IoT-Enabled Smart City Framework

Overview

Two barriers currently exist to effective and powerful smart city solutions. First, many current smart city ICT deployments are based on custom systems that are not interoperable, portable across cities, extensible, or cost-effective. Second, a number of architectural design efforts are currently underway (e.g. ISO/IEC JTC1, IEC, IEEE, ITU and consortia) but have not yet converged, creating uncertainty among stakeholders. There is a lack of consensus on both a common language/taxonomy and smart city architectural principles. The result is that these groups are likely to generate standards outputs, including standards that are divergent, perhaps even contradictory, which does not serve the global smart city community well. To remove these barriers, NIST and its partners are convening an international public working group to compare and distill from these architectural efforts and city stakeholders a consensus framework of common architectural features to enable smart city solutions that meet the needs of modern communities. The output of the working group will be a white paper providing a common, voluntary, consensus foundation of language/taxonomy and common architectural principles that can align these existing efforts to produce complementary, coherent, language/taxonomy and common architectural principles that will support interoperable and portable smart applications. Thus, the working group effort will facilitate the work being done by the various standards organizations, consortia, and others.

What

A smart city is a moniker that inspires a vision of a city where key components of infrastructure and services – environmental, emergency response, traffic and energy management to name a few – are integrated in such a way that features and applications can easily be combined with whatever capability existed before. Achieving that vision requires moving beyond many current implementations in which the degree of integration of core subsystems within smart cities is often limited by patchworks of legacy and fixed solutions connected by custom integrations. The public working group seeks to benefit from lessons learned by pioneers of smart city implementations to distill a composable Smart City Framework.

By “composable,” we imply that continuous integration and improvement would be achieved through graceful addition of functions as opposed to wholesale replacement or retrofitting. Cities integrating

each new capability should be able to simply acquire and add it to the existing infrastructure with a minimum of tailoring and reworking of existing component interfaces. The whole will be greater than the sum of its parts.

Why

Convening a public working group to achieve consensus on a smart city framework meets a number of needs. Cities and entrepreneurs worldwide seek to enable incrementally added "smarts" to various aspects of city life regardless of which community of interest the components come from. And they do not want to wait to deploy these capabilities in anticipation of the arrival of some grand scheme. A desirable architecture would draw on the existing work to minimize the barriers to integrating critical as well as new and novel applications to the benefit of citizens and city managers.

The recent progress of applications in smart cities has been explosive. In just one example, this is evidenced by the large engagement achieved last year in NIST's Global City Teams Challenge (GCTC)[1]. There are many teams of implementers and cities pioneering applications all over the globe. There are also many consortia and standards organizations developing architectures of various scopes appropriate for Smart City integrations. All of these groups would benefit from the ability to work together through a common language and shared architectural principles.

As well as industry interest, governments have a keen desire to benefit from the efficient integration of "smart" into their cities. A recent report[2] predicts that by 2017, twenty of the world's largest countries will have in place prioritized national smart city policies and one third of medium and large cities worldwide will have developed a smart city roadmap. In the U.S., the Office of Science and Technology Policy recently announced a "Smart Cities Initiative to Tackle City Challenges with Innovative Approaches"[3]. A shared smart cities framework can support informed policy and decision-making and promote the emergence of a vibrant global market for smart city technologies.

To meet the needs of all stakeholders, the public working group will be a technology- and business-model-neutral forum for capturing a minimum set of commonality that can be adopted to achieve the composable vision of a smart city. The goal is to find a common intersection of consensus among the stakeholders around which all participants can rally. To achieve this goal, the working group will:

- Be free and open for participation by anyone, anywhere in the world upon no-cost registration at the group web site;
- Comprise technical experts and city stakeholders from industry, academia, and government worldwide;
- Make its deliverables freely available on the web;

[1] https://www.us-ignite.org/globalcityteams/
[2] IDC FutureScape: Worldwide Smart Cities
[3] https://www.whitehouse.gov/blog/2015/09/16/launching-smart-cities-initiative-tackle-city-challenges-innovative-approaches

- Hold regular working meetings virtually to eliminate barriers of geography; and
- Develop a technical white paper on consensus principles for smart city architectures derived from comparative analyses of existing concepts (including M2m, IoT-A, FIWARE, NIST's CPS Framework, and others) and their mapping to exemplary smart city deployments (including those arising from the Global City Teams Challenge and others as the group may select).

How

This activity builds on the work of two related NIST efforts – the Global City Teams Challenge[4] that encourages "action clusters" to form and collaborate to demonstrate technologies at city scale, and, the CPS Framework[5] which provides for a scientific underpinning of the description of the Internet of Things.

The working group will produce a streamlined architecture that emphasizes Pivotal Points of Interoperability (PPI) (see inset to the right).

Pivotal Points of Interoperability

If you standardize everything, you freeze out innovation. If you standardize nothing, you get non-interoperable clusters that are not easily integrated. The principle of Pivotal Points of Interoperability is to find consensus standardized interfaces that deal with composition of CPS without constraining innovation.

To determine these PPI the participants will review the following:

- Analysis of current architectures
- Success stories about how seamless integrations and portability of applications across cities were achieved
- Standards that support the modular integration of function at city scale
- Standards that support updates, publication and access to information coming from different sources describing what is going on in the city
- Best practices on how to integrate PPIs into existing infrastructures
- Educational materials and tools that facilitate consumer/commercial understanding and usage of smart city capabilities and technologies

Who

Smart cities is a growing market and a global one with significant competitiveness implications for both industry and municipalities. NIST, as lead partner, is coordinating this activity through its Cyber-Physical Systems Program, part of the NIST Engineering Laboratory, to pursue its responsibilities for assisting industry in the development of measurements, measurement methods, and basic measurement technologies; and assuring the compatibility of United States measurement standards with those of other nations.

[4] https://www.us-ignite.org/globalcityteams/
[5] http://www.nist.gov/el/nist-releases-draft-framework-cyber-physical-systems-developers.cfm

ANSI's role is primarily outreach and awareness-raising to encourage technical experts to participate in the initiative and to use the working group's output in subsequent standards activities in which ANSI plays a role as coordinator of the U.S. standardization system and U.S. member to international standards bodies.

ENEA is analyzing (especially but not exclusively based on Italy) and elaborating specific aspects related to standards and smart cities (with a special focus on Interoperability issues) as contribution to the technical white paper. Moreover, ENEA intents to coordinate a group of Italian Cities and Organizations participating to the Framework to promote and disseminate standards for the smart cities though events, projects and communication actions.

MSIP's (Ministry of Science, ICT and Future Planning) role is to provide its expertise gained from Korea IoT Cluster Projects such as Busan Global Smart City and Daegu Daily Healthcare Centre, which are facilitating convergence of various IoT services based on an International IoT/M2M Standard (oneM2M) platform. In addition, as the government of South Korea, MSIP supports its role for enabling numerous IoT businesses and start-up companies to build up profitable services and establishing IoT ecosystem with the smart city frameworks derived from this activity.

ETSI's technical groups such as SmartM2M, and the global standards initiative oneM2M in which we are founding partner, are working on IoT service platform specifications that can be applied to Smart City scenarios. In addition ETSI is active in various EU initiatives such as AIOTI (The Alliance for Internet of Things Innovation) where we are considering what technical specifications exist or would need to be developed to support the ICT technologies. ETSI hopes that through this collaboration we may enable global cooperation and knowledge sharing as well as the development of global technical specifications and recommendations to help accelerate the numerous Smart City deployments around the globe.

The U.S. Green Building Council (USGBC)[6], along with Green Business Certification Inc. (GBCI)[7], is committed to a prosperous and sustainable future through cost-efficient and sustainable buildings, infrastructure, communities and cities. USGBC and GBCI will work toward their mission of market transformation and participation in this program through LEED and other key programs[8], offering a credible measure to evaluate, compare, manage and improve the performance of urban systems through transformative actions that improve the quality of life and wellness of citizens.

The FIWARE initiative is targeted to boost creation of an ecosystem around the FIWARE platform, which provides a rather simple yet powerful set of APIs (Application Programming Interfaces) that ease the development of Smart Applications in multiple vertical sectors. FIWARE API specifications are public and royalty-free supported by an open source implementation enabling multiple FIWARE providers to emerge faster in the market with a low-cost proposition. The FIWARE context management API has been adopted by more than 75 cities to support real-time open data. FIWARE aims at contributing to

[6] http://www.usgbc.org/
[7] http://www.gbci.org/
[8] http://www.gbci.org/certification

the definition of a reference architectural framework for smart cities that it can help implement as open source and promote.

NIST plans to convene a public working group including:

- Smart city leaders, administrators and planners
- manufacturers of Internet of Things and other smart city related components,
- academics studying the integrations of technologies into smart city designs
- standards organizations investigating and developing smart city standards
- industrial and commercial consortia developing smart city platforms and IoT specifications and designs
- state and federal government
- participants from around the globe

When

We plan to begin this activity in with two workshops in February/March. A draft result is planned to be available fall of 2016, and final draft spring 2017.

To get involved:

- Collaboration Web Site https://pages.nist.gov/smartcitiesarchitecture
- Email: to smartcitiesarchitecture@nist.gov; to join: smartcitiesarchitecture-join@nist.gov
- Contact: martin.burns@nist.gov

Sample Smart City Use Cases

The use cases for Smart Cities are varied in scope and depth. Below, find brief summaries of a few deployed smart city use cases from the 2015 Global Cities Team Challenge that illustrate the diversity of smart city architectures[9].

Safe Community Alert Network (SCALE): Montgomery County, MD

The Safe Community Alert (SCALE) network seeks to bring the safety and security of connected devices to everyone, regardless of their financial means or technical savvy. This showcases a new network of public safety with a diverse ecosystem of devices, standards, and connectivity options. The SCALE network, currently being demonstrated in a senior living facility in Montgomery County Maryland, senses hazardous air and water factors as well as some facets of the physical health and well-being of resident volunteers. This real world test bed has deployed environmental sensors to detect a variety of factors including: smoke, carbon dioxide and monoxide, some toxic gases, humidity, temperature, particulates, and some forms of pollen. Sensors also detect water consumption and contaminants. The data compliments information related to the health of a resident that comes from health devices such as blood glucose monitors, heart monitors, and oxygen machines. It can even detect events such as falls, unauthorized access to sensitive areas, or a resident that has wandered off. Data collected from sensing of events goes to the SCALE platform where applications can then be built. The SCALE network contains a text message notification system, automatically initiated conference calls with family and care providers, dashboards for first responders, and analytics for public health officials, all with affordable forms of technology and connectivity.

Managing Urban Air Quality: Chicago, IL

This project is investigating how cities might optimize air quality by managing traffic flow, for instance, via schedules or temporary routing. This requires understanding of the spatial and temporal dynamics of urban air contaminants, particularly related to vehicle emissions, and in the context of diverse weather, natural topology, and built form of cities. The project leverages Chicago's Array of Things (AoT) initiative, which uses resilient embedded systems technology developed at Argonne National Laboratory. The AoT provides an urban scale testbed to embed new technologies and services in the built infrastructure, enabling application developers to access near-real time, high spatial-temporal resolution data about urban air quality, weather, and other factors. Deploying technologies in urban spaces is costly, so the project leverages existing street furniture, integrating AoT's air quality and environmental sensors into solar powered, networked waste stations built by BigBelly, a waste solutions company. BigBelly operates nearly 30,000 waste stations in cities globally, and provides a vehicle through which sensors can be deployed in many diverse urban settings. The project brings together computer science, cyber physical systems, distributed systems, and sensor systems expertise to explore technical and societal challenges

[9] Global City Teams overviews, https://www.us-ignite.org/globalcityteams/actioncluster/archive/

and opportunities of urban-scale embedded systems in the public sphere, initially related to understanding and ultimately managing urban air quality.

Coruña Smart City: A Coruña, Spain

Coruña Smart City Platform aims to improve environmental quality (noise, air quality), reduce greenhouse gas emissions through the Smart management of energy and traffic and reduce consumption peaks in municipal infrastructures and buildings. Coruña Smart City project is promoted by the city council of A Coruña, Spain, and EMALCSA, the city's public water company. Coruña Smart City is a unique smart city project that is based on the development of the City's "brain," a powerful and open technological platform that incorporates data, in real time, from multiple sensing devices/data sources located throughout the city. The real-time data generated by different "smart projects" in the city, can be viewed in the advanced 3D visualization tool, eVidens, which is the platform interface. The eVidens tool displays information about public works, water cycle management, weather stations, public transportation, traffic conditions, tourist information, attractions, etc. Several smart projects are being developed in different areas of the City for mobility, environment, leisure, tourism, and e-administration. These projects compound the "neurons" of Coruña Smart City, and their objective is to provide more rapid, efficient, and sustainable services to the citizens. A key component of the Coruña Smart City project is the availability and visualization of live and open data generated from the projects. Today all the public data can be consulted by citizens, enterprises, council operators, and authorities at the Coruña Smart City and Open Data web portals, and through different mobile apps. Future plans include transformation of the data into valuable information to improve decision-making and the citizens' daily quality of life.

Smart Santander: Santander (Spain)

Santander (Spain) is one of the pioneers of IoT-enabled Smart Cities. With more than 15000 IoT devices deployed in the city, FIWARE is the platform providing access to real-time open data describing what is going on in the city. Part of this data comes from various verticals in the city, as traffic management, environmental control, public lighting management, noise, and many more. Additionally, it comes directly from citizens using the "Pace of the City" application, through which they report events related to the city context and provide data from their smartphone embedded sensors. Last but not least, it comes from devices embedded in the public bus fleet, parks and garden management fleet, a large number of taxis, and "intelligent tags" deployed in shops, touristic points, public transport stops, etc. All this real-time open data is made available to support development of smart city applications. Readings gathered from fixed and mobile sensors are used as the initial indicator of the severity of the environmental pollution (air quality, noise levels and luminosity levels) covering large areas. When levels over defined limits are observed, special alarms are generated by the system and actions triggered. IoT devices deployed in several green zones of the city, on the other hand, are devoted to monitor irrigation-related parameters such as moisture temperature and humidity, pluviometer, anemometer, in order to make irrigation as efficient as possible. Both are examples of the kind of smart city services developed in the city based on IoT-enabled context information.

Global Smart City Testbed: Busan (Korea)

Busan Global Smart City Testbed Project is an IoT-based Smart City building project whose goal is to secure global references by developing an Open Smart City Platform on which new commercializable urban services can be suggested and tested, demonstrate IoT-based promising urban services by building a testbed in Haeundae Busan for the realization of a sustainable city, and establish a governance for the operation of a smart city in order to vitalize a public self-sustainable ecosystem. The goal is to train 500 IoT professionals, promote 50 creative enterprises and 5 global hidden champions, and discover 5 global common services under the vision of global reference smart city, sustainable city, and IoT-centered knowledge city. The project scope includes developing an Open Smart City platform based on oneM2M standards, demonstrating promising urban services, and establishing governance for the operation. The foundation of the Busan smart city was successfully established for providing IoT services tailored to regional characteristics through the collaboration with local government, and expanding IoT infra & services on a national scale in 2015.