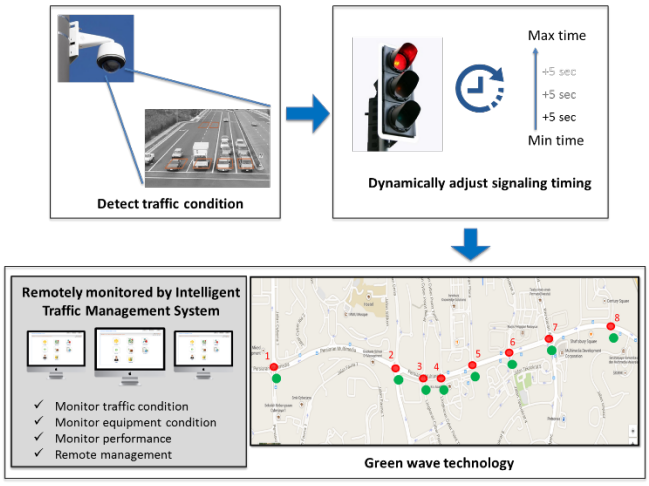


Figure 11. Flow of activity of Smart Traffic Management Systems

Video analytics data being sent to local traffic controllers and command centers. Local traffic controllers will process analytics and adapt to traffic conditions.

Traffic management software would be able to remotely monitor and manage traffic controllers (override if required).

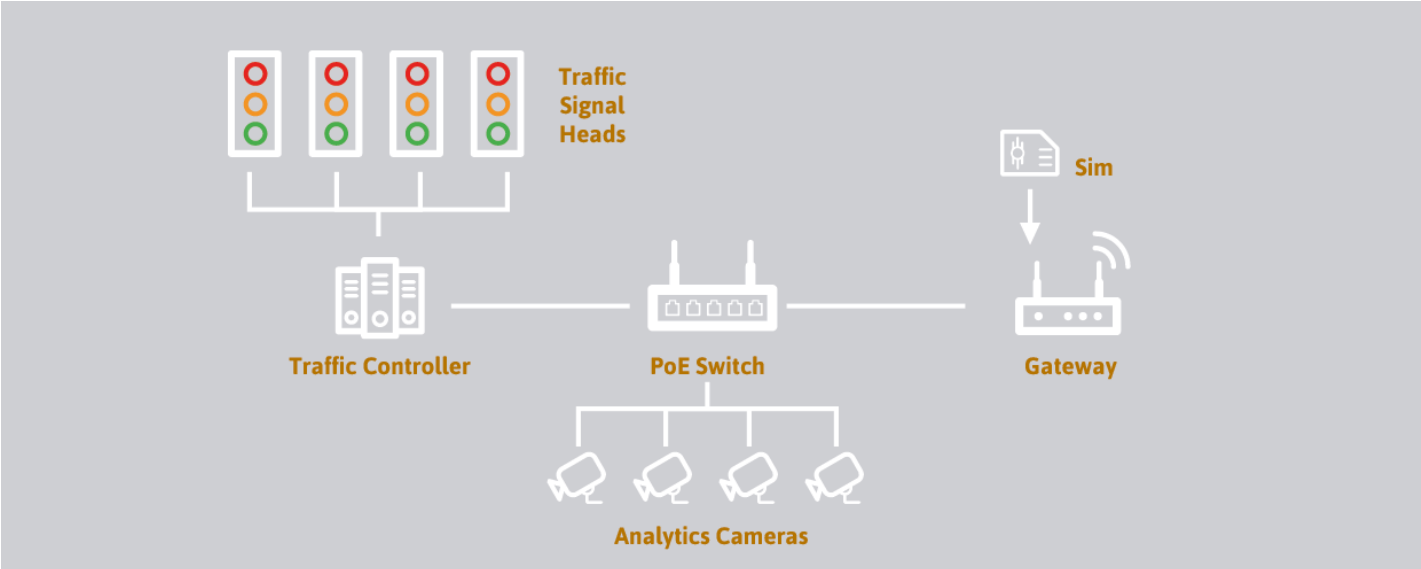


Figure 12. Local infrastructure installed

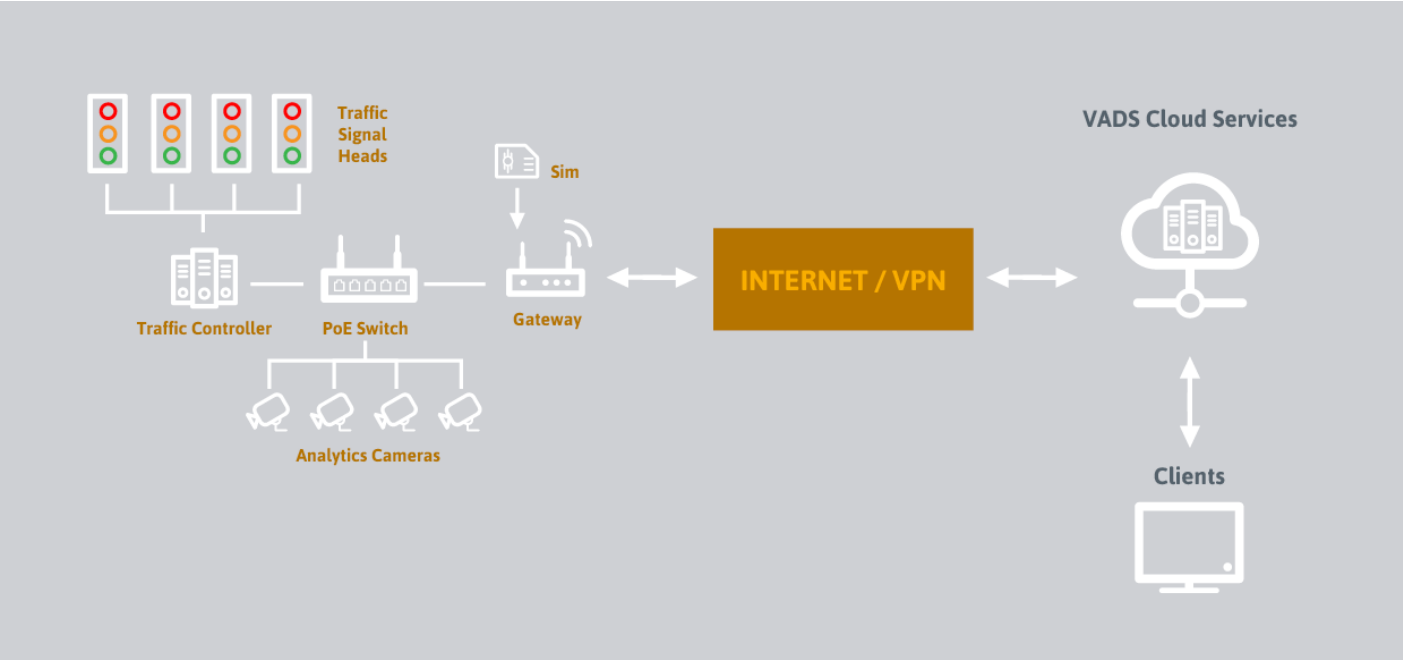


Figure 13. Remote Monitoring Architecture

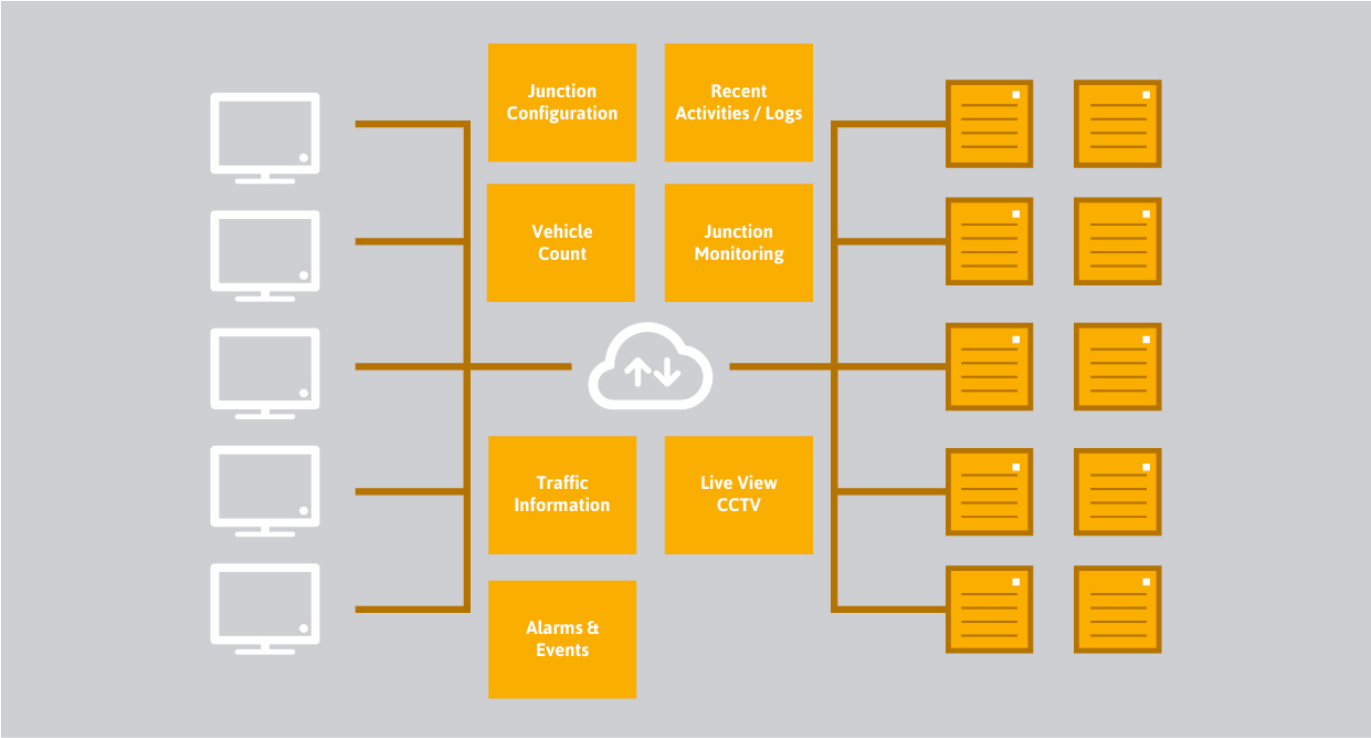


Figure 14. Remote Management Platform building blocks

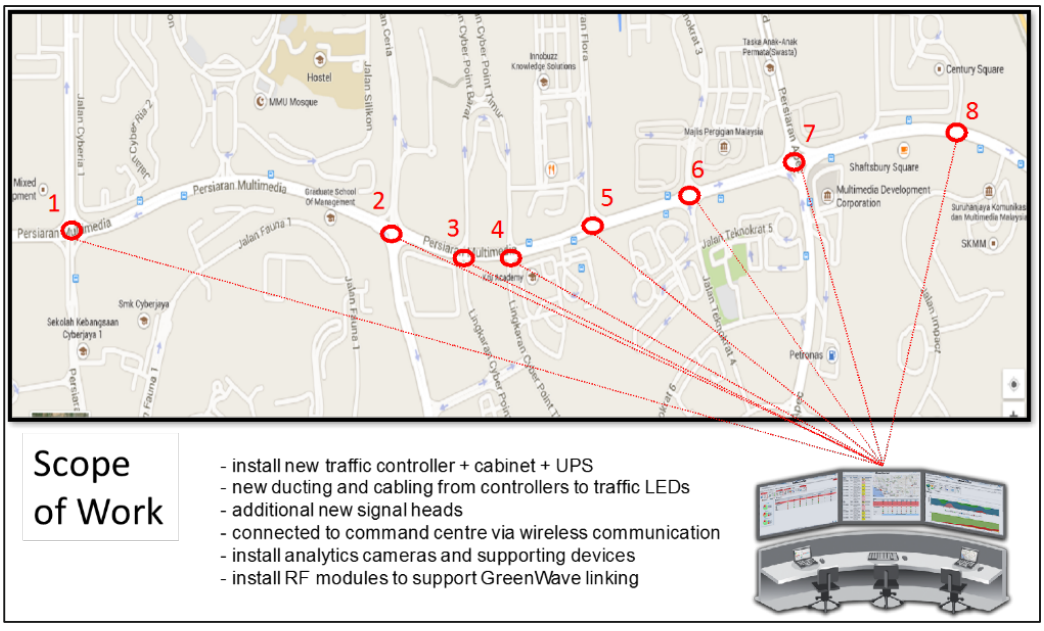


Figure 15. Scope of Work

7 Connected City architectures & framework

The first step is to identify several facts in applications of smart city concepts:

- Increase in new telecommunications services demand,
- Increase of migration between fixed and mobile applications,
- Increase of mobile applications costs
- Need of guidelines on QoS, data protection, resilience and security for new services.
- Most of the above facts generated silos solution for each services set.

The value chain and comprehensive platform supporting it, can be structured in 5 steps as shown in Figure 16.

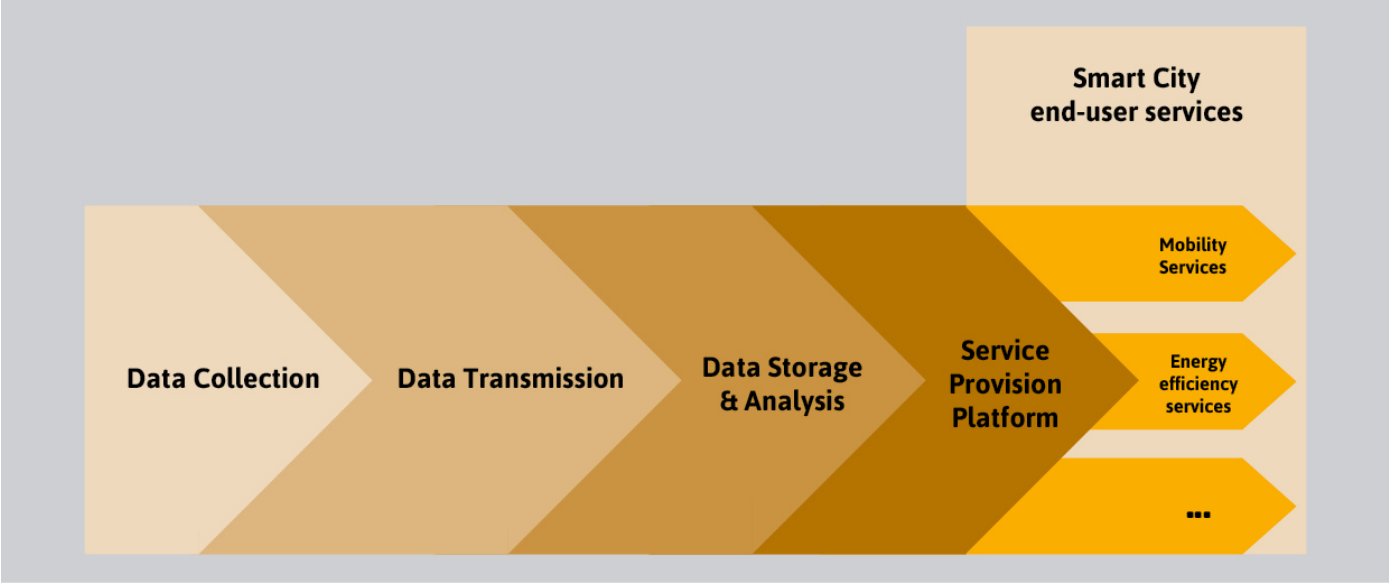


Figure 16. Value Chain and Supporting Comprehensive Platform

Where the data collection stage includes sensors, devices, social networks, physical infrastructure and other existing sources of information, actuators are considered as providers of its state data.

All data collectors send information using light protocols to gateways that route data through fixed and mobile networks to a data warehouse. This sector could work automatically (i.e. M2M)

Services interact with data warehouse in order to provide information to services and from services to data warehouse.

The main objectives of a comprehensive system for smart city management are:

a. Compiling information on the city complying with the pertinent privacy legislation.
b. Distributing information, processed or unprocessed of the different services.
c. Analyzing information according to the defined criteria.
d. Making decisions by returning the refined information to the systems carrying out the different tasks.
e. Making data and capacities available in open format to society.

It is essential for smart city services to be supported by platforms that ensure they are correctly functioning, in terms of efficiency, performance, security and scalability as well

7.1 Modelling City Services

Cities have deployed services in the past as silos due to an unintegrated city vision, where all services made its systems, networks and devices think only about its specific service requirements.

The future of Smart Cities goes to reuse resources in different services and think deployment in terms of a common conceptual management of resources (networks, databases, systems evolving from legacy to a new public management space model.

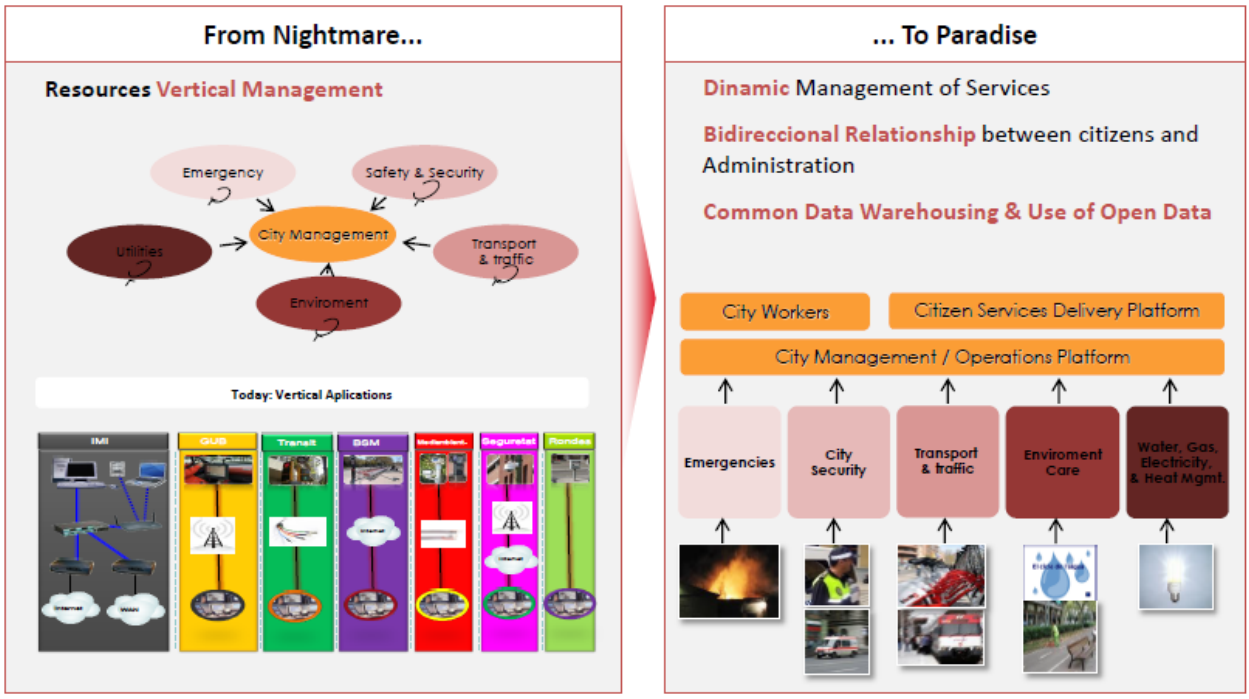


Figure 17. Smart Cities, From Nightmare to Paradise

Moreover, it will be a key issue to have a common definition of services where we can distinguish between services perceived by users (Final Services) and its parts as service (Basic Services).

All Basic Services could be modeled to a “Standard City Reference Unit” that permits city government to see most of the city’s services in terms of repeatability.

For example, in Barcelona they use “Macroblock/Superblock” (Supermanzana in Spanish). Macroblocks are defined theoretically as an "area of urban organization, from which a series of structured transformation strategies towards a new urban model, where mobility and reorganization of public space represent the first step”. They represent a population between 5,000 and 15,000 in an area without car traffic surrounded by high traffic streets. That permits a model/service in the Superblock area (i.e.: 2 sonometers/macroblock), and as a consequence, obtains a model for all the cities model as addition of macro blocks.

A clear definition of roles for ICT components in final services follows:

- City Council Technical Service Users (Police, Firefighter, Inspectors,..) define QoS:
  - Physical parameters will be measured,
  - Kind of sensors/actuators that will be used for a specific service,
  - Position for specific purpose

- How to install these devices in the streets
- The effectiveness of the user interface

- City Council ICT Department define ICT Related Basic Services:
  - The adaptation layer in IoT Network to adapt data offered and actions permitted to a Dynamic User Interface desired by Users.
  - Intelligence, privacy, addressing and security issues (DHCP, wpa2, AES, VPN IPSec,...) and its location.

From this point, ICT Department established in each RFP process key selections in order to normalize installation, access, transport network and data warehouse, example:

- Transport Network based in TCP/IP protocols over Telecom Operator products.
- Access Network which minimize latency and process working for each QoS defined. Ex.: WIFI, Bluetooth, ZigbeeIP SEP 2.0, 802.15.4e+ 6lowPAN,...
- All the batteries will be based on lithium or similar environment impact.
- All the elements will report a position and will be controllable remotely.
- Data warehouse access based on http+ REST in M2M & applications segments.

Periodically, ICT will evaluate if approved "local standards" could continue in the RFP processes. A team will evaluate the integration problems of new standards in terms of interoperability with existing elements (legacy) and new standards.

Consequently, this will lead to a normalized and flexible stack of standards that permits to integrate heterogeneous smart projects. Standardization is the key requirement for communicating, comparing and combining information from different devices.

Creation of a NORMALIZED Framework based in Standards at all levels allow an ordered massive construction of sensors in the streets and associate applications, based on:

1) Construction Model: Powering & Housing
2) Network Model for Access & Transport
3) Data Warehouse Model
4) Application Access Model

7.1.1 Target Architecture

Once the basic functions of a comprehensive smart city platform have been outlined, the next step is to develop a reference architecture:

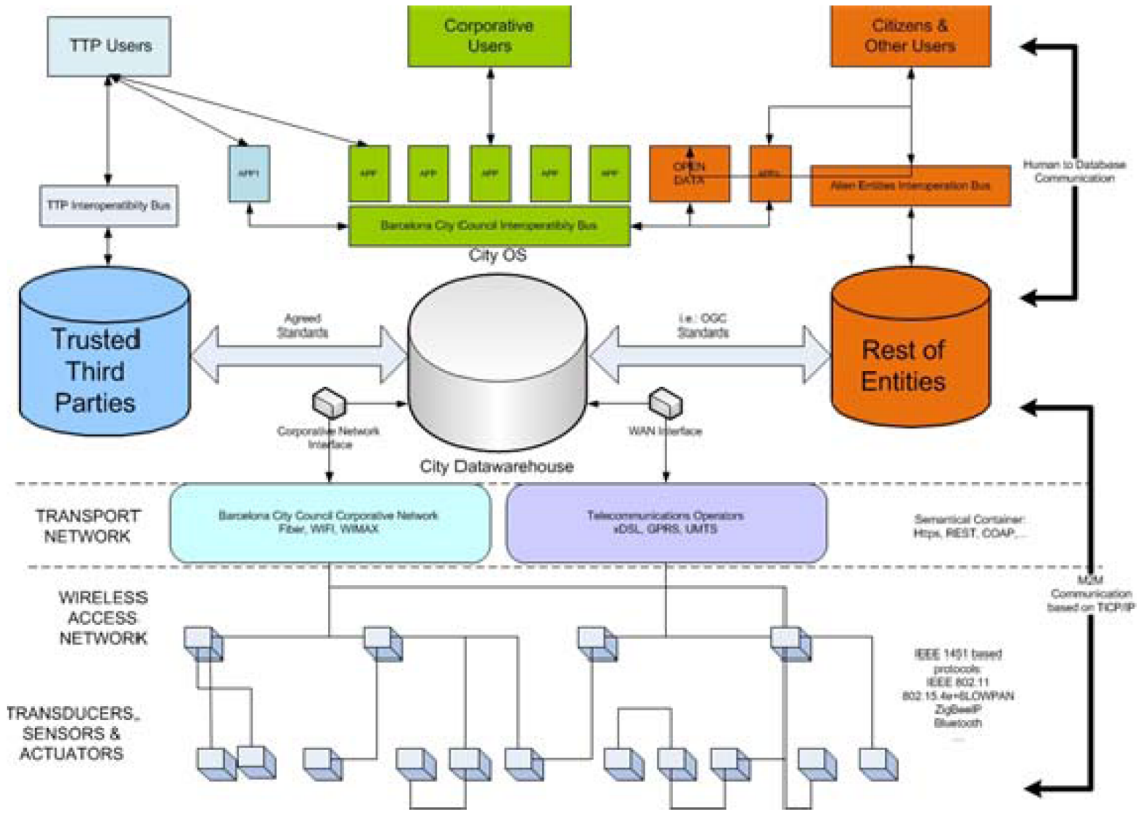


Figure 18. Reference Architecture

Taking human communication as the hypothesis is solved by operators and ICT architecture is not an issue for this section, we will evaluate different options in M2M area:

1) Field Network

Area composed by Transducers, Sensors and Actuators as tools of Defined Services.

2) Access Network

Link and devices involved in connection between Field Network Devices and Transport Network. This area will be wireless or wired from devices to gateways between Access Networks and Transport Networks.

3) Transport Network

Links and Devices involved in connection between gateways and city Data warehouse premises.

All these options could be private or owned by the city.

7.2 Overview over Standardization efforts

Example of City of Barcelona involvement on Industry Standardization efforts

Global standardizations bodies

Intragovernamental Bodies

International Electrotechnical Commission

International Telecommuncations Union

International Organization for Standardization

Other Relevant Groups

The Internet Engineering Task Force

Institute of Electrical and Electronics Engineers

US and European Organization for Standardization and Certification

American National Standards Institute

CPS Public Working Group

Spanish National Certification and Normalizations body

Spanish Association for Normalization and Certification

City of Barcelona

8 Interoperability and Roaming

8.1 The Wi-Fi Roaming Ecosystem

Outside homes, people are relying more than ever on their smartphones and tablets to stay in touch with colleagues, friends and families and access resources they need such as maps, restaurants and shopping establishments and much more. While mobile roaming services have become accessible, it's estimated that up to 70% of international travelers don't use traditional mobile services, instead relying on Wi-Fi networks to stay connected.

For Services Providers (SPs) in general, there's an opportunity to harness people's familiarity and acceptance of Wi-Fi to create new services and products, encouraging additional roaming usage and revenues. A managed Wi-Fi Roaming service can greatly improve the overall user experience with regard to:

- Simplifying the connection to a Wi-Fi hotspot
- Seamless roaming between Wi-Fi hotspots (nationally and internationally)
- Better technical performance of a Wi-Fi hotspot
- Secure authentication and connection to a Wi-Fi hotspot
- Privacy for the end user
- Access to a much larger Wi-Fi network across different geographies and venue types

There are three primary stakeholders in the Wi-Fi Roaming ecosystem. Due to the communal nature of Wi-Fi, a single company is often involved in providing more than one element of the ecosystem.

Visited Network Providers (VNPs) or Wi-Fi Network Owners – Perhaps the most complex group, a Wi-Fi network is made up of one or more Wi-Fi access points. The owner of a Wi-Fi network may be content to only allow private access to their network, and not share it with roaming subscribers.

Wi-Fi network owners come in all shapes and sizes; for example, single site locations like a venue, to multi-site locations like hotel chains or cities. There are service providers (such as BT, Boingo and Comcast) who have built Wi-Fi networks to complement fixed networks, and mobile providers (like AT&T) who've added Wi-Fi to augment mobile capacity. There are millions of one-off locations around the world offering free and open Wi-Fi, including Cities, Hotels, Coffee-shops, Airports, transportation hubs, among many other types of infrastructure. And there are aggregators like iPass that have built businesses around actively connecting and managing access to pools of Wi-Fi networks. These companies can bring millions of disparate access points into a roaming hub in a single connection.

These are the **Visited Network Providers (VNPs)** which provide access and Wi-Fi connectivity to subscribers.

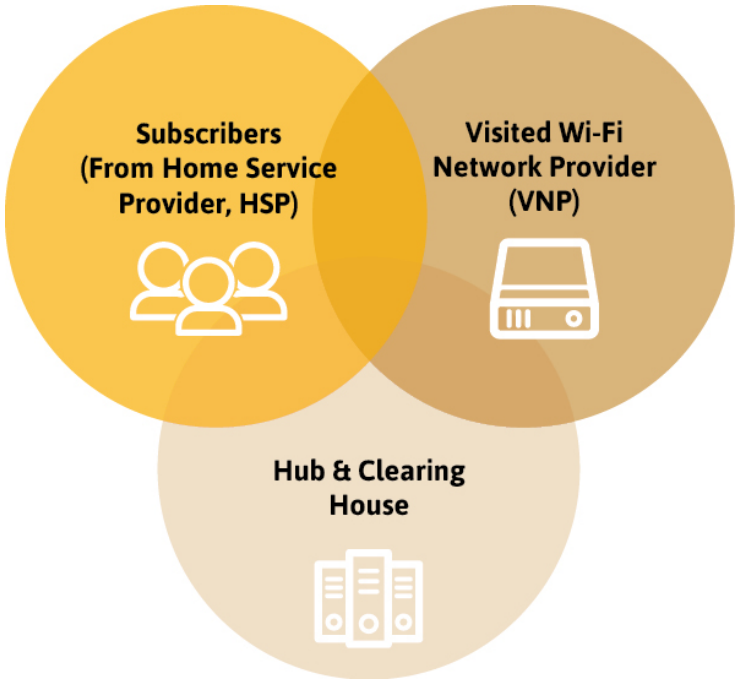


Figure 19. Typical WLAN roaming ecosystem

The Wi-Fi Hub provides a central connectivity point between the visited Wi-Fi networks and the home subscriber networks. Within the hub, there are two general functions –

- Inter-connectivity – maintaining information associated with each Wi-Fi access point in each Wi-Fi network, and managing the authentication/authorization process of an end-customer to that visited network back to their home network data base.
- Settlement and Clearing –accounting of usage between networks and reconciling that usage across the visited Wi-Fi networks to ensure that providers can get paid and users can get billed, if applicable.

To facilitate and standardize this process the WBA pioneered the Wi-Fi Roaming Intermediary Exchange (WRiX) specification.

Subscribers – these are the end customers who roam and ultimately use Wi-Fi managed by a Visited Network Provider (VNP). To facilitate access, the subscribers may have a downloadable app or have functionality embedded in their device, which helps them to find appropriate Wi-Fi access points and can manage the connection process. The subscribers may have an existing billing relationship from their Home Service Provider (HSP), and likely be assigned a service plan that includes roaming capabilities.

For the purposes of Wi-Fi roaming, the vast majority of subscribers are mobile-centric, with a smartphone (because it has Wi-Fi) and a SIM. Mobile Network Operators who choose to connect with a Wi-Fi roaming hub provider who can enable the appropriate subscribers to access Wi-Fi as defined in their service plan.

8.2 Wi-Fi Roaming Architectures

To provide Wi-Fi roaming services, the VNP and HSP must have interoperability mechanisms in place. Figure 20 illustrates the most common Wi-Fi-to-Wi-Fi roaming architecture based on the WRIX architecture as defined in WBA documentation.

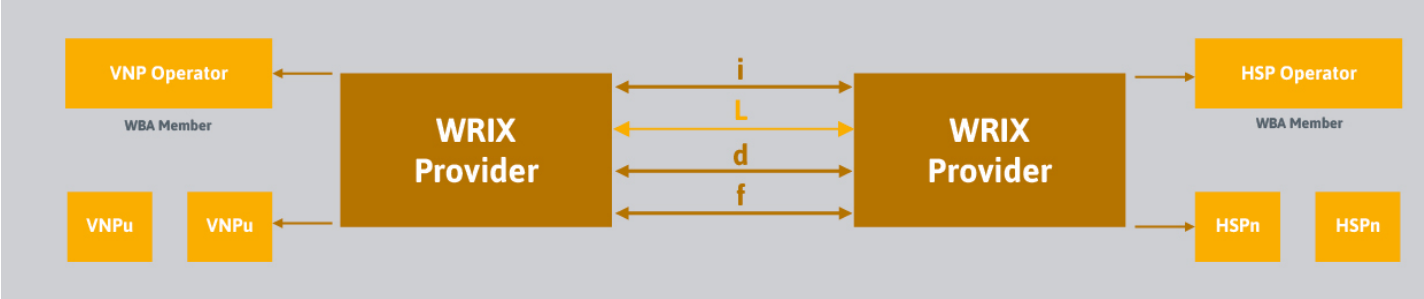


Figure 20. Typical WLAN roaming architecture

The visited network provides the connectivity to the client devices, but redirects the initial authentication of the roaming client devices to the home network AAA servers, typically via RADIUS (Remote Authentication Dial in User Service) proxy or from the Access Controller. Connection between the networks must be secured using private circuits, MPLS or Virtual Private Network (VPN) tunnels.

The authentication can be done between the home and visitor networks while the accounting and reconciliation of usage for billing purposes may be outsourced to a third party. RADIUS accounting is not lossless, so accounting records between the home and visited network providers might differ from each other. If sufficient resources cannot be allocated to compare the records and manage the discrepancies, the accounting should be outsourced to a third party.

Figure 21 does not show a policy controller, which is mandatory in some countries and for operators of a certain size. It is used to set the access policies to roaming customers and can provide feedback from both the visited and home network operators as well as the venue where the users are located.

Service Providers may have different approaches when developing a roaming strategy. There are two main scenarios available to interconnect their networks, either through a direct connection or by using a third party to facilitate that interconnection. For the latter there could be several hybrid models from both operators using the same hub or just one operator using a hub provider (see figures 22 and 23).

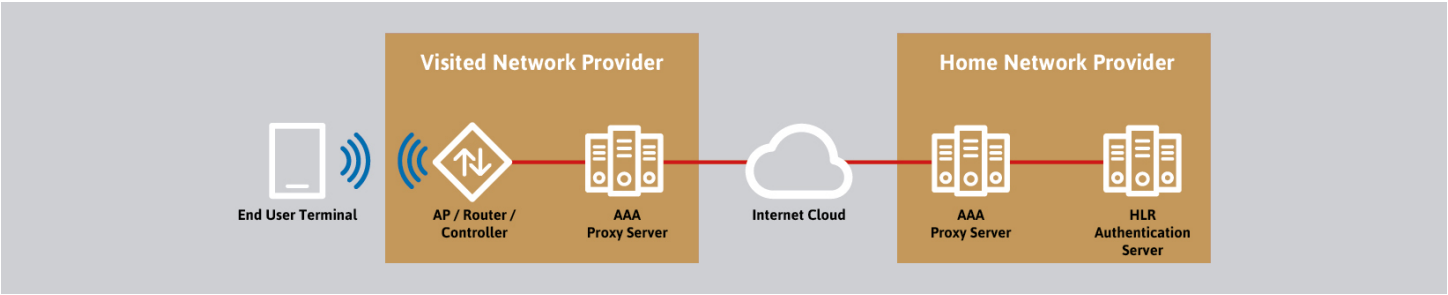


Figure 21. WLAN roaming with direct, bilateral interconnection

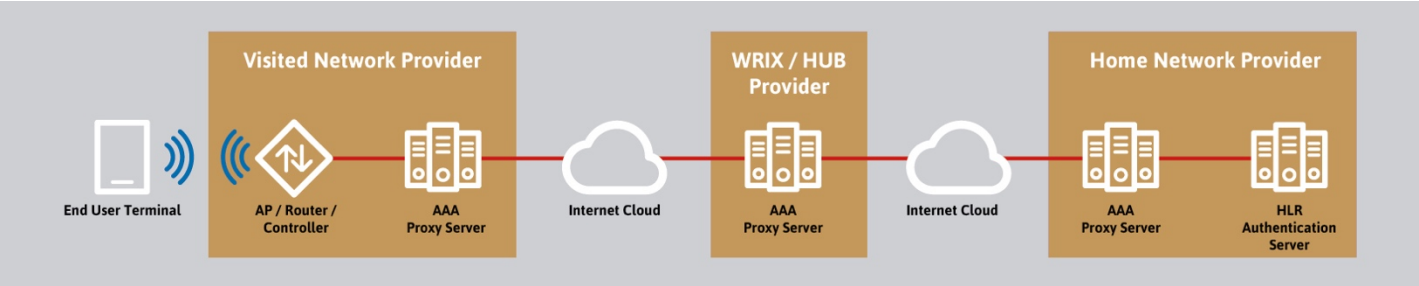


Figure 22. WLAN roaming bilateral interconnection using a third party provider

In a Wi-Fi roaming environment, there is likely to be a large number of relatively small visited Wi-Fi Network Providers. A hotel chain, an airport, a convention center, and perhaps other venues, may all be a part of a subscriber's Wi-Fi roaming experience. Thus, for the home network service provider to deliver a compelling experience, the broader and denser the visited Wi-Fi network, the more value for the end user.

As such, the role of a Wi-Fi Roaming Hub is quite important in enabling service providers to build and consolidate Wi-Fi footprint quickly, and delivering a compelling experience to their end users. The Wi-Fi Roaming Hub providers the following benefits:

- Consolidate Wi-Fi access across multiple networks/providers into a single 'Visited Network'
- Manage connectivity, accounting and access with and between a wide variety of Wi-Fi access networks
- Reconcile accounting and usage records between wide variety of networks and providers

To enhance the attractiveness of roaming service, a hub may propose and offer additional services to the HSP (and their end users), that are absent in the earlier arrangements, after reaching to an agreement with the HSP and VNP. It may be supplemented services unique to the host, unique not only in the literal sense, but, for example, associated with the peculiarities of the local legislation and so forth. In addition, it may be due to the technical features of the VNP network.

For more information, please refer to the WBA Roaming Technical Guidelines Whitepaper available at:

http://wballiance.com/2012/WBA-WiFi-Roaming-Guidelines-Dec2012.pdf

8.3 Multi-Network Governance

Ubiquitous connectivity through mobile devices is reshaping the social life, economic activity and governance of cities. A new surge of government investment in public Wi-Fi infrastructure is occurring within a telecommunications environment underpinned by market liberal principles. Raise the issue of what role and function of cities and local governments in providing Wi-Fi infrastructure and to manage third party networks available for Wi-Fi Roaming in the city territory.

Cities may explore the development of wide grids of coverage by combining different networks through roaming services, given to citizens as a single credential that can be used in a variety of networks.

These grids can be managed directly by the city's authorities or by a third party, either one of the network provides of roaming and interoperability hubs.

Other ways of organization can be explored to create specific consortium´s or federations of networks to pursuit a common interest and facilitate the delivery of connectivity to the citizens. These approaches will help to simplify the negotiation and implementation of Wi-Fi Roaming services with entities outside the city's territory, either other cities or operators.

In NYC there are many incumbent Wi-Fi providers; the Harlem Wi-Fi network, the Alliance for Downtown New York and the Downtown Brooklyn and other business improvement districts, Transit Wireless underground subway locations, as well as the thousands of kiosks being installed on the streets. All are independent, free, public Wi-Fi networks. New York is looking at a way to make a ubiquitous footprint, to federate this group and to have them work under a policy where they would have seamless roaming in their city.

New York has more than hotspots; it has large corridors of coverage areas. What the city is doing is becoming a network operator, and beginning to take a look at where each one of these access points are. Their current standard of operation, 802.11n, 802.11ac, and then taking a look at the physical characteristics in terms of their longitude, latitude and the heights of where these access points are. They're building a real world service area and they're federating their incumbents. At the end of the day, they're creating what they call a 'Wi-Fi heartbeat.'

8.4 Network Performance

In a Wi-Fi roaming environment, there are likely to be a large number of relatively small Wi-Fi Network Providers. An airport, a convention center, outdoor deployment and perhaps other venues, may all be a part of a user Wi-Fi roaming experience. Thus, for the network service provider to deliver a compelling experience Service Level Agreements may be agreed and defined to establish roaming. The implementation of Performance Indicators will facilitate the harmonization of the experience for the end user and align the network performance to maintain an end-to-end quality of the WLAN roaming service between networks.

Quality of Experience must be managed by the network provider to achieve service experience levels expected by the user. This includes: network reliability that provides expected throughput targets; supported mobility across access points (AP) within the Wi-Fi network to ensure a seamless user experience and support of multi advanced service differentiation (such as the ability to support premium video) and mobile multi-media across APs. Underlying these technical attributes is the need for radio conformance to radio protocols and air interface interoperability of devices and APs.

To provide a consistent user experience and managed quality of service (QoS), the Wi-Fi network needs to be manageable by a provider using existing standards and techniques adopted by the industry. Network providers need to manage policies and to support QoS with measureable results, including in highly dense interference environments. Network faults need to be automatically detected and reported to the operator's management system.

Effective and dynamic radio resource management is essential to realize network quality. Radio resource management on a massive scale (hundreds of thousands to millions of APs) requires conformance to radio protocol standards across vendor products. Dynamic load sharing across multi-band operations is needed as well as the use of interference mitigation techniques in dense deployments. Network providers need to manage their networks to optimize coverage, throughput and other Key Performance Indicators (KPIs).

Interoperability of management systems for the Wi-Fi network is essential in order to provide End-to-End management of the Wi-Fi network and to provide command and control capabilities from a Network Management Centre, for successful network operations to meet the network's management metrics.

Network manageability starts with standards-based provisioning of devices, APs and infrastructure. This includes auto-configuration and remote configuration methods. Network manageability includes automated troubleshooting and network optimization to help ensure reliable network performance to measureable KPIs. Load Management with optimal resource allocation are essential capabilities. Load and traffic conditions need to be reported to the Network Management Centre in a timely basis. Management capabilities to support regulatory compliance can be considered as well.

The network quality of Wi-Fi is assured with radio physical layer and protocol interface conformance to standards, effective operator radio resource management, and high levels of interoperability with certified devices, and support of KPIs.

Wi-Fi network providers should have the means to manage radio resources, including the ability to, but not limited to, manage the following list of parameters:

- Transmit power
- MCS rates
- MIMO and MU-MIMO configurations
- Beam forming configurations
- Channel bandwidth
- Maximum throughput per device
- Carrier sense thresholds
- Multi Band configuration and steering of devices, which can include dynamic traffic load sharing across bands
- Subscriber and service-driven dynamic load balancing among APs, bands and channels
- Channel assignments
- Interference avoidance and mitigation for higher density deployments
- Wi-Fi network providers should also have the support and ability to collect and monitor the KPIs listed below:
    - Received signal strength from devices
    - Noise and interference levels
    - Packet error rates and packet loss rates
    - Throughput of uplink and downlink per device
    - Device location
    - Load threshold indicators
    - Channel utilization
    - Band utilization
    - Rogue AP detection
    - Neighbor AP detection
    - Delays, latencies and jitter for traffic uplink and downlink

8.5 WRIX Standard

WRIX (Wireless Roaming Intermediary Exchange) is a set of service specifications published by the Wireless Broadband Alliance to provide a framework for Wi-Fi interconnection, data clearing, financial clearing and the exchange of Wi-Fi location information between Service Providers. The purpose of the service specification is to standardize both technical and business processes between Wi-Fi Roaming Partners.

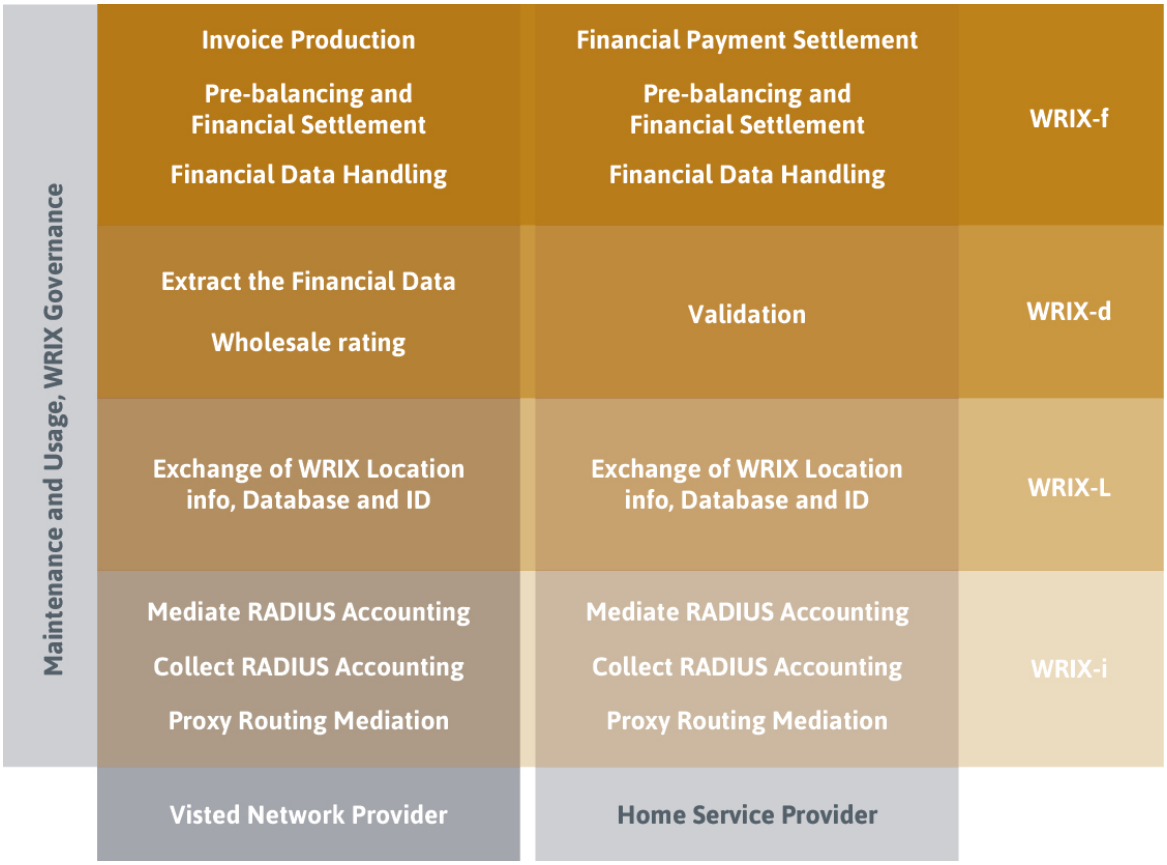


Figure 23. WRIX framework

The WRIX (Wireless Roaming Intermediary Exchange) is comprised of the four specifications listed below. The recommendation is for Service Providers to utilize all four of the specifications. However, it is acceptable for different partners to utilize the specifications only as guidelines, or part of it, when creating and maintaining Wi-Fi Roaming partnerships.

Specifications:

- WRIX-I : RADIUS Interconnection Specifications
- WRIX-D: Data Clearing Specifications
- WRIX-F: Financial Settlement Specifications
- WRIX-L: Locations Feed Formation and File Exchange Specifications

The full suite of the WRIX Specification documents is available here:

http://wballiance.com/uploads/2012/Wi-Fi-Roaming-Standard-WBA-WRIX.zip

8.5.1 WRIX-I

The WRIX-I specifies the interconnectivity, authentication and accounting processes between Wi-Fi Roaming Partners. Interconnectivity is established and maintained through either Private Leased Circuits (IPLCs) or IPSec VPNs. When selecting an interconnectivity method the performance and security considerations must be weighed versus cost. WRIX-I explicitly specifies the use of RADIUS authentication, authorization and accounting (AAA) as the transport of requests between the VNP and the HSP. This enables the support of a vast range of authentication methods including WiSPr, EAP-SIM, EAP-AKA, EAP-TLS, and EAP-TTLS. However, the VNP and the HSP must agree bilaterally to which method will be used.

There are three potential parties identified in the WRIX-I Specification:

- HSP: Home Service Provider
  - Maintain connectivity linkage
  - On-line proxy routing for RADIUS messages, sent to the correspondent WRIX-i (HSP)
  - Collect raw RADIUS accounting records generated by the proxy routing
  - Mediate raw RADIUS accounting records for wholesale billing
  - Send those records to the WRIX-d (HSP).
- VNP: Visited Network Provider
  - Maintain connectivity linkage
  - Proxy routing mediation for RADIUS messages.
  - Receive raw RADIUS accounting records generated by the proxy routing
  - Optionally mediate raw RADIUS accounting records for reconciliation of wholesale billing and send those records to the WRIX-d (HSP)
- HUB: An optional intermediary between the HSP and VNP
  - Perform duties on behalf of either the HSP or VNP

WRIX-i supports the implementation of Key Performance Indicators (e.g. RADIUS Server Uptime / Availability or IP Connectivity) to provide guidance in negotiating a Service Level Agreements (SLAs) and maintaining across the services the quality of the WLAN roaming between networks. Supports as well the implementation of Incident Severity Definitions.

Please refer to the WRIX-I Specification Document for further information.

8.5.2 WRIX-D

The WRIX-D is the data clearing specification of the Wireless Broadband Alliance. Within the specification are clearly defined roles and responsibilities between Wi-Fi Roaming Partners and the timeline of activities. WRIX-D utilizes the records generated from the WRIX-I platform to perform service validation that protects both Wi-Fi Roaming Partners and prevent any potential disputes during financial settlement.

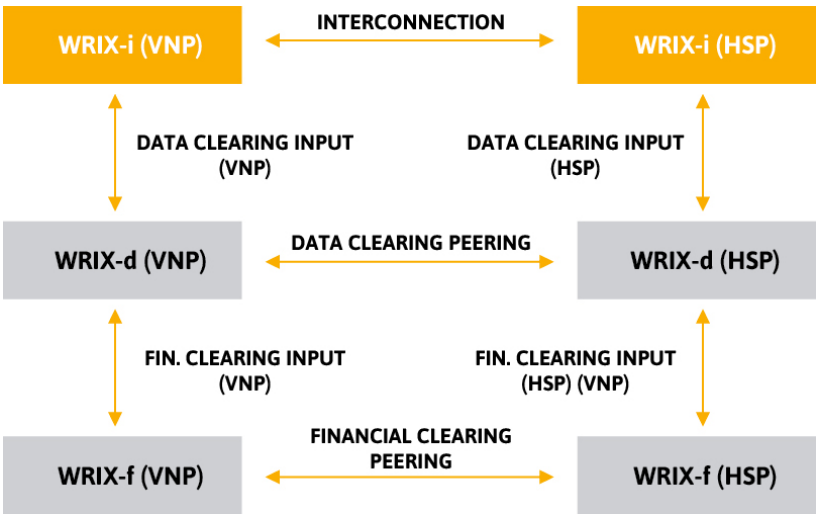


Figure 24. WRIX typical flow

The process begins by the VNP processing UDRs (usage details records) generated from the WRIX-I RADIUS AAA system to validate, perform exception processing (if necessary) and rate the records. After processing the rates, UDRs are transmitted to the HSP. The HSP receives and processes the rated UDRs. Upon successful UDR processing the HSP transmits a summary financial data (INPUT SFD) to the VNP as an acknowledgement to record acceptance. The VNP uses the SFD to generate an invoice for the HSP. A HUB provider may perform duties on behalf of either the VNP or the HSP.

Please refer to the WRIX-D Specification Document for further information.

8.5.3 WRIX-F

WRIX-F is the Financial Settlement specification of the Wireless Broadband Alliance. By proceeding after the WRIX-D processing, where records are either validated and rated or follow an exception processing method, the WRIX-F ensures that a smooth billing, payment and receivables process occurs every time. The WRIX-F specification includes detailed reports and a set timeline, which is displayed in this section.

WRIX-F begins by the VPN sending a Summary Financial Document (SFD) to the HSP. The SFD summarizes the traffic usage that occurred on the VPN's Wi-Fi Network by end-users of the HSP. The SFD is used by the HSP to assist with creating a net settlement position between the two Wi-Fi Roaming Partners. Alternatively, a HUB can be used to either deliver all of the SFDs to each of the HSPs on behalf of the VNP or to receive all of the SFDs from the VNPs on behalf of the HSP.

Once the SFDs are processed the Net Payment Reports (NPRs) are created and shared by both parties. The NPR summarizes the payables and receivables between the Wi-Fi Roaming Partners. Key data elements include settlement type, Net Payment, Net Payee, Net Receiver and currency. A HUB provider can act on behalf of an HSP, VNP or both.

Upon acceptance of the NPR between the Wi-Fi Roaming Partners the Wi-Fi Operator that is in the Net Payee position will invoice the Net Payer (debtor) based on the NPR values. In case mismatches are identified in the invoice the Net Payer can raise a dispute. In case of mismatch the disputes rules and limit levels of how to handle the payments are specified in the bilateral agreement. Note: The settlement cannot be carried out in case the invoice is not received. A HUB may act on behalf of either or both parties.

Once an invoice is created the debtor pays the Net Amount according to the method as agreed upon in the bilateral agreement.

Please refer to the WRIX-F Specification Document for further information

8.5.4 WRIX-L

WRIX-L is the Locations Feed Formation and File Exchange Specifications of the Wireless Broadband Alliance for the sharing of Wi-Fi Hotspot Location information. The use of accurate and up-to-date information is crucial to ensure a high quality experience for end-users and to maximize the revenue opportunity associated with network usage. Poor quality or outdated location information will result in unsatisfied, frustrated end-customers of the HSP and missed revenue opportunities of the VNP.

The WRIX-L specifies mandatory and operational data. Mandatory data includes critical data elements such as provider information, location information and SSID. This information is provided by the VNP so that the HSP is able to configure the end-user clients to display Hotspot location information and to configure the device to connect to the VNP Hotspot once the end-user is within range.

Often a HUB provider will receive WRIX-L data from all VNPs of a HSP and aggregate the data into one file. This offloads burden from the HSP from receiving data from many sources and provides a single location for all Hotspot information.

There are three potential parties identified in the WRIX-L Specification:

HSP: Home Service Provider

- Provides a location file
- Distributes to roaming partners

HSP: Home Service Provider

- Receives location file
- Uses the location file in connection client software distributed to subscribers

HUB: An optional intermediary between the HSP and VNP

- Act on behalf of either the HSP, VNP or both.
- Provides a centralized repository to receive or distribute WRIX-L information

Please refer to the WRIX-L Specification Document for further information.

9 Public-Private Partnerships Business models

A general concern for cities is the limited budgets that they often have. When they're thinking about infrastructure projects, whether it's about roads or energy or telecommunications, there can be difficulties in getting the funding to develop a transformational approach. It is an area where if there are public-private partnerships, they can make sense from a financial perspective. It can help relieve some of the burden on cities in adding this infrastructure.

To be successful in developing Public-Private Partnerships, there must be a long-term viable business model. Risk-sharing is a relevant key component for both entities, both the city and the private sector.

The private sector, especially technology companies, are used to taking on some level of risk, because any kind of new innovation, until it's been proven at scale, is going to have some inherent risk.. That's something that could be a little

more difficult on the government's side, because a city's perceived risk of failure seems higher to a lot of people within the government. It's the difference between a venture capital type approach where you're trying a lot of things and hoping that the ones that succeed, succeed so well that it makes up for any failures. I think from a government perspective, failures tend to be a little more painful and can be a challenge to find the right balance.

PPP are highways of innovation for cities; the more the public and private sector can partner on these types of challenges, the greater chances for truly innovative solutions to be the result. Whether that's a model that just involves start-ups getting exposed more closely to the key priority areas for the city government.

Those are some of the hurdles of adoption that has been evident for the past several years, and in the United States there is some positive movement with the federal government getting involved and helping to drive smart city initiatives with some special funding. Then the private companies that are stepping up to basically make it more palatable for cities to procure solutions and as technology advances and costs goes down, I think that will help drive adoption as well.

There is more and more discussion around public private partnerships in countries like the US and there are many of them that are loosely formed. They might not be formalized, but you will see, for example, in the city of Atlanta, you'll see that AT&T is working very closely with the city of Atlanta, with Georgia Tech as a research university, with Georgia Power and Southern Company that's a large utility and other businesses in the area, in order to drive value for the citizens of the region. It may not be a formed, public private partnership, but that in essence is what a public private partnership is, bringing those parties together and then of course, engaging the citizens.

Another example is a public private partnership in Dallas. The Dallas Innovation Alliance, or the DIA, has managed to pull together city leadership, the CIO and mayoral level, some large companies, (such as AT&T) as a foundational member and then smaller start-ups in the ecosystem. On regional level, there are real estate developers, the chamber of commerce and the business improvement district.

This PPP enables the creation of an environment of learning faster than the city itself could, primarily because it does not need to adhere to the same procurement policies. At the end of the day, what you are going to see is that some services will be procured directly from the city in a traditional manner and will need to be paid for through taxpayer dollars, or you will see public private partnerships potentially raise some money that could be used to drive issues around health, human services and socioeconomic opportunities.

Another good example is the franchise agreement between a consortium of companies in New York City. NYC is unable to have a long-term roll-out of fiber across the city to enable a network of gigabit Wi-Fi hotspots (between 7500 and 10000 over the next ten years) at no cost to the city or the taxpayers. The unique thing here is that the city saw this opportunity of unused, underutilized assets, and also had a contract vehicle in terms of the franchise agreement, in order to find a private sector partner to implement this.

Certainly, collaboration is not always easy. In the case of New York, what helped is that there was an ongoing dialogue between the public and private sectors that went back several years, to even before the first RFP was written, and there were other ways of engaging with the private sector. There was a design competition called Reinvent the Payphone several years ago where there was a call for creative ideas from a design perspective from the private sector. This helped to inform the city on what the potential could be for that particular telecommunications asset.

With the City of New York, there was another development called Urban Tech NYC, which was a set of programs that help connect start-ups to some of the key challenges the different city agencies identified, and then support the companies through incubator programs, mentorships, and/or pilot opportunities. This leads to a smaller gap between people that are working in the start-up world and the people who are within the city looking for solutions, while accelerating innovation and development of Public-Private Partnerships between the City of NY and start-up companies.

10 Big Data: Challenges, opportunities and benefits for Cities

Cities are looking to the Big Data opportunity to enable public agencies to better anticipate citizens' needs, improve delivery of services, and reduce inefficiencies.

Increasingly, we have seen cities embarking on national-level data initiatives. The objective is to make both public and private data sets available to companies to build new and innovative solutions to create a smarter city. Big data is one of those opportunities that is as much cultural as it is technical. What we see is the promise of big data is that we can get insights and make better decisions as an organization and as a community. What that involves though is, at maturity level 1, where we've been, is we just to publish a lot of information for transparency. It's not curated well, but there's basic information that people have access to. One step further that we see is that there's some regional collaboration and that we can push out information in a curated way that's consistent, so that we can make some decisions and insights, not just about ourselves and all we see as ourselves, but as peers, as other service providers, as well as the information that we're getting from the communities we serve. That broader and richer data set is what we see the next value point being.

From there, the third level and second and third can be interchanged. Cities have to develop that approach and culture in their organization to be a data driven organization. That means teaching cities how to be a good data scientist? Because it's not farfetched to say that someone misreads something, and makes large decisions incorrectly, and it has a major negative repercussion for a long time in a local government, and the state government. You have to make sure that we're doing the right things and we can sustain that work, and that there's enough quality in that work. It's not just that there being lots of data out there, but that we are also interpreting it well and using it well and validating that use.

The major challenges and the benefits that cities have on Big Data is that, when it works, it's beautiful. With predictive policing, for example, you can make sure that you read situations and your police department is there to intercept and stop potentially major crimes.

When looking at how much data is in a utility system, a number of questions can arise. Are we managing the flow? Are we using electricity correctly? Are we limiting the amount of water we're wasting? Is the product and the testing being there so we have high quality water and we're doing that regulatory reporting? All of this is essential to what Cities do. Cities are having so many data inputs that the fourth level of maturity allows for a clear understanding of the entire organization and community.

That raised the issue for the cities as well, in terms of if they not only need to align within the city agencies, but even beyond the city, almost at a county level or a state level interaction with other cities. It's a topic that someone raised already, on that importance of having a wider partnership and alignment, even beyond the city.

Level 4	Have a clear understanding of your entire organization and your entire community, and ensure that you're looking at the right data so that you make your way out of swimming in information to really getting high value information that your organization knows how to read and knows how to interpret and orient their decisions around.
Level 3	Develop ourselves to be a good data scientists. It's not about being able to deliver lots of data anymore but that cities are able interpreted it well and using it well and validating their own use. Focus on making sure that the city is doing the right things and can sustain the work, and that there's enough quality in that work
Level 2	Focus on wider collaboration to deliver information in a curated and consistent way. Used data to make some decisions and insights, not just about ourselves and all we see as ourselves, but as peers, as other service providers, as well as the information that we're getting from the communities we serve
Level 1	Provide basic information that people have access to, the main focus which is publishing information for transparency

Table 10-1: Level of Cities Maturity to use Big Data

Cities have different approaches in terms of the big data, such as a NIST or ANSI approach, saying, "Here's a methodology and structure and approach to how to manage big data and handle security, but also make yourself consistent enough that there can be a sharing of data." There can be consortiums, like the CCAB, where we say, "Here's an approach and a blueprint for how we're going to do this, and does it gain steam?"

Part of the reality is also creating that culture and organizational capacity. There's an educational piece of this that we can't neglect, which is how we encourage our academia, our certification programs, to create the educational material that's going to allow people to do smart cities, connected communities and big data. A lot of these terms are types of amorphous brands; they don't mean much, or they mean something different to a lot of people. What are the skills that are there, and how can we create those development channels to create those skills, programs, that help us hire and recruit the people who are going to help us make the next leap? There is a big divide that exists right now, and there's a lot of people trying to figure this out separately instead of together.

The issue of data management raises several questions of ownership and access. Those are real concerns, same as that of a connected smart city. Where do Cities put security? Where do Cities put redaction? Everything from video data capturing children, or health events, if cities have them on their officers and firefighters, to surveillance and security cameras cities have to manage properly all these data. That often has social security information or other identifying information that cities use to coordinate services with partners, security and privacy must be implemented properly.

If cities can find a good way to master data management, there is potential for a strong influx of benefits. Cities will be able to coordinate better, resource usage can be improved, and municipal services can be as high-quality as possible.

The way cities manage this is as much of a question of developing that culture inside your organization as it is working outside your organization. The question is, how can data sources be properly coordinated and curated? We can coordinate our access to it, but also create an ecosystem where the academia and businesses can tap that data in a safe way and gain insights that we don't necessarily have on our own.

These strategies must work through all departments – from the planning department, to the public works department, to IT, economic development groups, regulatory groups, etc. The strategies for cities both smart cities and big data, are going to have to work from the planning department to the public works department and engineers, to the IT department, to the economic development groups, to the regulatory groups and planning, building, and permitting. With the big data piece, it can also extend into that regional, national, global world, to create those data links, make sure they're high quality, and to create that ecosystem that's going to help everyone do better.

Cities in general are interested in big data opportunities, especially from that high level perspective, but depending on the city or who we're talking about in the city, the approach can be different.

In summary, the benefits and challenges for cities form the Big Data approach are the following:

BENEFITS	CHALLENGES
• Extraordinary transformation will be made possible by data, the "new oil" of the 21st century. Data analytics uses large datasets to reveal hidden patterns, important insights that can be used for decision making. Technology advances in areas like machine learning, text mining and greater emphasis in predictive modelling and statistical forecasting can help organizations make sense from the data gathered, and see trends based on history, together with real-time data, to intelligently support decision making • Being a connected city coupled with powerful computational technologies, data analytics can be a competitive tool that enables businesses to draw sharper insights into their customers and operations. It can make our businesses smarter, more productive, thereby powering our future economic growth as the global digital economy grows and businesses need to better understand their customers to stay relevant amidst fiercer business competition and savvier consumers. Analytics and data management will, therefore, be the cornerstone enablers behind industry transformation. • Data-driven innovation can bring about significant benefits, for example, in enhancing resource efficiency and productivity and economic competitiveness. A report by the Organization for Economic Co-operation and Development (OECD) indicated that firms using data-driven innovation had raised productivity faster than non-users by around 5-10%.	• Big data requires new, innovative and scalable technology to collect, host and the vast amount of data to derive real-time useful insights for urban planning. Cities must understand what insights they need to make good strategic and operational decisions. • To extract value from big data, it must be processed and analyzed in a timely manner, and the results need to be available in a way that can effect positive change or influence decisions. The effectiveness also relies on a city having the right combination of people, process and technology. • Challenges also lie in unlocking data from private organizations. Private organizations may resist participating in such data initiatives due to competitive or privacy reasons. The release of data sets outside of their organizations could expose individuals and businesses to risks, such as reputational risks, loss of control over confidential information and privacy risks.

Table 10-2: Benefits and Challenges for cities form the Big Data Approach

The way New York has approached it has been successful, and creating a Mayor's Office of Data Analytics, has led to creative thinking and the ability to draw from several different agencies for any problems that arise. Valuable insights have also been gained through the processing of huge volumes of data that the infrastructure has made possible.

Nevertheless, cities must worry about privacy issues, even for data that seems like it is anonymous. In New York, there have been a couple of examples of things like open data around taxi trips, where even though the individual records were not online, people were able to cross-reference those with other public data sets to find out things that might be considered more private information; for example, being able to look at a particular taxi and figure out what the earnings of that driver are based on the trips that they take and the starting and ending points. New York has seen success by working with organizations that have a strong social mission or particular set of issues that they focus on, such as homelessness or public housing. By working with them to specify the challenges and problems, the city has gained a stronger understanding than it otherwise would have through other means.

Another important example is Singapore, which created the Personal Data Protection Commission (PDPC) in 2013 to administer and enforce the Personal Data Protection Act (PDPA), with a mission to promote and enforce personal data protection. This was done to foster an environment of trust among businesses and consumers, contributing to a vibrant Singapore economy.

The PDPA generally follows a consent-based approach, and there are principles therein which support the concept of Big Data and the development of a Smart Nation. For one, the PDPA is non-prescriptive and centered largely on the notion of "reasonableness". Since the concept of "reasonableness" is not rigidly defined in the PDPA, it allows organizations a certain extent of flexibility in the use of personal data under their control.

PDPC is currently supporting national reviews of key data governance issues, and providing advice on personal data protection issues such as the types of personal data that should be handled, as well as how such data can be classified, and anonymized. With data protection issues being considered from the infrastructure level up, and ultimately ensuring that the Smart Nation initiatives are trusted by all stakeholders.

11 Conclusions and Next Steps

Leveraging on the valuable contributions provided from the different stakeholders to this report, the following conclusion and key takeaways could be derived:

Smart City Definition - Opportunities and Challenges:

- Having a common understanding of the definition of Smart City and Connected City should be the starting point for a wider discussion on the challenges and opportunities cities are having – "Smart city involves an ecosystem platform of multi-stakeholders and utilizes integrated information and communication technology systems, ICT, and data analytics, to transform its culture, its structure, its operations, and economic development, and citizens' engagement, to manage complexity and dynamically improve and enhance quality of life";
- Identifying the different players and their roles within the Smart City value chain is essential for a proper and valuable collaboration. Citizens, City Authorities, Private Sector, Innovators/Entrepreneurs and Academia all have a relevant role to play in the development of a smarter city;
- Understanding the challenges and opportunities that arise from the Smart City will be a fast track to accelerate the development of the building blocks for a Smart City;
- Smart Cities are more than just the implementation of various technologies. "Smart" does not only refer to technology or sensors. Smart is a concept and new kind of culture for how cities and its agencies can work more effectively both internally, with partner agencies and organizations and, of course, with their citizens. Smart is a way of transforming from the way things have always been done. Smart Cities are not a destination to arrive at, but a new process for managing how cities and agencies work;

Technology Benefits:

- Essential for cities to know and visualize the benefits from the different technologies available today and in the near future to pursue a more effective connected city and efficient collaboration with the other stakeholders;
- Unlicensed, Licensed, Broadband, Wireless, Internet of Things (IoT), Industry Collaboration Forums, among others, are all key technological elements that cities need to embrace to foster their connectivity plans and maximize their resources;

Services Deliver:

- Understanding the implementation models of various use cases (verticals), in areas of big data, network interoperability, public-private partnerships and others are critical factors for the success of the cities service delivery;
- Identifying best practices, gaps, share learnings, research, developing trials and tests, are all key elements for cities to develop in a more effective and efficient way their connectivity plans and the vision of a Smarter City;

As next steps the CCAB and the WBA intend to continue the development of this Connected City Blueprint, both in terms of additional content as well making it available to the industry in different channels, including an online eBook version. This is an Industry collaborative effort and the CCAB would like to invite the different stakeholders to get involved in this initiative. The Connected City Blueprint can be considered a living document and through 2017 the CCAB will be releasing updated versions.

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DRIVING NEXT WIRELESS EXPERIENCE

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