ENABLING SMART CLOUD SERVICES THROUGH REMOTE SENSING: AN INTERNET OF EVERYTHING ENABLER

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ABSTRACT

The recent coming out and accomplishment of cloud-based services has empowered remote sensing and made it very possible. Cloud-assisted remote sensing (CARS) enables distributed sensory data collection, and data sharing. Global resource, remote and real-time data access and elastic resource provisioning CARS has great potentials for enabling the so-called Internet of Everything (IoE), thereby promoting smart cloud services. In this paper, we survey CARS. First, we describe its benefits and capabilities through real-world applications. Second, we present a multilayer architecture of CARS by describing each layer's functionalities and responsibilities, as well as its interactions and interfaces with its upper and lower layers.Finally, discuss the sensing services models offered by CARS.

Index Terms—Cloud computing, Internet of Everything (IoE), remote sensing, smart cloud services

INTRODUCTION

Remote sensing plays a key role in the acquisition of dataabout and from everything without needing physical fieldvisits.With the recent emergence of cloud computing, remote sensing has been empowered and made possible even more than ever before. Unlike conventional ways of collecting and processing sensory data, cloud-assisted remote sensing (CARS) now enables: 1) decentralization of data sensing and collection, where sensory data can now be sensed and collected from everywhere instead of being restricted to limited areas; 2) sharing of information and cloud resources, where data and resources can be shared and used globally by all users; 3) remote access to global sensed information and its analytics, where sensed data can easily be accessed and analyzed online from everywhere; 4) elastic provisioning of cloud resources, where users can scale up and down their requested resources in real time based on demand; and 5) pay-as-you-go pricing models, where users can request (and hence pay for) only resources that they need based on their demand. CARS can then be viewed and foreseen as an emerging technology that has great potential for enabling the so-called Internet of Everything (IoE), thereby enabling smart cloud services.

IoEis a newInternet concept that tries to connect everything thatcan be connected to the Internet,where everything refers to people,cars, televisions (TVs), smart cameras, microwaves, sensors, andbasically anything that has Internet-connection capability.Arecentstudy by Cisco predicts that IoE is projected to create $14 trillionnet-profit value, a combination of increased revenues and loweredcosts, to private sector from2013 to 2022 [1]. IoE is not seen as anindividual stand-alone system, but as a globally integrated infrastructurewith many applications and services [2].When coupled with IoE, CARS gives birth to what we callEverything as a Service or Sensing as a Service (SenaaS) [3]. Forexample, a radio station can rely on CARS to lease a set ofdriverless cars which it can use to cover road accidents andbroadcast traffic information [4]. This is becoming a commerciallyviable solution, especially after states such as Nevada,Florida, and California legalized driverless cars to operate inpublic roads [5]. Another example is to have traffic lightscommunicate with and control approaching vehicles upon sensingthe presence of pedestrians and bikes [6]. Smart phones,which are typically (or can be) equipped with specialized sensors,can also be used to provide sensing and monitoring servicesfor environment, healthcare, and transportation [7], [8]. Theseapplication domain examples are just a few among many others

that can benefit from CARS to offer SenaaS.

In this paper, we survey the topic of using cloud computing to enable remote sensing services, referred to, throughout the paper, as CARS or simply CARS. First, we describe in Section II the benefits and uses of CARS by giving several real-world application domains where CARS can be applied. Second, we present in Section III a layered architecture for CARS that consists of four layers. For each layer, we describe the functionalities and responsibilities of the layer, as well as its interactions and interface with its upper and lower layers. Third, we discuss in Section IV three different models of sensing services that ARS can offer: infrastructure-based, platform-based, and analytics based models. Fourth, we go over in Section V popular commercial CARS platforms that have already been developed and been ready to use by highlighting their capabilities and their offered service models.

CARS SERVICES AND APPLICATIONS

CARS can be found useful in many real-world applications invarious domains, including industrial, medical, social, and environmental.Essentially, CARS services and applications extendtraditional sensor network applications by enabling:

1) distributed data collection and sensing, where sensoryinformation can be sensed and collected fromeverywhere;

2) global data and resource sharing, where sensory informationand resources can be shared globally;

3) remote and real-time data access, where sensed data canbe accessed and analyzed in real time from anywhere;

4) elastic resource provisioning and scaling, where serviceusers can provision and scale up and down their neededresources based on demand;

5) pay-as-you-go pricing, where cloud users can request,release, and pay for resources whenever needed.

CARS usages and benefits are classified intothree categories:

1)**Remote tracking and monitoring**: CARS enables remote tracking and monitoring of things ofinterest in real time, thereby allowing alerts to be raised andappropriate actions to be taken in a timely manner wheneverneeded. CARS can potentially be used for tracking andmonitoring animal behaviors, moving-object locations (e.g.,vehicles), environmental conditions, building surveillanceand security, patient-health conditions, smart-grid operations,aviation and aerospace safety, and vegetation production quality,just to name a few.

1) Animal Behaviors: CARS can track and record locations ofanimals (livestock or wild) by collecting global positioningsystem (GPS) data in real time and storing it in the cloud[9].

2) Environmental Condition Monitoring: CARS can be usedto monitor environmental condition changes by havingdistributed sensors, which collect and send data to the cloud.Data to be collected can, An environmental specialist can thenaccess this data and use it to monitor climate changes,estimate concentrations of dangerous chemicals in water andair [10], monitor and alert of possible forest fires [11], and getalerted by possible avalanche occurrences [12].

3) Agricultural Monitoring: CARS has potential uses formonitoring vegetation remotely, combating corps-threateningpests, and improving farming system productivity. Smart cameratechnology is being used for remote vegetation monitoring bycollecting and processing field images on the fly, generatingperformance reports, and sending processed reports to thecloud.

4) Building Surveillance and Security: CARS can also be usedto monitor and detect safety and security patterns, such asmalicious human activities and building structural problems,allowing to raise security alerts in a timely manner[13,14].

5) Healthcare Monitoring: Healthcare too requires anautomated system that allows continuous monitoring ofpatients' health conditions and real-time reporting ofabnormalities and condition alerts to physicians. [15,16].

6) Smart Meter Readings: CARS can be very handy inmeasuring and collecting smart grid operation information,allowing easy integration and automation of smart gridcomponents. [17].

7) Aviation and Aerospace Safety: CARS can be used toimprove security and safety of crew and air vehicles. [18].

B. **Real-Time Resource Optimization and Control :**CARS can also enable real-time optimization and control ofvarious resources, where resources vary from one applicationdomain to another. Waste management, traffic control, smartparking, water/irrigation management, and guided navigation area few applications where resources can be optimized and controlledefficiently via CARS.

1) Waste Management: CARS allows remote monitoring ofrecycling containers, making recycling waste pickup and routingprocesses effective. Waste management is a complex processthat involves generation, on-site handling, collection, transfer,processing, and disposal of waste. [19].

2) Smart Parking: Using CARS, one can provide real-timeinformation about parking availability to locate parking spotsfaster and more efficiently, which saves time of car drivers andreduces energy consumption. This can be achieved by quicklyidentifying

and reserving a free parking spot in the vicinity of thedrivers' final destination [20].

3) Traffic Control: CARS enables quick collection of real-timetraffic information that can be used to avoid traffic jams, reportaccidents, report road constructions, and reduce fuelconsumption. Traffic information can be sensed and collectedby designated sensors, or by participatory sensing devices (e.g.,smart phones and smart cameras) to monitor roads and trafficconditions in cities [21]. In addition, CARS can also be used tomanage fleets in public and private transportation [22].

4) Healthcare: CARS can be used in healthcare systems tostudy and control disease transmission, and support independentliving of elderly, inferior, and people with disabilities. In [23],sensors are used to construct a social network of high schoolstudents to control disease transmission. Mobile phones and specialized wearable sensor networksare being utilized to detect elderly people body posture andbiological signals to enable efficient allocation of needed clinicalresources for diagnosis, treatments, and surgeries [24, 25].

C. Smart Troubleshooting: Identify, Diagnose, and RepairCARS makes remote problem identification, diagnosis andrepairing possible and efficient. Application domains where thistechnology can be applied to are diverse; aviation and aerospace,automotive, network systems, buildings, smart grids, and oil andgas pipelines are some examples.

1) Aviation and Aerospace: CARS can remotely providepilots, dispatchers, and space mission controllers withnecessary and useful information that help them quicklyidentify, locate, and fix problems. [26].

2) Automotive: This industry has been witnessing a paradigmshift, as makers have been installing hundreds to thousands ofsensors and embedded systems in their vehicles. One key use ofthese sensors is for enabling smart and efficient maintenance. Asan example, Hull et al. [27] develop a computing system thattakes advantages of these deployed sensors to collect, process,and visualize sensed data to enable remote and in-vehiclepreventive diagnosis.

3) Network Systems: CARS provides networking andinformation technology (IT) troubleshooters with the ability toremotely diagnose and identify networking component failures,and repair them also remotely and in a timely manner. For

example, CARS has been used for providing real-timemonitoring of data cloud centers to identify and repair(hardware and software) faults [28] and to make wiseenergy management decisions so as to reduce energyconsumption in data centers [29]

4) Buildings: CARS can render buildings and bridges actsmarter. It can enable easy and fast detection and localization oflight failures, air conditions stalling, or structural defects. [30]

5) Smart Grids: Power grids are becoming very complex insize, heterogeneity, and behavior. CARS can play an extremelycritical role in keeping these grids operational at minimum costs.One potential use of CARS is to help maintain these grids faultfreefor as long as possible by enabling remote failure detection

and diagnosis so that repairs can be made quickly [31].

6) Oil and Gas Pipelines: These rely heavily on fast failuredetection typically enabled through monitoring of specialparameter

values (e.g., leakage and high pressure) collectedvia designated sensors that are spread out along the pipelines(length could be thousands of kilometers). CARS can make datamonitoring, collection, and analysis more efficient than ever,thus reducing pipeline maintenance cost and increasing pipelineproductivity [32].

CARS ARCHITECTURE FOR ENABLING IOE

The different CARS applications are discussed above. Here a new architectural design ofCARS in order tobe able to enable smart cloud services. This motivation istriggered by the unique characteristics and features that distinguishCARS from other traditional distributed systems. Sensoryinfrastructure deployment and sensing technique developmentacross different domains may share common challenges andspecificities, which should be taken into account when designing architecture.

The proposed CARS architecture: Such architecture can be viewed as a geographicallydistributed platform that connects many billions of sensorsand things, and provides multitier layers of abstraction ofsensors and sensor networks. Fig. 1 shows the proposed CARSarchitecture. The CARS architecture has four main layers: 1) fog layer; 2) stratuslayer; 3) alto-cumulus layer; and 4) cirrus layer.

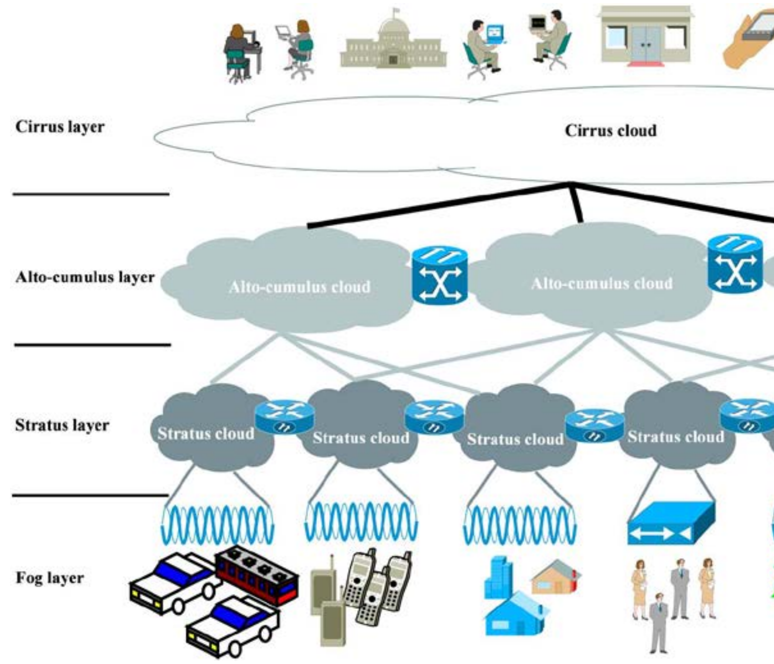

Fig 1: CARS Architecture

1. Fog Layer: Fog layer encapsulates all physical objects, machines, andanything that is equipped with computing, storage, networking,sensing, and/or actuating resources, and that can connect to andbe part of the Internet. The sensory elements of this layer arethose that collect and send raw sensed data to stratus layer, byeither being pulled by stratus layer or being pushed by fog layerto stratus layer.

   Major functions of fog layer are to provide:

   1) Heterogeneous networking and communication infrastructuresto connect billions of things

   2) Unique identification of all things through Internet ProtocolVersion 6

   3) Data aggregation points to serve as sensing clusters.

Although the capabilities of sensing elements of this layermay vary depending on their type and purpose, it is safe toconsider that they are very likely to be resource (e.g., power,memory, and CPU) limited and that they may operate onopportunistic wireless access mode only. As a result, sensorclustering and network virtualization techniques have emergedas possible ways to tackle such resource limitation of sensorydevices, thus enabling distributed CARS services. When mobility is considered as the metric for categorization,we have the following three types:

1) fixed SANs, where sensors are stationary, and networkconnectivity is known and controllable;

2) mobile SANs, where sensors are mobile, but their locationsare known and controllable (e.g., Google driverless vehicles),and network connectivity is known and may becontrollable;

3) participatory SANs, where sensors are private devices(e.g., smart phones) owned by people who, at their will,may or may not choose to participate in sensing tasks [7, 8]. Network connectivity could be intermittent and mayor may not be known, but definitely not controllable.

2. Stratus Layer :Stratus layer is a mid, tier-2 layer that consists of thousands ofclouds whose main resources are sensory devices and SANs.Each stratus cloud manages and acts as a liaison for a differentgroup of SANs that share similar features, context, or properties.

The functions of stratus layer include:

1) Abstracting and virtualizing physical SANs through virtualnetwork embedding (VNE) techniques;

2) Handling and managing virtual SAN migration and portabilityacross different clouds;

3) Managing and ensuring operations and functionalities of virtual SAN instances

4) Enabling and managing (physical or virtual) SAN configurationsto ensure network connectivity and coverage;

5) Controlling the layer's operations and functionalities toensure that customers' service level agreements (SLAs)communicated from higher layers (as detailed later) aremet.

Stratus layer provides an abstraction of the physical worldrepresented via fog layer to alto-cumulus layer. This layer doesnot interact directly with CARS customers, but serves themthrough requests received from higher layers. Conceptually,stratus clouds are optimized to handle heterogeneous connectivityof SANs by having software-defined networking interfaceswith alto-cumulus layer.

C. Alto-Cumulus Layer: Alto-cumulus is a middle layer that serves as a point of liaisonbetween stratus and cirrus layers. It facilitates negotiationsrelated to pricing, policy and regulations, and SLAs betweenstratus and cirrus layers, and ensures that the agreed upon termsare not violated. While stratus clouds are domain specific; i.e.,each cloud is very likely to be concerned with one applicationdomain (e.g., medical, environment, and agriculture), an altocumuluscloud may map to and orchestrate multiple statusclouds belonging to different domains. As mentioned earlier,this can enable inter-cloud resource sharing, thereby increasingresource elasticity and scaling.

Major functions of alto-cumulusare as follows:

1) Serving as a point of liaison between cirrus and statuslayers by translating policy and regulation requirementsexpressed by cirrus layer into domain-specific requirementsunderstood by stratus;

2) Enabling business and payment transactions betweencirrus and stratus layers by providing two-way brokerageservices;

3) Enabling and facilitating SLA negotiations between cirrusand stratus, and monitoring and ensuring that these SLAsare met; i.e., playing the role of a policy enforcementagent;

4) Coordinating and facilitating inter-cloud interactions, dataexchange, task migration, and resource sharing acrossdifferent stratus clouds.

4. Cirrus Layer:Cirrus layer is the highest layer in the CARS architecture, andits main role is to interact with CARS service customers andsatisfy their requests with the aid of lower layers. It does not dealwith resource virtualization, nor does it need to know whichcloud handles which resources. It just needs to communicatecustomers' requests specified via their SLAs to alto-cumulusclouds.

The major functions of Cirrus layer are as follows:

1) Acting as the customers' entry point to CARS systems byallowing them to specify their required services via SLAsand to select their desired service models;

2) allowing CARS customers to set up their sensing taskrequirements and do whatever their chosen service modelallows them to do (e.g., software configuration/ deployment)

3) Negotiating SLAs with customers and communicatingthem to alto-cumulus layer.

4) Providing online applications for remote data analysis tobe used by customers to visualize their data in real time.

This layered CARS architecture essentially consists of connectingsensory devices (fixed, mobile, and participatory)through the fog layer, managing SAN virtualization and embeddingthrough stratus layers, managing cloud domains and thesevirtual SANs through the alto-cumulus layer, and providingabstractions of cloud services to customers through the cirruslayer.

IV. CARS SERVICE MODELS

The objectives of CARS are to provide cloud customers withflexible access to data and sensing services, allow them todevelop their own domain-specific applications, and allowclouds to share physical resources. The servicesoffered by CARS into three smart models those are 1) IaaS; 2) PaaS; and3) SaaS.

These models are Sensing and Actuating Infrastructure asa Service (SAIaaS), Sensing and Actuating Platform as a Service(SAPaaS), and Sensing Data and Analytics as a Service(SDAaaS).

A. SAIaaS: SAIaaS model requires that physical sensor and SAN resourcesserve multiple sensing tasks concurrently. Customerscannot make changes to physical resources (i.e., SANs andsensors), but have full control over their allocated virtual instances.

Fig. 2 depicts an example of multiple virtualSANs.

In this illustration, three sensing tasks are requested to be carried out by the platform, leading to the creation of three virtualSANs (two mobile and one fixed).

B. SAPaaS:SAPaaS model offers sensing platforms as a service. In thismodel, CARS customers are provided with a set of applicationprogramming interfaces (APIs) and libraries that they can use todevelop their own sensing and actuating applications withoutworrying about the physical (SANs).

C. SDAaaS: Many practical applications need only to have access and beable to process sensed data without needing to change anythingin the physical sensors or in the virtual realizations of SANs.CARS service customers using this service model, referred to asthe SDAaaS model, are only interested in the context in whichsensed data is collected, its accuracy, and its sufficiency to beable to generate meaningful inferences.

CONCLUSION

This paper surveys CARS applications and services. Thesurvey starts off by describing the potentials and capabilities ofremote sensing when empowered via cloud services. It supportsthese CARS' capabilities and benefits through applications takenfrom real-world scenarios. The survey then presents four-layerarchitecture for CARS by describing the functionalities, responsibilities,and inter-layer interactions of each layer. The surveythen describes three different CARS services models and presentssome existing commercial platforms. Finally, it describeskey design components that are required for enabling CARS anddiscusses some of its major challenges.

REFERENCES

[1] J. Bradley, J. Barbier, and D. Handler, "Embracing the Internet of everythingto capture your share of $14. 4 trillion," 2013.

[2] J. A. Stankovic, "Research directions for the Internet of Things," IEEEInternet Things J., Volume 1, no. 1, Pages: 3–9, Mar. 2014.

[3] C. Perera, A. Zaslavsky, P. Christen, and D. Georgakopoulos, "Sensing as aservice model for smart cities supported by Internet of Things," Transactions emerging TeleCommunication Technol., Volume 25, no. 1, Pages: 81–93, 2013.

[4] J. Huang, C. M. Kirsch, and R. Sengupta, "Virtual vehicle and cyberphysicalcloud computing," 2013.

[5] Z. Chong et al., “Autonomy for mobility on demand,” in IntelligentAutonomous Systems 12.NewYork,NY,USA: Springer, 2013, Pages: 671–682.

[6] A. Zanella, N. Bui, A. P. Castellani, L. Vangelista, and M. Zorzi, “Internet ofThings for smart cities,” IEEE Internet Things J., volume. 1, no. 1, Pages: 22–32,Feb. 2014.

[7] X. Sheng, J. Tang, X. Xiao, and G. Xue, “Sensing as a service: Challenges,solutions and future directions,” Cyber-Phys. Cloud Computer Lab, University.California at Berkeley, Berkeley, CA, USA, Tech. Rep., Working PapersCPCC-WP-2013-01-01, 2013.

[8] N. D. Lane et al., “A survey of mobile phone sensing,” IEEE CommunicationMag., Volume 48, no. 9, Pages: 140–150, Sep. 2010.

[9] S. Ehsan et al., “Design and analysis of delay-tolerant sensor networks formonitoring and tracking free-roaming animals,” IEEE Trans. WirelessCommunication, Volume 11, no. 3, Pages: 1220–1227, Mar. 2012.

[10] S. Bhattacharya, S. Sridevi, and R. Pitchiah, “Indoor air quality monitoringusing wireless sensor network,” in Proceedings6th InterbationalConference Sens. Technol.(ICST), 2012, Pages: 422–427.

[11] A. K. Jain, A. Khare, and K. K. Pandey, “Developing an efficient frameworkfor real-time monitoring of forest fire using wireless sensor network,” inProceedings2nd IEEE InterbationalConference Parallel Distrib. Grid Computer (PDGC), 2012,Pages: 811–815.

[12] T. Vaidya, P. Swami, S. Rindhe, S. Kulkarni, and S. Patil, “Avalanchemonitoring& early alert system using wireless sensor network,” InterbationalJPURNALAdv.Res. ComputerScience Electron. Eng., Volume 2, no. 1, p. 38, 2013.

[13] B. Hariharan, A. Sasidharan, and A. V. Vidyapeetham, “iWEDS intelligentexplosive detection and terrorist tracking system using wireless sensornetwork,” InterbationalJPURNALComputersCience Issues, Volume 8, no. 4, Pages: 245–250, 2011.

[14] S. Simi and M. V. Ramesh, “Real-time monitoring of explosives usingwireless sensor networks,” in Proceedings1st Amrita ACM-W Celebration WomenComputer India, 2010, p. 44.

[15] D. Diamond, S. Coyle, S. Scarmagnani, and J. Hayes, “Wireless sensornetworks and chemo-/biosensing,” Chem. Rev., Volume 108, no. 2, Pages: 652–679,2008.

[16] H. Alemdar and C. Ersoy, “Wireless sensor networks for healthcare: Asurvey,” ComputerNetwork, Volume 54, no. 15, Pages: 2688–2710, 2010.

[17] N.-Q. Nhan, M.-T. Vo, T.-D. Nguyen, and H.-T. Huynh, “Improving theperformance of mobile data collecting systems for electricity meter readingusing wireless sensor network,” in ProceedingsInterbationalConference Adv. Technol. Communication(ATC), Pages: 241–246, 2012.

[18] W. Wilson and G. Atkinson, “Wireless sensing opportunities for aerospaceapplications,” NASA Langley Res. Center, Hampton, VA, USA, NASATech. Rep. LF99-5739, Jan. 2007.

[19] S. Longhi et al., “Solid waste management architecture using wirelesssensor network technology,” in Proceedings5th InterbationalConference New Technol. MobilitySecur. (NTMS), 2012, Pages: 1–5.

[20] M. Idris, E. Tamil, N. Noor, Z. Razak, and K. Fong, “Parking guidancesystem utilizing wireless sensor network and ultrasonic sensor,” Inf.Technol. J., Volume 8, no. 2, Pages: 138–146, 2009.

[21] P. Mohan, V. N. Padmanabhan, and R. Ramjee, “Nericell: Rich monitoringof road and traffic conditions using mobile smartphones,” in Proceedings6th ACMConference Embedded Network Sens. Syst., 2008, Pages: 323–336.

[22] M. R. Raut, “Intelligent public transport prediction system using wirelesssensor network,” InternationalJournal Computer. SCience Appl., Volume 6, no. 2, 2013.

[23] M. Salathé et al., “A high-resolution human contact network for infectiousdisease transmission,” Proc.Nat. Acad. Science, Volume 107, no. 51, Pages: 22 020–22 025,2010.

[24] Y. Sun, “Human daily activity detect system optimization method usingBayesian network based on wireless sensor network,” in Advances inComputer Science, Intelligent System and Environment. New York, NY,USA: Springer, 2011, Pages: 721–725.

[25] K. Lorincz et al., “Mercury: A wearable sensor network platform for highfidelitymotion analysis,” in Proceedings7th ACM Conference Embedded Network Sens.Syst. (SenSys), 2009, Volume 9, Pages: 183–196.

[26] A. Reehorst et al., “Progress towards the remote sensing of aircraft icinghazards,” ProceedingsSPIE, Volume 7088, Pages: 70880J–1, 2008.

[27] B. Hull et al., “Cartel: A distributed mobile sensor computing system,” inProceedings4th InterbationalConference Embedded Network Sens. Syst., 2006, Pages: 125–138.

[28] R. Khanna, D. Choudhury, P. Y. Chiang, H. Liu, and L. Xia, “Innovativeapproach to server performance and power monitoring in data centers usingwireless sensors,” in Proccedigns. IEEE Radio Wireless Symp. (RWS), 2012,Pages. 99–102.

[29] R. Antonini, G. Fici, and M. Gaspardone, “Energy management of telecommunicationplants using wireless sensor network,” in Proceedings14th InterbationalConferenceIntell. Next Gener. Network (ICIN), 2010, Pages: 1–6.

[30] S. Kim et al., “Health monitoring of civil infrastructures using wirelesssensor networks,” in Proceedings6th InternationalSymp. Inf. Process. Sens. Network(IPSN’07), 2007, Pages: 254–263.

[31] S. N. Pakzad and G. L. Fenves, “Statistical analysis of vibration modes of asuspension bridge using spatially dense wireless sensor network,” JPURNALStruct.eng., Volume 135, no. 7, Pages: 863–872, 2009.

[32] V. C. Gungor, B. Lu, and G. P. Hancke, “Opportunities and challenges ofwireless sensor networks in smart grid,” IEEE Trans. Ind. Electron., Volume 57,no. 10, Pages: 3557–3564, Oct. 2010.