Wireless Networks to Enable Pervasive Sensing and Control in Smart Cities

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As the world population continues to grow, we are seeing an increasing trend of urban densification. One of the major challenges of this century is sustaining the quality of life for these rapidly increasing urban populations. While reduction in per-capita usage of key resources such as energy, water, non-recyclable materials, and reduced car driving are being pursued through public campaigns and are having some impact, it is becoming clear that we cannot only "save" our way out of the growing problems, but rather technological innovations are needed at all levels. At USC, in collaboration with academic, government, and industrial partners, we have been pursuing a number of research activities aimed particularly at the deployment of heterogeneous wireless sensor and communication networks for improving the sensing of relevant environmental and transportation parameters and the control of pertinent urban infrastructure.

At an urban scale, we believe that what is needed is not a single network type or flat architecture, but rather a scalably inter-operable heterogeneous network that includes many types of devices and network elements, including:

- Statically mounted low power wireless and wired embedded sensors for road-side monitoring, and vehicle-mounted sensors for on-road monitoring of environmental and transportation parameters such as air quality, noise, micro-climate sensing, road condition, traffic congestion, parking
- Hand-held mobile devices with apps for crowd-sensing and citizen science
- Cellular-based cloud connectivity to vehicles and sensors
- Vehicular radios for communication between vehicles and for communication with road-side units that provide always-on communication as well as store-and-forward capabilities
- Roadside low power mesh networks
- A diversity of cloud servers, federated and orchestrated for computation offloading, data analytics and visualization, taking into account privacy and data security considerations

Concretely, our ongoing and past research in this domain has included a pilot deployment of vehicle-mounted sensors on USC transportation buses, estimating and visualizing transportation traffic flow in downtown Los Angeles based on data streaming from embedded inductive loop sensors [2], algorithms for multi-objective transportation control that take into account both commuter delays and vehicular pollution impact in directing traffic [2], a hybrid cellular-V2V architecture for information centric networking in vehicles [3,4] enabling distributed road-condition monitoring [5]; coded storage & caching algorithms [6], community analysis and vehicular helper-node allocation for enabling timely dissemination of firmware updates to connected vehicles [7]; algorithms for privacy-preserving traffic sensing [8] and efficient compression mechanisms for city-scale sensor data collection.

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