International Virtual Workshop on

Smart cities: A Road Map for Future Development

Jan 10th to 12th 2022

About the workshop:

Smart cities are being planned and promoted in significantly large scale by not only the Government of India but also the Governments across the globe. The objective is to promote sustainable and inclusive cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. Some of the core infrastructure elements in a Smart City would include assured electricity supply, efficient urban mobility and public transport, robust IT connectivity and digitalization, sustainable environment, and security of citizens. Application of Smart Solutions will enable cities to use technology to improve infrastructure and services.

This International Workshop aims to envisage such challenges and control strategies for Smart Cities. This event will provide a platform to the enthusiastic researchers, including students and young faculties of universities and research institutes to share and learn from the experiences through discussion and interactions. Renowned speakers from different parts of world will deliver talks on the recent development in their respective areas of research including Socio-Technology Framework, Innovative Urban Infrastructure and Advanced Techniques for Durability in Smart Cities.

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SPARC
Scheme for Promotion of Academic and Research Collaboration

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About SPARC:

The Scheme for Promotion of Academic and Research Collaboration (SPARC) aims at improving the research ecosystem of India's Higher Educational Institutions by facilitating academic and research collaborations between Indian Institutions and the best institutions in the world from 28 selected nations to jointly solve problems of national and/or international relevance.

The scheme proposes to enable productive academic co-operation by supporting the following critical components that can catalyze impact making research, namely:

- Visits and long-term stay of top international faculty / researchers in Indian institutions to pursue teaching and research.
- Visits by Indian students for training and experimentation in premier laboratories worldwide.
- Joint development of niche courses, world-class books and monographs, translatable patents, demonstrable technologies or action research outcomes and products.
- Consolidation of Bilateral co-operation through academic and research partnerships through Indo-X Workshops in India.
- Publication, Dissemination and Visibility through a high profile annual international Conference in India.

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About BITS Pilani:

Started in 1946, Electrical & Electronics Engineering Degree Program is one of the oldest in BITS Pilani. BITS offers three integrated First Degree and four Higher Degree on-campus programmes under the Department of Electrical & Electronics Engineering apart from several off-campus programmes under continuing education scheme. The curricula are highly demanding and attract exceptionally meritorious students from all over India. Research is emphasized in all three tiers of education, First Degree, Higher Degree and PhD by involving students in project-type courses that benefit industry, society and the environment. The EEE department has numerous academic associations / clubs in which students enroll depending on their interest and compete globally in various academic competitions. There is a huge potential in the department for industrial consultancy as well as technology development and product incubation.

About Signals and Systems Laboratory, Centralesupélec:

The signals and systems laboratory (L2S), created in 1974, is a joint research unit of CNRS, CentraleSupélec, and Paris-Saclay University (UMR 8506). Research at L2S focuses on fundamental and applied mathematical aspects of control theory, signal and image processing, information and communications theory. Interdisciplinary themes related to life and health sciences, the industry of the future, and digital developments in the field of energy occupy an important place. The researchers are divided into 3 research poles: automatic and systems, signals and statistics, telecoms, and networks.

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Conveners:

Prof. Alivelu Manga Parimi and Prof. H.D. Mathur

Co-Conveners:

Dr. Sudha Radhika

Dr. Ponnalagu R N

Dr. Pratyush Chakraborty

Dr. Gopal Krishna Kamath M

Dr. Rabindra Mohanty

Dr. Bijoy Krishna Mukherjee

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Schedule of Events

Name of the speaker	Title of the talk	Country	Time (IST)
Webinar 1 (January 10, 2022): "Socio-Technology Framework in Smart Cities"			
	Opening Ceremony		09:00 Hrs
Prof. Pramod Khargonekar (University of California, Irvine)	Smart Cities: Ensuring Social Benefits from Advanced Technologies	USA	09:30 Hrs
	Break		11:00 Hrs
Dr. Ayan Mallik (Arizona State University)	Advanced Power Electronics for Transportation Electrification in Smart Grids	USA	11:15 Hrs
	Lunch		12:30 Hrs
Dr. Wei Chen (Peking University)	Duration-Deadline Jointly Differentiated Energy Services	China	14:00 Hrs
Prof. Naveen Chilamkurti (La Trobe University)	Privacy Preserving Framework for Non-Intrusive Load Monitoring using GAN -based Obfuscation in Smart Grid	Australia	15:30 Hrs
	Break		17:00 Hrs
Dr. M. Ali Fotouhi Ghazvini (Hitachi ABB)	Smart Peak Demand Management	Sweden	17:15 Hrs
Prof. Vijay Gupta (University of Notre Dame, Indiana)	Data Enabled Distributed Control of Congested Transportation Networks	USA	18:30 Hrs
	Closing Ceremony for the Webinar Series: DAY 1		19:30 Hrs

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Webinar 2 (January 11, 2022): "Innovative Urban Infrastructure in Smart cities"			
Prof. Prabir Barooah (University of Florida)	How to Convert the Air Conditioners in a City into a Giant Battery to Help Integrate Wind and Solar Energy	USA	09:00 Hrs
	Break		10:15 Hrs
Prof. Pravin Varaiya (University of California, Berkeley)	What Connected Vehicle Data reveals about City Transportation?	USA	10:30 Hrs
Prof. Subhas Mukhopadhyay (Macquarie University)	IoT Enabled Sensors for Smart City and Environmental Monitoring	Australia	12:00 Hrs
	Lunch		13:30 Hrs
Prof. Henrik Madsen (Technical University of Denmark)	Digitalization for Smart Energy Systems for the Future Low Carbon Society	Denmark	14:00 Hrs
Prof. Aswin Khamadkone (National University of Singapore)	Challenges of Electric Vehicle Growth in Dense Urban Environments: An Overview and Some Solutions	Singapor e	15:30 Hrs
	Break		17:00 Hrs
Prof. Houria Siguerdidjane (Centralasupelec)	Static and Dynamic Friction Modelling	France	17:30 Hrs
	Closing Ceremony for the Webinar Series: DAY 2		18:30 Hrs

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Webinar 3 (January 12, 2022): "Advanced Techniques for Durability in Smart Cities"			
Prof. Anurag K Srivastava (West Virginia University, Morgantown, WV)	Resilience of Smart Grid	USA	09:00 Hrs
	Break		10:15 Hrs
Dr. Michael Wetter (Lawrence Berkeley National Laboratory)	Future Energy Eystems for Combined Heating and Cooling at the Building, District and City-level	USA	10:30 Hrs
Dr. Jan Drgona (Pacific Northwest National Laboratory)	AI Application in Smart Grids	USA	11:30 Hrs
	Closing Ceremony of the workshop		13:00 Hrs

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Speaker and Topic Details

1) **Speaker:** Prof. Pramod Khargonekar, Vice Chancellor for Research and Distinguished Professor of EECS at the University of California, Irvine, USA

Title: Smart Cities: Ensuring Social Benefits from Advanced Technologies

Abstract: Infusion of sensors, communications, networks, computation, machine learning, and control into the physical infrastructures and social systems is ushering in a smart society. The term smart-X refers to what is common in smart electric grids, smart mobility, smart city, smart government, smart health, etc. These are examples of smart cyber-physical-human systems. From the point of view of systems and control, we will focus on improvements in extracting useful information from data from sensors over communications networks to improvements in control and decision making, both enabled by internet-of-things. We will highlight specific examples from our ongoing work to draw more general conclusions on the role of systems and control fields in smart-X. We will end the presentation with a vision of the future of smart-X where systems and control can join related and complementary disciplines to usher in a new era of smart society where people can enjoy improved as well as sustainable lives.

Speaker Bio: Pramod Khargonekar received B. Tech. Degree in electrical engineering in 1977 from the Indian Institute of Technology, Bombay, India, and M.S. degree in mathematics in 1980 and Ph.D. degree in electrical engineering in 1981 from the University of Florida, respectively. He has been on faculty at the University of Florida, University of Minnesota, The University of Michigan, and the University of California, Irvine. He was Chairman of the Department of Electrical Engineering and Computer Science from 1997 to 2001 and also held the position of Claude E. Shannon Professor of Engineering Science at The University of Michigan. From 2001 to 2009, he was Dean of the College of Engineering and Eckis Professor of Electrical and Computer Engineering at the University of Florida till 2016. He also served briefly as Deputy Director of Technology at ARPA-E, U. S. Department of Energy in 2012-

13. He was appointed by the National Science Foundation (NSF) to serve as Assistant Director for the Directorate of Engineering (ENG) in March 2013, a position he held till June 2016. In this position, Khargonekar led the ENG Directorate with an annual budget of more than $950 million. In addition, he served as a member of the NSF senior leadership and management team and participated in setting priorities and policies. In June 2016, he assumed his current position as Vice Chancellor for Research and Distinguished Professor of Electrical Engineering and Computer Science at the University of California, Irvine.

Khargonekar's research and teaching interests are centered on theory and applications of systems and control. His early work was on mathematical control theory, specifically focusing on robust control analysis and design. During the 1990's, he was involved in a major multidisciplinary project on applications of control and estimation techniques to semiconductor manufacturing. His current research and teaching interests include systems and control theory, machine learning, and applications to smart electric grid and neural engineering. He has authored more than 160 refereed journal publications and 200 conference publications. He has supervised 38 doctoral students. He has been recognized as a Web of Science *Highly Cited Researcher*.

He is a recipient of the IEEE Control Systems Award, IEEE Control Systems Society Bode Lecture Prize, NSF Presidential Young Investigator Award, the American Automatic Control Council's Donald Eckman Award, the Japan Society for Promotion of Science fellowships, World Automation Congress Honor, the IEEE W. R. G. Baker Prize Award, the IEEE CSS George Axelby Best Paper Award, the Hugo Schuck ACC Best Paper Award, and the Distinguished Alumnus and Distinguished Service Awards from the Indian Institute of Technology, Bombay. He is a Fellow of IEEE, IFAC, and AAAS. At the University of Michigan, he held the Claude Shannon Chair and received the Arthur F. Thurnau Professorship. In the past, he has served as Associate Editor for IEEE Transactions on Automatic Control, SIAM Journal of Control, Systems and Control Letters, and International J. of Robust and Nonlinear Control, and is currently on the Editorial Board of the Proceedings of IEEE. He has served on numerous committees in IEEE, IFAC, and AAAS. He is currently a member of: the Governance Board of Clean Energy Smart Manufacturing Innovation Institute (CESMII), Board of Directors of California Council on Science and Technology, External Advisory Board of Institute for Systems Research at the University of Maryland, Governing Board of CENIC, Advisory Board of NSF Engineering Research Visioning Alliance (ERVA), Scientific Advisory Board of NSF ERC on Internet of Things for Precision Agriculture, and co-chair of the Applied Research Working Group of the University of California Global Climate Leadership Council (GCLC).

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2) **Speaker:** Dr. Ayan Mallik, Arizona State University, USA

Title: Advanced power electronics for transportation electrification in smart grids

Abstract: Power electronics has emerged as an enabling technology in deployment of next generation of transportation systems including electric vehicles (EV), more electric aircraft, shipboard systems, and spacecrafts. The demands for higher efficiency, enhanced reliability, higher power density, specific power and better thermal management pose stringent challenges for the power electronic converters to accommodate. This presentation will put forward some of the emerging research areas, which have been pursued with the emphasis on mission critical space flight systems, next generation onboard chargers for electric vehicles and more-electric-aircrafts (MEA). The talk firstly will focus on a high-density and efficient bi-directional triple active bridge power converter module with unique wide bandgap (WBG) power device components, specifically designed to be used for Space missions. The power flow control technique in a multi-port converter system using loop decoupling method will then be discussed. Secondly, the talk will emphasize on electrification in more-electric-aircraft (MEA) systems through introducing a novel approach to replace transformer rectifier units (TRUs) by actively controlled and lightweight Regulated Transformer Rectifier Units (RTRUs) while employing the advantages of cutting-edge wide band gap (WBG) semiconductor technology and advanced control techniques. Thirdly, design optimization, development and characterization of a novel bidirectional integrated dual-output EV onboard charger will be discussed. Special focus will be given on the schemes for enhancing power density, efficiency, and power quality. The talk will finally introduce a novel active compensation-based harmonic reduction (ACHR) technique to model and mitigate existing third harmonic components in the input current of the front-end AC- DC stage for power quality enhancement under simultaneous high-volume charging/discharging of grid-connected EVs.

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Speaker Bio: Dr. Ayan Mallik joined Arizona State University as an assistant professor in August 2019. Dr. Mallik received his bachelor's degree (B.Tech) in Electrical Engineering from Indian Institute of Technology (IIT), Kharagpur, India in 2014. He received his Master of Science (MS) and Doctor of Philosophy (PhD) degrees in Electrical Engineering from the University of Maryland, College Park in 2018 and 2019, respectively. Dr. Mallik's research interests include the design, control and multi-objective optimization of power electronic converters, highly efficient and high-density power conversion solutions in the applications of more-electric-aircrafts, electric vehicles, renewables, wireless charging, and data centers. Dr. Mallik is an author/co-author/co-inventor of over 60 peer-reviewed publications and 3 US Patents. He has worked on research, development and testing of regulated transformer rectifier units for more-electric-aircrafts, integrated bidirectional onboard charger design for electric vehicles, high density DC-DC conversion for data centers, among many other projects.

Dr. Mallik is the recipient of various awards and recognitions, including first place in Dean's Doctoral Dissertation award competition at UMD (2019), ECE distinguished dissertation award at UMD (2019), University of Maryland's (UMD) Invention of the Year award (2018), Jimmy H.C. Lin invention award (2018), and third place in Allegheny Region Cleantech University Prize Collegiate Competition (2017) sponsored by the US Department of Energy, among many others.

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3) **Speaker:** Dr. Wei Chen, Peking University, China

Title: Duration-deadline jointly differentiated energy services

Abstract: This talk features a framework of duration-deadline jointly differentiated energy services proposed in a bid to unlock the flexible loads to compensate for the uncertain supplies in a smart grid with high renewables. Specifically, the energy services are differentiated by both the duration and deadline requirements. We study the adequacy and allocation problems, i.e., under what conditions a given supply profile is adequate to satisfy all the demands and how to allocate if so. This amounts to solving a constrained binary matrix completion problem. We also study a market implementation of such energy services and show the existence of an efficient competitive equilibrium.

Speaker Bio: Wei Chen received the B.S. degree in engineering and the double B.S. degree in economics from Peking University in 2008. He received the M.Phil. and Ph.D. degrees in electronic and computer engineering from the Hong Kong University of Science and Technology in 2010 and 2014, respectively. He is currently an Assistant Professor in the Department of Mechanics and Engineering Science at Peking University. Prior to joining Peking University, he worked in the ACCESS Linnaeus Center of KTH Royal Institute of Technology and the EECS Department of University of California at Berkeley for postdoctoral research, and in the ECE Department of the Hong Kong University of Science and Technology as a Research Assistant Professor. His research interests include linear systems and control, networked control systems, optimal control, smart grid, cyber physical security, and network science.

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4) **Speaker:** Prof. Naveen Chilamkurti, La Trobe University, Australia

Title: Privacy Preserving Framework for Non-Intrusive Load Monitoring using GAN -based Obfuscation in Smart Grid

Abstract: The integration of sustainable energy resources and increased energy consumption have created new challenges for the traditional electrical network and its aging infrastructure. To address these chal-lenges, numerous efforts have been made to transform the existing power grid into a modernized electrical network called the smart grid. The enhanced smart grid features and privileges have resulted in a larger surface for cyberattacks, enabling the remote exploitation of these smart devices without the need for physical access. This includes exploiting consumer privacy by analysing the power consumption data of a consumer using disaggregation algorithms. A large number of studies have been conducted and diverse approaches have been developed to preserve consumer privacy in the smart grid Advanced Metering Infrastruc-ture (AMI). However, there are two fundamental challenges in these approaches. First, most of these studies do not effectively obfuscate consumer data, therefore, an effective privacy preserving architecture is needed to protect the consumers' power consumption data. Second, those privacy preserving techniques that use disaggregation algorithms, do not use accurate metrics to quantify the performance of the proposed approaches. The metric that have been used to measure the accuracy and performance of these privacy preserving approaches do not accurately reflect the performance of the algorithms based on the state detection and the energy estimation of multi-state devices. In this thesis, we present a privacy preserving architecture that obfuscates the power consumption data of a consumer by generating a synthetic time series based on the information from an obfusca-tor

and from a generative adversarial network. The proposed architecture workflow consists of three key components: the obfuscator, the generative adversarial network, and the non-intrusive load mon-itoring component. Furthermore, we propose a novel multi-state energy classifier (MEC) metric to quantify the performance of the architecture. The proposed architecture is designed, implemented, and evaluated using a real-world dataset of power consumption data

Speaker Bio: Prof Naveen Chilamkurti (NC) is currently the Head of the Cybersecurity discipline at La Trobe University, Melbourne, Australia. Naveen serves as the Technical Editor of the highly ranked IEEE Wireless Communications Magazine and IEEE Transactions on Vehicular Technology. He has published more than 330 journal and conference papers, including IEEE and ACM Transactions. He is active in editing and authoring 9 books with Elsevier, Springer, IGI-Global and NOVA publishers. He has successfully attracted 20 research grants since 2000 to support PhD Scholarships, fellowships, and travel grants for research collaboration. In 2012 and again in 2018, he was awarded a research fellowship to work with IIT Kanpur and IIT Hyderabad. Prof. Chilamkurti successfully secured 24 competitive grants from various sources, including SMART SAT CRC, Data61/CSIRO, Defence Science Institute, Australian Academy of Science, and OPTUS telecommunications.

He is also a Guest Editor for various high impact international journals. Since 2010, he has contributed to 100 special issues in various international journals, including IEEE and Elsevier journals. His current research areas include Cybersecurity, IoT, Anomaly detection in IoT, Internet of Medical Things, Wireless Security, Federated Learning in IoT, wireless multimedia, wireless sensor networks, and Software Defined Network.

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5) **Speaker:** Dr. Ali M. Fotouhi Ghazvini, Hitachi ABB, Sweden

Title: Smart peak demand management

Abstract: Supplying electricity to meet the peak demand periods could have significant environmental and economic impacts. During the peak periods, the generating units with the highest levels of emissions are usually used to serve the demand. Besides the need for more generating units, the power system needs reinforced infrastructure to meet the demand during peak hours. Peak load management is becoming one of the emerging roles of distribution system operators. Using capacity charges is a way to compensate for the costs of serving the peak demand. The DSOs have started to charge the customers to reduce the overall peak demand, and thus the cost for peak demand is passed to the end-users. Load shedding during peak hours is an opportunity for the suppliers and the users to reduce the energy cost. Effective peak demand management requires smart solutions at both sides of the energy provider and the user. The providers offer demand response programs, and it is the end-user that should have the capability to participate in such programs to reduce the peak demand. In this workshop, different solutions that the distribution system operators and the end-users could employ to manage the peak demand are presented. The impact of distributed energy sources, smart contracts, market mechanisms, and demand response programs to reduce the peak demand is introduced.

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Speaker Bio: Dr. M. Ali Fotouhi Ghazvini (Memebr, IEEE) is currently working as a technical consultant at Hitachi ABB Power Grids, Gothenburg, Sweden. He received the M.Sc. degree in Electrical Engineering from the K. N. Toosi University of Technology, Iran, in 2009. Dr. Ali received his PhD in Electrical and Computer Engineering from the University of Lisbon, Portugal. He was also a researcher at the Electric Power Engineering division at Chalmers University, Sweden where he was working on developing energy management systems for energy flexible buildings to ensure the supply of sustainable energy systems and providing flexibility for the grid. His main research interests include power system operation and control, portfolio optimization in retail energy markets, multi-carrier energy systems, and energy management system development for smart buildings and microgrids.

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6) **Speaker:** Prof. Vijay Gupta, University of Notre Dame, Indiana, USA

Title: Data enabled distributed control of congested transportation networks

Abstract: Fluid-like models, such as the Lighthill-Whitham-Richards (LWR) model and their discretizations like Daganzo's Cell Transmission Model (CTM), have proven successful in modeling traffic networks. In general, these models are not linear; they employ discontinuous dynamics or nonlinear terms to describe phenomena like shock waves and phantom jams. Given the complexity of the dynamics, it is not surprising that the stability properties of these models are not yet well characterized. Recent results have shown the existence of a unique equilibrium in the free flow regime for certain classes of networks modeled by the CTM; however, these results restrict inflows to the system to be bounded or constant. Further, it is of interest to understand the system behavior in congested regimes, since links in various practical networks are often congested.

In the first part of this talk, we analyze traffic flow on a network modeled by the CTM. We show that the trajectories of the system are persistent in every mode of the system and that if the inflows are constant, the system admits multiple congested equilibria. We then draw upon entropy-like Lyapunov functions used in chemical reaction network theory to show that these equilibria are locally asymptotically stable. With further restrictions on system inflows, these equilibria degenerate to the free flow equilibrium in existing results.

In the second part of the work, we focus on mitigating urban traffic congestion. Traditionally, urban traffic congestion control has been carried out via fixed-time or partially real-time traffic light scheduling policies obtained using models that are developed and calibrated offline. With the increasing ubiquity of mobile devices and connected vehicles, it is now possible to obtain real-time traffic density estimates in urban transportation networks. We will develop a scalable compositional control algorithm to mitigate congestion in urban transportation networks that uses real-time local information and local controllers (traffic lights) to limit the propagation of congestion in the network. The algorithm relies on using the traffic data to learn a control-oriented piecewise affine hybrid dynamical fluid model of urban traffic with desirable dynamical properties like monotonicity in certain operating regimes, which is of independent interest.

This work has been done jointly with Sivaranjani Seetharaman, Sadra Sadraddini, and Calin Belta.

Speaker Bio: Vijay Gupta is in the Department of Electrical Engineering at the University of Notre Dame, having joined the faculty in January 2008. He received his B. Tech degree at Indian Institute of Technology, Delhi, and his M.S. and Ph.D. at California Institute of Technology, all in Electrical Engineering. He received the 2018 Antonio J Rubert Award from the IEEE Control Systems Society, the 2013 Donald P. Eckman Award from the American Automatic Control Council and a 2009 National Science Foundation (NSF) CAREER Award. His research and teaching interests are broadly in the interface of communication, control, distributed computation, and human decision making.

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7) **Speaker:** Prof. Prabir Barooah, University of Florida, USA.

Title: How to convert the air conditioners in a city into a giant battery to help

integrate solar and wind energy.

Abstract: As we move away from fossil fuels and toward intermittent renewable energy sources such as solar and wind, inexpensive energy storage technologies are required. An alternative to batteries – which are quite expensive – is "smart loads", such as air conditioners equipped with computation and communication capability. With appropriate software, the power consumption of air conditioners -- and many other loads -- can be varied around a baseline. This variation is analogous to the charging and discharging of a large battery. Loads equipped with such intelligence

have the potential to provide a vast and inexpensive source of energy storage. Two principal challenges in creating a reliable "virtual battery" from millions of consumer loads include (1) coordinating the actions of many loads to track a grid-supplied reference signal while maintaining every consumers' Quality of Service (QoS) within strict bounds, and (2) determining capacity of a collection of such loads that can be used for planning, e.g., answering questions such as "how many MW/MWh is a collection of 100,000 air conditioners equivalent to?". The on/off nature of residential loads is a key challenge, since a direct approach leads to an intractable mixed integer optimization problem. This talk describes a novel approach that addresses these challenges by using

randomized control architecture and a Markovian aggregate model of the collection. A key advantages of our approach – compared to prior work – are that (i) it allows determining capacity with all QS constraints: temperature, lock-out time, and energy cost of the consumer (while prior work only considers temperature), (ii) it yields a decentralized coordination scheme that is scalable to millions of loads with minimal communication, and (iii) it provides computationally tractable methods for real-time scheduling and off-line planning that are useful to the grid operator.

Speaker Bio: Prabir Barooah is a Professor of Mechanical and Aerospace Engineering at the University of Florida, where he has been since 2007, and is currently a University Term Professor. He received the Ph.D. degree in Electrical and Computer Engineering in 2007 from the University of California, Santa Barbara. From 1999 to 2002 he was a research engineer at United Technologies Research Center, East Hartford, CT. He received the M. S. degree in Mechanical Engineering from the University of Delaware in 1999 and the B. Tech. degree in Mechanical Engineering from the Indian Institute of Technology, Kanpur, in 1996. Dr. Barooah is the winner of the ASEE-SE (American Society of Engineering Education, South-East Section) outstanding researcher award (2012), NSF CAREER award (2010), General Chairs' Recognition Award for Interactive papers at the 48th IEEE Conference on Decision and Control (2009), best paper award at the 2nd Int. Conf. on Intelligent Sensing and Information Processing (2005), and NASA group achievement award (2003).

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8) **Speaker:** Prof. Pravin Varaiya, Professor Emeritus, University of California, Berkeley, USA

Title: What connected vehicle data reveals about city transportation?

Abstract: Most data about urban vehicle traffic is obtained from locationally fixed sensors such as magnetic loops or wireless detectors. These detectors report the presence and speed of every vehicle that travels over them, every 30 seconds. Since they are expensive to install and maintain, these detectors are placed only at busy intersections. There are about 6M intersections in the US of which 300K are signalized. Thus 5 percent of intersections have detectors that measure traffic going through them. Traffic is usually not measured outside of intersections,

A growing number of vehicles now provide data directly. These so-called “connected vehicles” (CVs) record their GPS location, speed, heading and other information and transmit this record to the vehicle dealer or manufacturer. These mobile detectors are sampled every 2 or 3 seconds. Thus CVs transmit their trajectories in real time. However, at present only about five percent of vehicles are connected. New vehicles are almost all connected.

So we have two complementary sources of traffic information. Fixed detectors give continuous traffic information from about 5 percent of intersections. CVs report continuous trajectories from about 5 percent of vehicles. But the CV population will grow since most new vehicles are connected (for nontraffic purposes). CV trajectory data is costless compared with fixed detector data.

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This talk will discuss what can be learned from connected vehicle data and fixed detector data together. In particular we will focus on measuring queues at stop lights, evaluating safety near intersections, and partitioning the city into areas within each of which travel is relatively easy but inter-area travel is difficult.

This work has been done jointly with Akhil Shetty and Jared Porter, UC Berkeley.

Speaker Bio: Pravin Varaiya is Nortel Networks Distinguished Professor in the Department of Electrical Engineering and Computer Sciences at the UC Berkeley. From 1975 to 1992 he was also Professor of Economics at Berkeley. From 1994 to 1997 he was Director of the California PATH program, a multi-university research program dedicated to the solution of California's transportation problems.

Varaiya has held a Guggenheim Fellowship and a Miller Research Professorship. He received Honorary Doctorates from L'Institut National Polytechnique de Toulouse and L'Institut National Polytechnique de Grenoble, and the Field Medal and Bode Lecture Prize of the IEEE Control Systems Society. He is a Fellow of IEEE, a member of the National Academy of Engineering, and a Fellow of the American Academy of Arts and Sciences.

He is on the editorial board of "Discrete Event Dynamical Systems" and "Transportation Research---C". He has co-authored three books and over 300 technical papers. The second edition of *High-Performance Communication Networks* (with Jean Walrand and Andrea Goldsmith) was published by Morgan-Kaufmann in 2000. *Structure and Interpretation of Signals and Systems* (with Edward Lee) was published by Addison-Wesley in 2003.

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9) **Speaker:** Prof. Subhas Mukhopadhyay, Macquarie University, Australia

Title: IoT Enabled Sensors for Smart City and Environmental Monitoring

Abstract: smart sensing systems. IoT enabled sensors empowers the vision of a Smart City to become a reality. IoT enabled sensors provides real time environmental data which will provide full awareness of weather/climate and can be used to take any strategic/corrective actions to address issues. This seminar will discuss fabrication and developmental works on IoT enabled sensors at Macquarie University based on MEMS as well as flexible materials for home, health and environmental monitoring. The success of the Commonwealth funded (Govt. of Australia) Smart city project and New South wales Government Funded Water project will be shared.

Speaker Bio: Dr. Subhas Chandra Mukhopadhyay (M'97, SM'02, F'11) currently is working as a Professor of Mechanical/Electronics Engineering with the School of Engineering, Macquarie University, NSW 2109, Australia. He is the Discipline Leader of the Mechatronics Engineering Programme. He is also the Director of International Engagement for the School of Engineering. His fields of interest include Sensors and Sensing Technology, Instrumentation, Wireless sensor networks, Internet of Things, Mechatronics and Robotics etc.

He has authored/co-authored 9 books, over 400 papers in different international journals, conferences and book chapters. He has edited eighteen conference proceedings. He has also edited thirty two special issues of international journals as guest editor and thirty six books.

He is a FIEEE (USA), a FIET (UK) and a FIETE (India). He is a Topical Editor of IEEE Sensors journal, an Associate Editor of IEEE Transactions on Instrumentation and Measurements and an Associate Editor of IEEE Review of Biomedical Engineering. He is EiC of S2IS journal and Springer Nature Computer Science journal

He is the Founding Chair of the IEEE Instrumentation and Measurement Society New South Wales, Australia Chapter and currently ex-chair of the chapter. He is also the Founding Chair of the IEEE Sensors Council New South Wales, Australia Chapter.

He is a Distinguished Lecturer of the IEEE Sensors Council 2017-2022.

He has organized over 20 international conferences either as General Chair or Technical Programme Chair. He is organizing the IEEE Sensors Conference 2021 in Sydney as General Co-chair.

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10) **Speaker:** Prof. Henrik Madsen, Technical University of Denmark, Denmark

Title: Digitalization for Smart Energy Systems for the future Low Carbon Society

Abstract: Today energy systems are operated and planned such that the production follows the demand. However, an efficient implementation of the future low-carbon society calls for systems where the electricity demand follows the weather-driven energy production. This highlights a need for a disruption of the whole spectrum of methods ranging energy systems operation to planning. Most importantly we need methods for enabling energy flexibility at all levels of the society; examples being buildings, supermarkets, offices, wastewater treatment plants, districts and cities.

This talk describes a framework called the Smart-Energy Operating-System (SE-OS) for autonomous control of the electricity load in integrated energy systems using big data analytics, AI, edge/fog/cloud computing and IoT solutions. The framework can also be used for providing ancillary services (like congestion management, voltage and frequency control) for systems with a large penetration of wind and solar power. The framework also describes how district energy systems and smart buildings can be used to provide the needed virtual storage and flexibility for large-scale integration of wind and solar power. The set of methodologies is based on grey-box modelling, forecasting, optimization and model predictive control for integrated (power, gas, thermal) energy systems. We will demonstrate that by carefully selecting the cost function associated with the optimal controllers, the system can ensure energy, cost and emission efficiency.

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Speaker Bio: Prof. Henrik Madsen is the Section Head and Professor in Stochastic Dynamical Systems at the Technical University of Denmark in Lyngby (near Copenhagen), Section for Dynamical Systems at the Department for Applied Mathematics and Computer Sciences. Since January 2014, he is heading a National Strategic Research Centre (DSF Centre) entitled: Centre for IT-Intelligent Energy Systems in Cities (CITIES). This centre aims at being a leading research centre related to Smart Cities and Green IT activities. Prof. Madsen has been guest lecturing at a number of universities, such as University of Lund (Mathematics), Fourier University in Grenoble (Section for Mathematical Statistics), University of Copenhagen (Mathematical Statistics), Technical University of Münich (TUM), Iowa State University (Department of Statistics), University of Almeria in Spain (Department of Physics), Charles III University of Madrid in Leganés (Department of Statistics), and many other places.

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11) **Speaker:** Prof. Aswin Khamadkone, National University of Singapore, Singapore

Title: Challenges of Electric Vehicle growth in dense Urban Environments: An overview and some solutions

Abstract: Plug-in Electric vehicles will be growing in many countries due to aggressive targets set-up by Governments around the world. India also has set ambitious goals around the world. For EVs to be green in India, it has to move away from fossil fuels from the generation mix. India has also set up aggressive targets for growth of solar and other renewables. Both these trends will create certain challenges. Currently, EV charging seems to be the major point of discussion in India. The issue of EV charging in dense urban environments that exist in many mega cities in India needs to be addressed. Today, it seems to be chicken and egg problem of not enough EVs to not enough chargers. The talk will discuss many of these challenges and present some solutions that can address these issues.

Speaker Bio: Ashwin M. Khambadkone (SM'04) received the Dr.-Ing. degree in 1995 from Wuppertal University, Germany. He joined National University of Singapore in 1998 where is currently an Associate Professor at the Department of Electrical and Computer Engineering. His current areas of research are Distributed Energy Resources Networks, Fuel Cell based Systems, and Control of Power Electronics based Energy systems, Digital Control of PFC and VRM and Multi-level Inverters. From 1987 to 2001 his research was in the areas of PWM methods, field-oriented control, parameter identification, and sensorless vector control. He has worked at University of Wuppertal, Germany, University of Queensland, Australia and Indian Institute of Science, India.

Dr. Khambadkone is the recipient of the outstanding paper award for the year 1991 and the Best paper award for the year 2002 both in the IEEE Transaction on Industrial Electronics and the Prize paper from IEEE IAS IPCC for 2005. He has also received the Outstanding Educator Award in 2008 from National University of Singapore.

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12) **Speaker:** Prof. Houria Siguerdidjane, Université Paris-Saclay, CNRS, CentraleSupélec, L2S, France

Title: Static and Dynamic Friction Modelling

Abstract: When controlling a dynamical system, one may take into account the frictions in the differential equations that describe its motion and that coming out from the moment equations. Nevertheless, when the friction terms are negligible, namely, they are small enough; the required performance might be met with an adequate and efficient control law. However, in many cases, the frictions may induce severe problems, so the required performance cannot be reached due to the impact of their presence. The frictions are present throughout nature and in all machines even carefully lubricated.

In this talk, we will discuss the types of frictions encountered especially in mechanics and the most popular models that one may take into consideration when starting the study of a whole system modelling in perspective of outputs regulation, optimization or advanced control.

Speaker Bio: Houria Siguerdidjane is currently full Professor and Deputy Dean of Research at CentraleSupélec, L2S, Université Paris-Saclay. Her research interests at the Signals and Systems Laboratory (L2S) include linear and nonlinear control systems and applications to aerospace, mechanical and power systems for which her main recent research work concerns the optimization and regulation of wind power. She obtained the Engineering degree from CentraleSupélec. She received the Doctorate degree in Automatic Control and Signal Processing and the Habilitation degree (HDR) in Physics Sciences from University Paris XI (now Université Paris-Saclay). In 1994-1995, she was on sabbatical leave at the industrial company Alstom T&D, where her main interest was the application of new concepts to improve the relaying protection performance in high voltage electrical networks. She has been the Chair of the IFAC TC on Aerospace from 2006 to 2014. She is the Associated Editor of the IFAC International Journal Control Engineering Practice (CEP) from 2007.

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13) **Speaker:** Prof. Anurag K Srivastava, West Virginia University, Morgantown, WV, USA

Title: Resilience of Smart Grid

Abstract: Keeping the power on especially to the critical facilities in a smart city, such as hospitals and fire department during extreme adverse operating scenarios is essential. There is a need for a flexible and resilient grid to minimize the impact of component failures given adverse events. Availability of data from massive sensor deployment enables new monitoring and control strategies such as early alarm and diagnosis, predictive analysis, distributed and decentralized control, flexible and adaptive control. Data in power grids are largely unexploited in discovering knowledge and new solutions for critical power grid applications to enhance the resiliency. Availability of additional sensor data brings its own challenges including data anomalies, real time processing, data fusion, data management and cyber-security management. This talk will focus on real time data analytics to enhance situational awareness and decision support for enabling resiliency of the cyber-physical power grid and associated challenges and opportunities.

Speaker Bio: Anurag K. Srivastava is a Raymond J. Lane Professor and Chairperson of the Computer Science and Electrical Engineering Department at West Virginia University. He is also an adjunct professor at the Washington State University and senior scientist at the Pacific Northwest National Lab. He received his Ph.D. degree in electrical engineering from the Illinois Institute of Technology in 2005. His research interest includes data-driven algorithms for power system operation and control including resiliency analysis. In past years, he has worked in a different capacity at the Réseau de transport d´électricité in France; RWTH Aachen University in Germany; PEAK Reliability Coordinator, Idaho National Laboratory, PJM Interconnection, Schweitzer Engineering Lab (SEL), GE Grid Solutions, Massachusetts Institute of Technology and Mississippi State University in USA; Indian Institute of Technology Kanpur in India; as well as at Asian Institute of Technology in Thailand. He is serving as chair of the IEEE Power & Energy Society’s (PES) PEEC committee, co-chair of the microgrid working group, vice-chair of power system operation SC, chair of PES voltage stability working group, chair of PES synchrophasors applications working group, co-chair of distributed optimization application in power grid, vice-chair of tools for power grid resilience TF, and member of CIGRE C4C2-58 Voltage Stability, C4.47/ C2.25 Resilience WG. Dr. Srivastava is serving as an editor of the IEEE Transactions on Smart Grid, IEEE Transactions on Power Systems, IEEE Transactions on Industry Applications, and Elsevier Sustainable Computing. He is an IEEE Fellow and the author of more than 300 technical publications including a book on power system security and 4 patents.

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14) **Speaker:** Dr. Michael Wetter, Staff Scientist, Lawrence Berkeley National Laboratory, USA

Title: Future energy systems for combined heating and cooling at the building, district and city-level

Abstract: Due to demands caused by climate change, the energy sector is undergoing a rapid transition. Energy systems for buildings and communities need to become decarbonized, grid-responsive, resilient, and adaptive to changes in usage, technology options, and markets. This leads to increased complexity in their design and operation. Fortunately, new energy systems provide an opportunity to integrate and optimize renewables and storage across multiple prosumers and energy carriers. New system architectures and control challenges emerge, as do new requirements on design flows that can manage the increased complexity. After laying out these challenges, we will present recent progress on new generation computational tools for building and district energy and control systems. We will also present new tool chains that allow for rapid system-level prototyping, model-based design flow and digitization, ranging from design to installation and operation. We will close with a discussion about what foundation should be built to meet design and operation challenges of decarbonized energy systems.

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Speaker Bio: Michael Wetter is a Staff Scientist at the Simulation Research Group at Lawrence Berkeley National Laboratory (LBNL). His research includes integrating building performance simulation tools into the research process, as well as their use for design and operation. He is leading the development of Spawn of EnergyPlus, a next-generation simulation engine for building and district energy and control systems, OpenBuildingControl, a project that digitizes the control delivery process, and the Modelica Buildings Library, the largest Modelica library for building energy and control systems. He has also been developing the Building Controls Virtual Test Bed software for co-simulation and model-based operation, co-simulation tools based on the Functional Mockup Interface standard and the GenOpt optimization program. He is the co-operating agent of IBPSA Project 1 and was co-operating agent of IEA EBC Annex 60, two multinational collaborations that develop new generation computational tools for buildings and community energy systems between 2013 and 2022. Prior to joining LBNL, he led the development of building system models at the United Technologies Research Center (UTRC). He did his dissertation at the University of California at Berkeley and at LBNL, where he created the GenOpt optimization program and the BuildOpt building simulation program and where he developed the first building energy optimization technique that provably converges to the optimal building design. He is a recipient of the bi-annual Outstanding Young Contributor Award of IBPSA and of the bi-annual Distinguished Achievements in Building Simulation Award of IBPSA-USA. He is the Chair of the College of Fellows of IBPSA, an IBPSA Fellow, and a member of the Board of Directors of the Modelica North America Users' Group. He was Treasurer of IBPSA and President of IBPSA-USA.

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15) **Speaker:** Dr. Jan Drgona, Pacific Northwest National Laboratory, USA

Title: Differentiable Programming for System Identification and Control of Buildings

Abstract: In this talk we introduce a differentiable programming methodology for domain-aware learning of surrogate models and constrained control policies for nonlinear dynamical systems. In particular, we present a differentiable predictive control (DPC) methodology as a data-driven solution to multiparametric programming problems emerging from explicit nonlinear model predictive control (MPC). DPC method is based on two sequential steps, i) system identification using a constrained neural state-space model, and ii) optimization of closed-loop dynamics with explicit neural control law. By incorporating domain knowledge and leveraging established techniques from optimal control, the DPC method leverages deep neural networks as nonlinear function approximators for system identification and explicit control laws while avoiding concomitant costs of intractably large datasets. The scalability, data eciency, and constrained optimal control capability of the proposed DPC method are demonstrated in simulation using a multi-zone building emulator. Furthermore, we experimentally demonstrate the computational and memory efficiency of DPC in embedded implementation on a laboratory device with nonlinear dynamics.

Speaker Bio: Jan is a data scientist in the Physics and Computational Sciences Division (PCSD) at Pacic Northwest National Laboratory. His current research focus falls in the intersection of deep learning, constrained optimization, and model-based optimal control. Before joining PNNL, Jan was a postdoc at KU Leuven, Belgium, where he was working on the implementation of model predictive control (MPC) in real-world oce buildings. Jan has a PhD in Control Engineering from Slovak University of Technology in Bratislava, Slovakia. His PhD thesis was on Model Predictive Control with Applications in Building Thermal Comfort Control with the focus on explicit and learning-based MPC.