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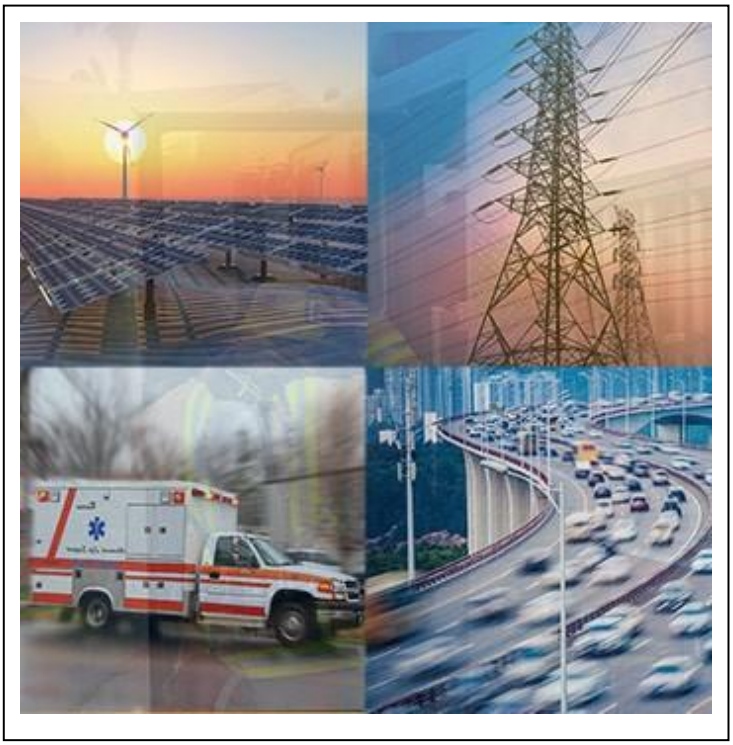
National Institute of Standards and Technology
U.S. Department of Commerce

Cyber-Physical Systems for Global Cities

Summary

Smart cities are enabled by cyber-physical systems (CPS), which involve connecting devices and systems – such as Internet of Things (IoT) technologies – in fundamentally new ways. When applied to diverse sectors such as transportation, energy, manufacturing, and healthcare, these technologies enable cities and communities to improve services, promote economic growth, and enhance the quality of life. CPS provide cities with a pathway to enhance and integrate key infrastructures and systems to dramatically improve delivery of government and other services to citizens. Many Cyber-Physical Systems (CPS) innovators already have technologies (i.e., building blocks) and their impact can be maximized by fostering collaboration among the innovators to create interconnected solutions to provide tangible benefits to end users. Many smart community efforts are one-off projects with heavy emphasis on customization and inadequate consideration for future upgradability and extensibility, which end up causing increased cost and inefficiency. As a result, many Smart Cities/Communities deployments are isolated and do not enjoy economies of scale. This project addresses key needs for smart cities efforts: convergence towards a consensus standards-based foundation supporting interoperability, replicability, and trustworthiness across systems, and measurement science for performance comparisons and evaluation, validation, verification, and management. Central to the project's strategy is the development of measurement science and standards in the context of real deployments at scale to ensure the outcomes are relevant and useful in the real world.

Description



Objective - To provide the measurement science and standards-based foundations for interoperable, replicable, scalable, and trustworthy cyber-physical systems that can be readily and cost-effectively deployed by cities to improve their efficiency, safety, security, resilience, and sustainability and enhance the quality of life for their residents across the U.S. and around the world.

What is the technical idea? Two key concepts shape this program. The first is the need to connect implementers and innovators in ways that promote and deploy replicable, interoperable, and secure CPS solutions at scale. In many cases, smart city decision-makers and planners are unaware of innovative advanced technologies that can be applied to meet the needs of their community. Similarly, many technology innovators lack the familiarity with actual community operations and requirements that are needed to design usable, effective and secure systems. Additionally, actual implementations today are often undertaken in an infrastructure-by-infrastructure and city-by-city approach leading to isolated solutions that do not interact. Many U.S. companies with smart city solutions have limited opportunities to participate in a global market based on the lack of standardized approaches in countries and regions around the world. The Global City Teams Challenge (GCTC) is designed to create connections, promote and deploy replicable and interoperable solutions in multiple cities with the goal of demonstrating tangible and measurable benefits of the deployed solutions at a global scale.

The second concept is the need to develop standards-based foundations and measurement science that work at the scale of city and regional infrastructures and are usable by planners, managers, and operators in real world environments. At present, NIST testbeds lack the scale and realism needed to address this need. The GCTC

overcomes this limitation by partnering with communities and innovators in real deployments at scale.

What is the research plan? Over the past several years, NIST has built up the Global City Teams Challenge community of multi-city teams and partnerships (organized into action clusters) to deploy shared and replicable solutions in collaborative manner, and encouraged participants to set tangible and measurable goals to be accomplished by the teams and developing useful measures and performance metrics to characterize their achievements. The most recent GCTC initiative has introduced the concept of multi-city, multi-team "SuperClusters" organized around common project objectives and shared solutions in sectors including transportation, public safety/emergency preparedness/disaster recovery/resilience, energy/water/waste management, city data platform/dashboard, public Wi-Fi, and healthcare. NIST has encouraged the GCTC community to share best practices in their deployment efforts and evaluations of the measurement science and standards requirements for robust smart cities efforts, through mechanisms such as a technical publication series and "SuperCluster" blueprints or playbooks, which will help the cities and communities to jumpstart planning and deployment of replicable and successful best practices.

For FY18, the research plan is to introduce the concepts of trustworthiness and secure systems into the NIST GCTC community, to encourage continued updating and publication of SuperCluster blueprints, and to leverage the at-scale city/community real-world application environment to identify and address measurement science problems of CPS-enabled smart cities. A transition plan will also be developed to support evolution of GCTC into a peer-driven self-sustaining community of practice.

The importance of trustworthiness including security for CPS/IoT is increasingly recognized, however the readiness of smart cities and communities to address trustworthiness/security issues is generally low. With interest, and potential funding support, from other-agency partners (e.g., DHS), the GCTC community of practice represents a significant opportunity to enhance awareness of trustworthiness and security concerns and to address them with GCTC teams and SuperClusters. These advances in trustworthiness for smart cities/integrated infrastructures can then be incorporated into revised SuperCluster blueprints to share best practices between smart cities and communities. For FY18, a collaboration with NCCoE is being initiated to develop a secure smart city/community technology reference case.

Finally, efforts will continue to leverage the at-scale real-world application environment to identify and address measurement science problems of CPS-enabled smart cities. By analyzing the measurable goals of GCTC teams and understanding the mutual dependencies of key performance indicators (KPIs), cities will be better able to leverage investments for desired results. The project will continue to develop mathematical tools for constructing correlation between the KPIs to measure impacts of CPS in cities and communities, and identify real-world examples from the GCTC community to validate and improve the tools. The project will work to advance the measurement science of KPIs and evaluation methodologies, and provide opportunities for GCTC community participants to publish their contributions. An example of this is the Science of Smart City Operations and Platforms Engineering (SCOPE) workshop

which was created by NIST and Vanderbilt University to elevate the awareness of the importance of science and research in smart cities and CPS, and to provide a venue for researchers to present their accomplishments. This international workshop covers a broad range of research challenges in smart cities and CPS such as multi-tiered interoperable architecture, metrics and key performance indicators (KPIs) that can measure the impact of smart city solutions and platforms, and modeling and simulation paradigms that can help test and validate the smart cities solutions. The first SCOPE workshop was held in Vienna, Austria in April 2016 as part of CPS Week, and 11 peer-reviewed research papers were presented. The second SCOPE workshop was held in Pittsburgh in April 2017, and 12 peer-reviewed research papers were presented (3 papers with NIST co-authors). The third SCOPE workshop is currently being planned and is expected to be held in April 2018 in Porto, Portugal, as part of CPS Week. Finally, the project will work to understand scalability of real-world deployments from the perspective of enhancing the capabilities of the NIST CPS (and Smart Grid) testbed for remote federation.

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Dates

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Related NIST Projects

Cyber Physical Systems Program (https://www.nist.gov/programs-projects/cyber-physical-systems-program)
Cyber-Physical Systems Testbed Design Concepts (https://www.nist.gov/programs-projects/cyber-physical-systems-testbed-design-concepts)
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