SMARTSYS – Issues in Smart Systems and the Internet of Things

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***Abstract*—The concept of "Smart Systems" is becoming pervasive, from smart homes to autonomous vehicles to smart grids and cities, and beyond. These advances are driven by small, embedded, and high-powered computing systems which interconnect using rapidly-advancing technologies, and which produce ever-increasing amounts of data. Although the "Internet of Things" may produce useful applications and new distributed architectures, there are issues and challenges being revealed almost as fast as data is produced by these Smart Systems. A special session on Smart Systems is included in the Twelfth International Conference on Digital Telecommunications (ICDT 2017), held in Venice, Italy. Three papers address the challenges and issues in topical areas related to Identity-Based Encryption for Smart Grids, Technology Enhanced Infrastructure for Smart Cities, and Logical/Geospatial Device Location in Smart Grids.**

***Index Terms*—Smart Grid, Encryption, Identity, Privacy, Infrastructure, Prediction, Sensors, Schematic Location**

I. Introduction

The revolution in "Smart Systems" is affecting every aspect of modern life, including city lighting, transportation, water management, infrastructure monitoring, energy provisioning, and safety/security. The incorporation of lighting solutions into active environments is just an example of the breadth and importance of this trend. From municipal systems participating in mesh networks to context-responsive municipal lighting systems, the proliferation of "Smart Systems" is penetrating every hour of the day, in every corner of the globe. As a result, "Smart Systems" provide a variety of technologically-based approaches for helping citizens manage their communities more efficiently and effectively. Key aspects of the smart city are described in subsequent sections, along with brief summaries of the papers presented in the SMARTSYS special session of ICDT 2017 [1]. Much of the following is abstracted from [2] where the topics are covered in greater detail.

A. Transportation and Mobility

Transportation and mobility are key considerations in every city. With the advent of "Smart Systems," conventional approaches to transportation are undergoing a profound transformation. Beyond conventional mass transit solutions such as light rail, subway and buses, these smart transportation systems will change the way humans, products, and supply chains interact. Smarter, more autonomous, and safer vehicles will become the norm. Vehicle-to-Vehicle communication (V2V) as well as Vehicle to Infrastructure (V2I), Vehicle to Grid (V2G), and Vehicle to "whatever" (V2X) communication will enable constant evolution. Interchange of data between vehicles, buildings, traffic signs, and other infrastructure will enable new applications and services. Transportation and mobility challenges are not limited to citizens and services. Energy resources such as water and electricity must also be transported from source to destination, and automation of these activities may produce substantial economic and lifestyle benefits.

B. Energy and Water

Energy and other municipal services such as water and refuse collection are central functions in every city. New "Smart Systems" have the potential to revolutionize activities from energy management to citizen involvement, creating massive efficiencies in municipal operations. For example, the power grid is the backbone of modern society. It delivers the energy required for daily operations from water reclamation to entertainment. The smart grid integrates conventional power management technologies with newer Information and Communication Technology (ICT) systems to create an energy distribution system which is responsive, stable, and efficient.

Emissions from transportation and electricity generation are every nation's largest sustainability issues. Widespread adoption of electric vehicles (EVs) is an example of a "Smart System" approach to this issue. The energy capacity of most EVs is substantial, and can be viewed as an ugly uncontrollable load if not managed or sequenced, or as a large, distributed battery system if controlled in a V2G system. Thus, EVs can (a) optimize charging and loading of the grid, and (b) provide spare electrical capacity. As a result, management of EV charging via "Smart System" principles provides tremendous value to the electric grid, while V2G promises enhancements to grid reliability and stability.

C. *Information and Communications Technology*

Information and communications technologies are central to the smart city and "Smart System" concepts. These technology platforms, tools and interoperability standards provide the foundation for innovative solutions to real problems. At the heart of ICT are "the Cloud" and "the Internet of Things."

As centralized infrastructure, the data centers which form "the Cloud" provide highly secure, reliable services. These facilities offer power efficiency and operational flexibility that is unmatched by private or decentralized IT infrastructure. As smart cities develop, the processes and activities they manage will become increasingly data-intensive. As a result, access to cloud-based services will become increasingly important for distributed, autonomous, and "Smart Systems."

The Internet of Things (IoT) is in many respects the definition of "Smart Systems." IoT deployments are quickly becoming a critical aspect of the smart city. IoT devices are typically embedded computers, with wireless communications technologies that interface with "the Cloud" in some fashion. Collectively, a group of IoT devices comprises an autonomous machine-to-machine or device-to-device network that is part of a "Smart System." As IoT and sensor applications are deployed, some forecasts predict that the amount of data they produce will exceed *hundreds of billions of terabytes* per year. Clearly the storage, transmission and processing of this information will be a challenge, even for "the Cloud."

II. Addressing The Challenges

A number of "Smart Systems" can be envisioned for an unending collection of municipal, personal, and societal challenges. The topics addressed in this special session focus on the three complementary issues of identity management, system operations, and technology enhanced infrastructure. Taken as subsets of the "Smart City" problem, these focal areas may be quite important in the near future.

A. *Identity-Based Encryption*

In "*An Identity-Based Encryption Scheme with Performance Optimization for Privacy Preservation in Smart Grid Communication*" [3], Baloglu and Demir propose an identity-based encryption scheme which optimizes the data structure of meter readings to improve privacy. This approach also reduces communication overhead and is more computationally efficient than previous methods. By focusing on optimizing the encryption *processes* for the smart grid, the authors achieve better efficiency than existing approaches which focus on optimizing the encryption *algorithms*.

For future work, the approach will be extended to analyze the communication overhead and improve computational overhead by modifying the encryption algorithm according to the meter's data structure.

B. *Technology Enhanced Infrastructure*

In "*Using Smart Sensors to Monitor Concrete Infrastructure Assets for Useful Life Prediction Modelling*" [4], Schemmel, et.al. describe the use of monitoring systems to develop predictive models for approximating the remaining useful life of an asset. A method is presented which uses sensors to develop empirical models for the lifetime of concrete structures, and sensors are examined which enable this concept.

Engineering parameters are measured in the field by smart sensors, then correlated with data gathered from accelerated testing of construction material in the laboratory. The novel concept may provide a new tool for early warning of impending structural failure, allowing for more efficient management of infrastructure lifecycles. As a result, the approach could contribute to more resilient and "Smart" or "Technology Enhanced Infrastructure" systems.

C. *Smart Grid Location Mapping*

In "*A Novel Smart Grid Device Location Mapping Technique*" [5] Shima, et.al. propose a technique to determine and resolve the geo-spatial and electrical location of grid-resident devices. By comparing "downstream current profiles" (at the meter) with the superposition of "upstream current profiles" (at the substation), small perturbations can be leveraged to discriminate active devices on the grid. As a result, the electrical location of grid-resident devices can be determined using non-invasive methods and signal processing at the datacenter.

The use of temporal comparison, feature extraction, and application-specific data compression of signals at upstream and downstream points in the grid allows the method to scale easily. GPS data from smart meters assists in the reconciliation of geo-spatial information to produce an accurate electrical location of the devices.

III. Conclusion

In a special session on Smart Systems, held as part of the ICDT 2017 conference in Venice, Italy [1], three papers are presented that discuss various aspects of "Smart Systems," including the challenges and issues related to Identity-Based Encryption for Smart Grids [3], Technology Enhanced Infrastructure for Smart Cities [4], and Logical/Geospatial Device Location in Smart Grids [5]. These approaches collectively provide a glimpse into several important aspects of the development of "Smart Systems" for "Smart Cities."

References

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