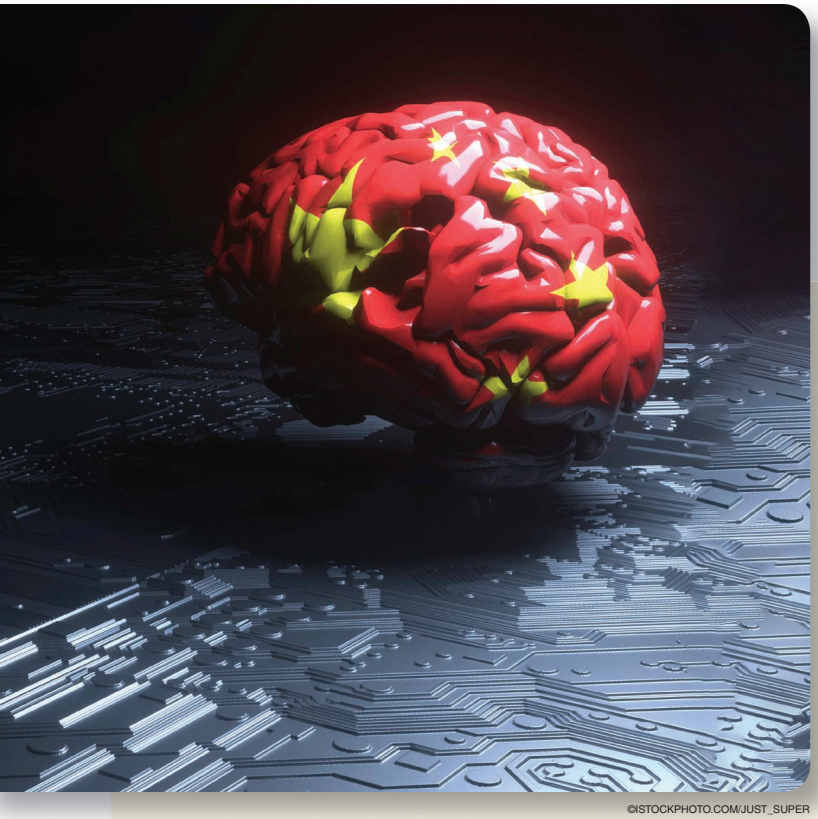
A Report on CPSS-Based Parallel Intelligence in SOLI, ICVES, and FISTS 2016



©ISTOCKPHOTO.COM/JUST_SUPER

Shuangshuang Han, Meng Lu, Xueliang Zhao, Hongxia Zhao, and Nan Zhang

***Abstract*—On July 10-12th, 2016, IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI), IEEE International Conference on Vehicular Electronics and Safety (ICVES), and IEEE International Forum on Integrated and Sustainable Transportation Systems (FISTS) were held together in Beijing, China. These three conferences were organized by the State Key Laboratory for Management and Control of Complex Systems (SKL-MCCS), Institute of Automation, Chinese Academy of Sciences, China and Chinese Association of Automation. With continuous efforts and improvement, IEEE SOLI, ICVES, and FISTS have already become an influential event and good communication platform. The scholars, researchers and practitioners have been attracted from academic institutions, universities and industrial companies all over the world, focusing mainly on SOLI, VES, and ISTS. More than one hundred participants from various countries had deep discussions on definition, challenges and alternative solutions for SOLI, VES and ISTS areas. These conferences were honored to have 7 distinguished keynote speakers, who shared their ideas, studies, field applications, and vision of parallel intelligence for future research and industrial directions. The theory of parallel intelligence can thus be seen widely applied to a variety of areas including parallel transportation management systems, parallel driving, parallel blockchain, parallel testing, parallel networks and other areas.

Digital Object Identifier 10.1109/MITS.2018.2880267
Date of current version: 19 November 2018

I. Introduction

IEEE/INFORMS International Conference on Service Operations and Logistics, and Informatics (SOLI) [1] is one of the most important conference in service science area. It aims to provide a platform for academic and industrial experts in this area to deeply discuss related techniques, issues, challenges and the future directions, and communicate the new research achievements and experience with each other in the related areas, such as service design, innovation, marketing, operations and so on. With continuous efforts and improvement, SOLI has already become an influential event and good communication platform for the scholars, researchers and practitioners from academic institutions, universities and industrial companies all over the world, focusing mainly on service operations and logistics, and informatics. IEEE SOLI 2016 received submitted papers from all over the world related service operations, service innovation, logistics and supply chain, service marketing, service management and many other aspects. Research contents cover the whole field of the development of service science and technology, and reflect the latest achievements in this field.

IEEE International Conference on Vehicular Electronics and Safety (ICVES) [2], and IEEE International Forum on Integrated and Sustainable Transportation Systems (FISTS) [3] are sponsored by IEEE Intelligent Transportation Systems Society (ITSS) [4]. These two conferences are mainly focused on intelligent vehicle and integrated transportation systems field, and provide the experts and scholars a communication platform for the discussions in automotive electronics & security and integrated traffic systems. IEEE ICVES 2016 and FISTS 2016 received submitted papers from the corresponding areas, such as vehicle detection technology, signal processing, microelectromechanical systems (MEMS), automotive/engine control, vehicle bus, driver assistant systems, sensor networks, adaptive cruise control system, water transportation, energy management, and so on. The research extends beyond information technology and intelligent technology developments applied in intelligent vehicles and transportation systems, and plays an important role for the future academic and industrial directions.

FIG 1 Opening speech from Professor Fei-Yue Wang.

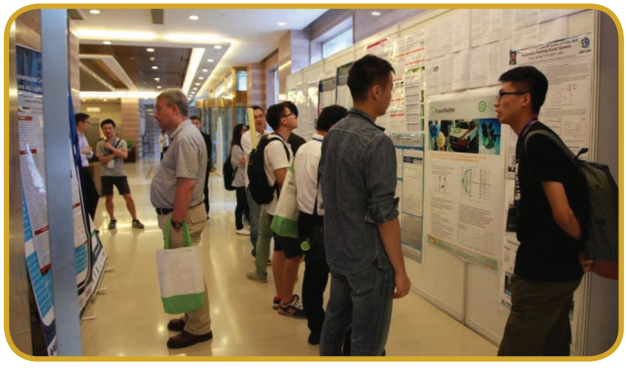


FIG 2 The poster area during the conferences.

These three conferences provide participators the precious opportunity to actively present their latest R&D achievements, renew contacts with colleagues, familiarize with new friends, and discuss the common interest R&D topics freely. Then, the researchers can identify challenges and future directions of these areas, and clarify the future R&D plan correspondingly. Artificial Intelligence has entered the 2.0 era with its one of the most important features, Hybrid Intelligence, where machines, information, and humans are tightly coupled through pervasive physical and social signals. This fact puts forward new requirements for us to think about the problems among complex systems in a cyber-physical-social systems (CPSS) way. The paradigm of Parallel Intelligence was originally proposed by Professor Fei-Yue Wang [5]–[8], which is an important and basic theory of Hybrid Intelligence. Parallel Intelligence is generated by the interactions between the physical and artificial systems, which is characterized by data-driven, modeling based on software-defined system, and system behavior analysis and evaluation based on computational experiment.

During the conferences, CPSS-based parallel system based on ACP (Artificial societies, Computational experiments and Parallel execution) approach [9]–[12] and its applications [13]–[20] have attracted great attention from academic and industrial experts. During the conferences, it was honored to invited 7 keynote speeches [21]–[27], who shared their ideas, studies, field applications, and vision for future research and industrial directions. These talks includes applications of CPSS-based parallel system in intelligent transportation, intelligent vehicles, logistics, etc. All the invited experts stated that parallel system and ACP approach would be a novel paradigm for service operations and logistics, and informatics, vehicular electronics and safety, and integrated and sustainable transportation systems areas.

II. The Conferences

These conferences attracted scholars and experts from many countries, e.g. the United States, China, Britain, Germany, Finland, Austria, Holland, Japan, Singapore and so on. Hundreds of participants attended the conferences, which includes 7 keynote speeches, 3 workshops, 41 technical presentations and 37 poster presentations (Fig. 2). The main topics consists

of academic achievements, key issues & concerns, and the future directions about service operations, logistics & information technology, vehicular electronics & safety and integrated & sustainable transportation systems. Experts, scholars and researchers all over the world had a deep discussion on problems, issues, solutions, definitions, and directions on these areas.

A. Keynote Speeches

Seven lecturers shared their research and studies from various perspectives in SOLI, VES and ISTS area (Fig. 3).

The first talk is "Introduction of Automated Vehicle on Roads - Impact to Society and Technology" from A3PS Austrian Association for Alternative Propulsion Systems, Austria [21]. 100 years development of road vehicles and building the required road infrastructure had an enormous impact to mobility and society we experience today. One can anticipate another paradigm change to our society and mobility within a timeframe to 2050. Beside the significant technology progress in vehicle automation on roads up to SAE level 5 - which includes significant challenges in technology and applications - the bigger challenges will appear on the societal aspect. Automated vehicle will allow every citizens to drive - without driver license - in the age from 0-100+, resulting in an even higher number of vehicles (or not?). Accessibility to mobility shall be equal to every citizen - not just those own a road vehicle. How can we organise vehicle movement on road in a way not necessarily request building new roads or restrict mobility by legal regulations. How can we better utilise infrastructure capacity to balance demand on mobility of citizens. Which technologies will lead this development on vehicle side, on infrastructure side and the future role on mobile devices each individual will use to organise his mobility demand? Opportunities and threats have been discussed to address major challenges for the mobility system of the future and there stepwise transition from today towards 2050.

The second talk, from University of Michigan Transportation Research Institute, USA, is titled by "Next Generation Traffic Control with Connected and Automated Vehicles" [22]. Traditionally traffic signal systems are designed in such a way that different time slots are allocated to conflicting traffic streams in order to ensure vehicle safety. In the future, such design constraints may be relaxed with connected and automated vehicle (CAV) streams because crash avoidance can be achieved through distributed control of vehicle trajectories, therefore traditional traffic signals may no longer be needed. Although the duration of the transitional period from the state-of-the-practice with very low percentage of CAVs to the future "signal-free" state is uncertain, it is important for both traffic management agencies and traffic control industry to understand what might be happening during the transitional process and how we can better prepare and facilitate the transition. This talk discussed the opportunities and challenges for traffic control systems with varying percentage of connected and automated vehicles. In particular, it presented their findings using the massive data set collected from the Safety Pilot Model Deployment project and Ann Arbor Connected Vehicle Test Environment, both supported by USDOT.

The third talk, from Department of Automation, Tsinghua University, China, is titled by "Intelligence Testing for Autonomous Vehicles: A New Approach" [23]. They study how to test the intelligence of an autonomous vehicle. Thorough testing is crucial to both vehicle manufactories and customers. Existing testing approaches can be categorized into two kinds: scenario-based testing and functionality-based testing. This talk first discussed the shortcomings of these two kinds of approaches, and then proposed a new testing framework to combine the benefits of them. Experiments show that this new approach answers what the intelligence of an autonomous vehicle is and is able to solve how to test the intelligence of an autonomous vehicle.

The fourth talk, from Institute of Automation, Chinese Academy of Sciences, China, presented about "Transportation 5.0: Five Transportations in One and Blockchain-based ITS" [24]. Blockchain, widely known as one of the disruptive technologies underlying Bitcoin and other cryptocurrencies, is experiencing rapid development and has the full potential of revolutionizing the increasingly centralized intelligent transportation systems (ITS) in applications. Blockchain can be utilized to establish a secured, trusted and decentralized autonomous ITS ecosystem, creating better usage of the legacy ITS infrastructure and resources, especially effective for crowdsourcing technology. This talk presented the basic idea of blockchain, an ITS-oriented blockchain model (B2ITS), the key features and research issues in B2ITS, as well as the relationship between B2ITS and PtMS (Parallel Transportation Management Systems). It also discussed the potential applications of B2ITS in "Five Transportations in One", which is a new direction for ITS theory and application, and also a major project being implemented in the beautiful eastern coastal city of Qingdao, China.

The fifth talk, from Advanced Vehicle Engineering Centre, Cranfield University, UK, is titled with "Collaborative Decision Making in Automated Vehicles towards Parallel Driving" [25]. Emerging development of intelligent vehicles and automated driving has received considerable attention recently worldwide, towards safer and more efficient road transportation. This talk will first review Cranfield's capacity along with recently secured more than £20 m funds in intelligent road mobility research, also including the £9 m 1-mile autonomous road living lab (MUEAVI (Multi-User Environment for Autonomous Vehicle Innovation)) on campus. Then a few selected recent/on-going research activities around joint decision making in automate vehicles will be presented, towards the framework of cyber-physical-social systems (CPSS) based parallel driving which has been under development.

The sixth talk presented "ACP-Based Self-Driving Vehicles" from Colorado State University, USA [26]. Self-driving vehicles are at the cutting edge of the intelligent technologies, which has attracted great attention and market potential. With

FIG 3 Keynote speeches of the conferences.

the development of intelligent technologies, self-driving vehicles are getting closer and closer to our daily life, and the corresponding techniques have been the focus of worldwide research and Industrial area. However, it is difficult to realize complete self-driving and its commercialization due to its low safety/reliability and high cost. As a novel self-driving system, ACP-based self-driving vehicles/roadside infrastructure system incorporates the theory of ACP, which performs the real-time interaction and optimization of the artificial self-driving system and the actual self-driving system. As a result, the proposed ACP-based self-driving system can achieve the intelligent control of self-driving vehicles and the global optimization of the system by vehicle modification, intelligent infrastructure construction, multi-sensor fusion, and machine learning algorithm application, etc. The proposed ACP-based self-driving system can effectively reduce the cost of high-precision equipment comparing to the conventional self-driving system, and it also achieves higher safety and reliability through the intelligent infrastructure and centralized control. Therefore, the proposed ACP-based self-driving system can meet the demands of self-driving and its commercial extension by providing high safety/reliability and low-cost solutions to self-driving application.

The last talk, from Beijing Jiaotong University, China, presented "Parallel Logistic Systems: ACP based Analysis and Management for China's Integrated Logistic Operations" [27]. With the promotion of economy development and logistics policies, Chinese logistics industry develops rapidly. The proportion of rail freight in total social freight has been declining while Social freight always increases. So it's necessary to renovate the rail transportation for solving related problems fundamentally and enhancing its competition. In this report, the core issue was discussed. That is how to avoid rail & truck disadvantages and give full play to their strengths, and build an integrated logistics system with rail transportation for the main mode and road for the other service such as receiving, transporting and distributing. The integrated logistics system could collect social bulk cargos and satisfy the rail transportation demand such as same time, same direction and large batch, as well as distribute bulk cargos to satisfy the social transportation demand of convenience. After that, this talk proposed a framework of parallel intermodal road-rail transportation systems (IRRTs) based on ACP approach. Therefore, the management and control for this system can be tested and computed, and the systems' operation efficiency will be improved.

B. The Applications

As discussed during the conferences, CPSS-based parallel system and ACP approach have been applied in various fields, e.g., parallel transportation management system, parallel vehicles, parallel network, parallel blockchain, parallel logistics, parallel testing, etc.

As one typical application, parallel transportation management system have been implemented in Qingdao, Shandong, China. The budget for that was over RMB 720 million (around $120 million). This project jointly considered mobile app data into the system, and used social signals from its artificial system. Due to its significant contribution for urban traffic in Qingdao, this project was honored "IEEE ITS Outstanding Application Award" at ITSC 2015.

Parallel driving, as another typical application, have also been launched in Changshu, Jiangsu, China. This project focused on conducting various services for operators under the principle of "simple inside vehicles, complex outside vehicles" for design and the implementation of connected vehicular platforms. Hopefully, the demo system of parallel driving would be finished on April, 2018.

Acknowledgment

These conferences would not have been successfully held without the tremendous efforts of the program and organizing committees. We are grateful to the Program Committee for their outstanding efforts in assembling such an excellent program, and to the authors who submitted the high quality papers from which the program was selected. We also gratefully acknowledge the IEEE/ITSS and INFORMS for sponsoring the conference. A special acknowledgment goes to the State Key Laboratory for Management and Control of Complex Systems, Chinese Academy of Sciences, and Chinese Association of Automation, who were mainly organizing IEEE SOLI, IEEE ICVES, and IEEE FISTS 2016 together. Our sincere appreciation also goes to all authors including those whose papers were not included in the program. And, finally, we will extend our thanks to all reviewers, volunteers and participants for their valuable contributions to this conference.

This work was supported in part by the National Natural Science Foundation of China 61501461 and 61533019; and the Early Career Development Award of SKLMCCS (Y3S9021F34).

About the Authors

Shuangshuang Han received the B.Eng. degree in communication engineering and the M.Eng. Degree in communication and information systems from Shandong University, Jinan, China, in 2006 and 2009, respectively. She received the Ph.D. degree in the Department of Electrical and Computer Engineering, University of Alberta, Edmonton, AB, Canada, in 2013. Currently, she is an assistant professor with the State Key Laboratory for Management and Control of Complex Systems, Institute of Automation, Chinese Academy of Science. Her research interests include parallel networks, social signal processing, Internet of Vehicles, and performance analysis of parallel network systems. Email: shuangshuang.han@ia.ac.cn.

Meng Lu Strategic Innovation Manager at Dynniq, The Netherlands; VP, IEEE ITS Society; Co-Chair, WG Industry

Engagement, IEEE 5G Initiative; In 2011-2015 Programme Manager at Dutch Institute of Advanced Logistics, The Netherlands; Participation in European initiatives and projects on ICT-based ITS since 2005 as Coordinator WP Leader and/or Partner. Education: PhD at LTH (Faculty of Engineering), Lund University, Sweden; Master's title and degree of Engineering in The Netherlands and P.R. China. Email:wklm@xs4all.nl.

Xueliang Zhao received the B.S. degree in automation from Beijing Forestry University, Beijing, China, in 2008 and the M.S. degree in computer applied technology from Institute of Automation, Chinese Academy of Sciences, Beijing, China, in 2011. He is currently an Engineer at the Institute of Automation, Chinese Academy of Sciences, and Chinese Association of Automation, and also working toward the Ph.D. degree with the State Key Laboratory for Management and Control of Complex Systems, Institute of Automation, Chinese Academy of Sciences, and with the University of Chinese Academy of Sciences. His research interests include social computing and intelligent information processing. Email: xueliang.zhao@ia.ac.cn

Hongxia Zhao received the Ph.D. degree in control theory and control engineering from the Institute of Automation, Chinese Academy of Sciences, Beijing, China, in 2009. She is currently working as an Assistant Researcher with The State Key Laboratory for Management and Control of Complex Systems, Institute of Automation, Chinese Academy of Sciences. Her research interests include intelligent control, data analysis and display. She is a member of the IEEE Intelligent Transportation Systems Society. She has been involved in the organization of many IEEE international conferences. Email: hongxia.zhao@ia.ac.cn.

Nan Zhang received the PhD Degree in Automatic Control from Institute of Automation, Chinese Academy of Sciences in 2009. Currently, she is an associate professor at Institute of Automation, Chinese Academy of Sciences, she is also the vice secretary and office director of Chinese Association of Automation. Her research interests include social computing, intelligent information process and social network. Email: nan.zhang@ia.ac.cn.

References

[1] "The handbook of conference program," *IEEE Int. Conf. Service Operations and Logistics & Informatics*, Beijing, China, 2016.

[2] "The handbook of conference program," *IEEE Int. Conf. Vehicular Electronics & Safety*, Beijing, China, 2016.

[3] "The handbook of conference program," *IEEE Int. Forum Integrated & Sustainable Transportation Systems*, Beijing, China, 2016.

[4] The IEEE Intelligent Transportation Systems Society. [Online]. Available: https://www.ieee-itss.org/. Accessed on: Nov. 14, 2018.

[5] F.-Y. Wang, "Moving towards complex intelligence?" *IEEE Intell. Syst.*, vol. 24, no. 4, pp. 2–4, July–Aug. 2009.

[6] F.-Y. Wang, X. Wang, L. Li, and L. Li, "Steps toward parallel intelligence," *IEEE/CAA J. Autom. Sin.*, vol. 3, no. 4, pp. 345–348, Oct. 2016.

[7] F.-Y. Wang, "Computational dissemination: Toward precision and smart impacts for computational social systems," *IEEE Trans. Comput. Soc. Syst.*, vol. 4, no. 4, pp. 193–195, Dec. 2017.

[8] F.-Y. Wang, Y. Yuan, X. Wang, and R. Qin, "Societies 5.0: A new paradigm for computational social systems research," *IEEE Trans. Comput. Soc. Syst.*, vol. 5, no. 1, pp. 2–8, Mar. 2018.

[9] F.-Y. Wang, "The emergence of intelligent enterprises: From CPS to CPSS," *IEEE Intell. Syst.*, vol. 25, no. 4, pp. 85–88, 2010.

[10] F.-Y. Wang, "Control 5.0: from Newton to Merton in popper's cyber-social-physical spaces," *IEEE/CAA J. Autom. Sin.*, vol. 3, no. 3, pp. 233–234, July 10, 2016.

[11] F.-Y. Wang, "Parallel system methods for management and control of complex systems," *Contr. Dec.*, vol. 19, no. 5, pp. 485–489, 2004.

[12] F.-Y. Wang, "On the modeling, analysis, control and management of complex systems," *Complex Syst. Complexity Sci.*, vol. 3, no. 2, pp. 26–34, 2006.

[13] F.-Y. Wang, "Parallel control and management for intelligent transportation systems: concepts, architectures, and applications," *IEEE Trans. Intell. Transp. Syst.*, vol. 11, no. 3, pp. 630–638, Sept. 2010.

[14] F.-Y. Wang et al., "Where does AlphaGo go: from church-turing thesis to AlphaGo thesis and beyond," *IEEE/CAA J. Autom. Sin.*, vol. 3, no. 2, pp. 113–120, Apr. 2016.

[15] L. Li, Y. L. Lin, D. P. Cao, N. N. Zheng, and F.-Y. Wang, "Parallel learning: A new framework for machine learning," *Acta Autom. Sin.*, vol. 43, no. 1, pp. 1–8, Jan. 2017.

[16] L. Li, Y. Lin, N. Zheng, and F.-Y. Wang, "Parallel learning: A perspective and a framework," *IEEE/CAA J. Autom. Sin.*, vol. 4, no. 3, pp. 389–395, 2017.

[17] F.-Y. Wang, "Agent-based control for networked traffic management systems," *IEEE Intell. Syst.*, vol. 20, no. 5, pp. 92–96, Sept. 2005.

[18] F.-Y. Wang, "Toward a revolution in transportation operations: AI for complex systems," *IEEE Intell. Syst.*, vol. 23, no. 6, pp. 8–13, 2008.

[19] F.-Y. Wang, L. Yang, X. Cheng, S. Han, and J. Yang, "Network softwarization and parallel networks: Beyond software-defined networks," *IEEE Netw.*, vol. 30, no. 4, pp. 60–65, 2016.

[20] F.-Y. Wang, "Parallel driving with software vehicular robots for safety and smartness," *IEEE Trans. Intell. Transp. Syst.*, vol. 15, no. 4, pp. 1381–1387, Aug. 2014.

[21] R. Pfliegl, "Introduction of automated vehicle on roads: Impact to society and technology," *Invited talks in IEEE Int. Conf. Service Operations and Logistics & Informatics, IEEE Int. Conf. Vehicular Electronics & Safety, and IEEE Int. Forum Integrated & Sustainable Transportation Systems*, Beijing, China, 2016.

[22] H. Liu, "Next generation traffic control with connected and automated vehicles," *Invited talks in IEEE Int. Conf. Service Operations and Logistics & Informatics, IEEE Int. Conf. Vehicular Electronics & Safety, and IEEE Int. Forum Integrated & Sustainable Transportation Systems*, Beijing, China, 2016.

[23] L. Li, "Intelligence testing for autonomous vehicles: A new approach," *Invited talks in IEEE Int. Conf. Service Operations and Logistics & Informatics, IEEE Int. Conf. Vehicular Electronics & Safety, and IEEE Int. Forum on Integrated & Sustainable Transportation Systems*, Beijing, China, 2016.

[24] Y. Yuan, "Transportation 5.0: Five Transportations in One and Blockchain-based ITS," *Invited talks in IEEE Int. Conf. Service Operations and Logistics & Informatics, IEEE Int. Conf. Vehicular Electronics & Safety, and IEEE Int. Forum Integrated & Sustainable Transportation Systems*, Beijing, China, 2016.

[25] D. Cao, "Collaborative decision making in automated vehicles towards parallel driving," *Invited talks in IEEE Int. Conf. Service Operations and Logistics & Informatics, IEEE Int. Conf. Vehicular Electronics & Safety, and IEEE Int. Forum Integrated & Sustainable Transportation Systems*, Beijing, China, 2016.

[26] L. Yang, "ACP-based self-driving vehicles," *Invited talks in IEEE Int. Conf. Service Operations and Logistics & Informatics, IEEE Int. Conf. Vehicular Electronics & Safety, and IEEE Int. Forum Integrated & Sustainable Transportation Systems*, Beijing, China, 2016.

[27] X. Zhang, "Parallel logistic systems: ACP based analysis and management for china's integrated logistic operations," *Invited talks in IEEE Int. Conf. Service Operations and Logistics & Informatics, IEEE Int. Conf. Vehicular Electronics & Safety, and IEEE Int. Forum Integrated & Sustainable Transportation Systems*, Beijing, China, 2016.

ITS