Computing Community Consortium (CCC) Response to NITRD
"Smart Cities and Communities Federal Strategic Plan: Exploring Innovation Together"

Elizabeth Mynatt, Dan Lopresti, Klara Nahrstedt, Shwetak Patel,
Jennifer Rexford, Ben Zorn

Computing Community Consortium
Catalyst

This response was prepared by the Computing Community Consortium (CCC). The mission of the CCC is to catalyze the computing research community and enable the pursuit of innovative, high-impact research. Our goal is to call attention to major research opportunities for the computing community. The draft NITRD plan highlights several key research areas, but it misses others that are critical and falls short in laying out an ambitious agenda that will maximize the long-term success and broad impact of major infrastructure investments.

While this plan lays out a comprehensive, multi-agency approach for smart cities and communities, bridging research to implementation to evaluation, this plan does not fully capture the *transformative potential* to reshape our lived environments, ranging from rural communities to dense urban environments. The research community can and should be engaged in articulating grand challenges that raise smart city and community efforts from settling for incremental improvements to reaching for transformative change in economic opportunity and inclusive innovation, civic participation and privacy, and interactive and intelligent systems. Additionally challenges in research infrastructure, authentic evaluation, sustainability and workforce development should not be underestimated. Addressing these barriers will require deep multi-disciplinary research from computer science to public policy and sustained civic-academic-industry partnerships.

Economic Opportunity: Many persistent socio-economic barriers to education, economic well-being, and healthcare and wellness could be challenged through far-reaching, integrative approaches to smart communities and cities. It is unrealistic to expect that these improvements will occur unless these challenges are incorporated from the start in strategic plans for smart cities and communities. The benefits of intelligent infrastructure should be applied in overcoming long-standing structural impediments to broad-based equality in these areas.

Universal Access: Access to city and community services by people with physical and cognitive impairments is problematic. "People-Centered Solutions" should address barriers to access and use; a significant percentage of the population faces such barriers due to injury, disease, and aging. Moreover, any work with small and rural communities needs to address basic barriers to Internet access, especially among older adults.

Security: Security is a foundational challenge in intelligent infrastructure. Key points missing from the draft plan include the difficulty of key management for diverse IoT devices interconnected across differing networks and sectors; security protocols to span smart city

services (transportation, smart grid, water); and long-term approaches to maintaining the security of embedded smart technologies. Physical infrastructure (e.g. bridges, roads) is built for decades, while cyber-infrastructure may need software upgrades every few months.

Privacy: While the draft plan raises privacy considerations, it should also call for new research in privacy-preserving approaches to data collection and use. For example, approaches to Differential Privacy[1] could help manage the tradeoffs between data collection and privacy needs. This issue is particularly important for smart cities and communities where pervasive data collection will span many aspects of daily life.

Computational Materials: The current plan makes no mention of computational materials that extend beyond cyber-physical systems and anticipate the greater integration of computer science and the programming of biological and other physical materials, ranging from self-healing building materials to bio-mechanical-digital environmental sensors and actuators. For example, recent advances in metamaterials have demonstrated the feasibility of this new paradigm.

Learning Systems / AI: Also conspicuous in its absence is a discussion of how intelligent infrastructure should incorporate machine learning and mixed initiative experimentation and control. Developing these capabilities is critically important. Big data analytics is just the first step in providing descriptive, prescriptive, and predictive systems. What is needed are approaches to multiple loops of learning ranging from automation, to decision support, to the eventual production of generalized knowledge. For example, advanced transportation systems could incrementally learn to manage different patterns of traffic, then provide decision support for proactively managing special cases (e.g., disaster response), to supporting planning and prioritization for new road/control modifications, to advancing generalized knowledge that can be applied across different city and transportation capabilities.

Scale: This plan frequently collapses attention to cities and communities as if those needs are interchangeable. In fact, these needs vary tremendously and **we recommend a specific focus on small and rural communities**. Basic access to Internet-based capabilities is critical to delivering on the human-centric needs for smart communities. A recent PCAST report[2] points to the pervasive access needs of aging adults, especially in small and rural communities. Hence, more research will need to be done on mobile platforms, mobile integrated end-to-end systems with easy setup, portable, low-cost, data cyber-infrastructures, edge computing and tele-services that allow for different economic contexts.

---

[1] Dwork, Cynthia. "Differential privacy: A survey of results." *International Conference on Theory and Applications of Models of Computation*. Springer Berlin Heidelberg, 2008.

[2] President's Committee of Advisors on Science and Technology, *Report to the President on the Independence, Technology, and Connection in Older Age,* March 2016.

Infrastructure for research and authentic evaluation: We also wish to emphasize the importance of research infrastructure and "authentic evaluation," i.e. evaluating systems in the context of real use. Developing a comprehensive plan for investing in research infrastructure remains an ongoing challenge. Another challenge is that for smart cities and communities, many evaluation metrics are non-traditional. Success may not be measured as to whether a technology is robust, secure, or real-time (traditional CS metrics), but rather whether its deployment increases the number of visitors, new residents, and business activity, or decreases crime, traffic, and waste. Hence, evaluation of smart city/community technologies must bring together teams of computer scientists, engineers, social scientists, urban planners, economists and local leaders.

IT Sustainability: Sustainability is a formidable barrier for the long-term success of intelligent infrastructure investments. Local governments want to see concrete, actionable plans from vendors or groups of researchers who propose deploying smart technologies. These barriers may be especially high in the case of small towns and rural areas where government resources are tight. Another major challenge of IT sustainability is community education. Will citizens be able to understand and use the deployed technologies? Third, a major challenge of IT sustainability is lack of innovative economic models to deploy and upgrade smart cyber-infrastructures. Some gains (e.g., decreasing crime) may not have direct revenue implications while others (e.g., decreasing parking) may reduce city revenue. A fourth major challenge of IT sustainability is the lack of evaluation methods for integrated/interdependent smart technologies.

Education and workforce development: We wish to amplify the importance of educational programs and approaches that integrate key information regarding data analytics, sensing, communication, security, and privacy. We also want to call attention to the need for basic and applied research in workforce tools that will enable people to access and harness these capabilities. For example, research in visual analytics addresses challenges of working with complex data sets, understanding probabilistic and predictive information and supporting collaborative decision making. Likewise, wearable and augmented reality systems offer the ability to "see" and interact with layers of information connected to physical objects.

In conclusion, meeting these challenges requires sustained investment in basic research while proactively integrating these visions into current smart community and city approaches to ensure capacity and interoperability for future gains. While some of these transformative visions may be implied in the NITRD plan, we maintain that audacious visions will drive substantial change and that a focus on human-centric, socio-economic needs and barriers will help ensure that all people benefit from these investments. We should also aspire that these systems reach for transformative capabilities, ranging from managing privacy tradeoffs, programming new materials and learning at many scales.