

## IECON08 Tutorial – Mo-Yuen Chow

### 1. Title: Distributed Network-Control Systems

### 2. Presenter contact information

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### 3. Abstract

A Networked Control System is a feedback control system wherein the control loops are closed through a real-time network. Distributed NCS (D-NCS) are multi-disciplinary efforts whose aim is to produce a network structure and components that are capable of integrating sensors, actuators, and control algorithms over a communication network in a manner to suit real-time applications. D-NCS has been gaining popularity due to their high potential in widespread applications and becoming realizable due to the rapid advancements in embedded systems, wireless communication technologies.

This tutorial presents fundamental details of network control systems. We will then present several concerns including network delay, packet loss, security, and resource allocation about NCS, D-NCS and solutions to integrate distributed sensors, distributed actuators, and distributed controllers. Several NCS and D-NCS projects in the Advanced Diagnosis, Automation and Control laboratory at North Carolina State University are used as examples to illustrate the technologies.

### 4. Presenter Biography

[Mo-Yuen Chow](#) earned his degree in Electrical and Computer Engineering from the University of Wisconsin-Madison (B.S., 1982); and Cornell University (M. Eng., 1983; Ph.D., 1987). Dr. Chow joined the [Department of Electrical and Computer Engineering](#) at [North Carolina State University](#) as an Assistant Professor in 1997, became an Associate Professor in 1993, and a Professor since 1999. He worked in U.S. Army, TACOM TARDEC Division as a Senior Research Scientist during the summer of 2003. He spent his sabbatical leave as a Visiting Scientist in 1995 in ABB Automated Distribution Division.

Dr. Chow's research focuses on diagnosis, control, and computational intelligence. He has been applying his research to areas including mechatronics, motors, power distribution systems, network-based distributed control systems, and robotics. He has established the *Advanced Diagnosis, Automation and Control* Laboratory at NC State University. He has published one book, five book chapters, and over one hundred journal

and conference articles. Dr. Chow is an IEEE Fellow, an Associate Editor of the *IEEE Transactions on Industrial Electronics*, and the Vice President for Publication of IEEE Industrial Electronics Society. He was the General Chair of IEEE-IECON05. Dr. Chow served as a guest editor for the *IEEE Transactions on Industrial Electronics* special sections on *Distributed Network-Based Control Systems and Applications* (2003), on *Motor Fault Detection and Diagnosis* (2000), and on *Application of Intelligent Systems to Industrial Electronics* (1993). He was a Senior Fellow of *Japan Society* for the Promotion of Science in 2003. He has received the IEEE Eastern North Carolina Section Outstanding Engineering Educator Award in 2004, and the IEEE Region-3 Joseph M. Biedenbach Outstanding Engineering Educator Award in 2005.

Selected Recent Publications related to the topic:

1. R. A. Gupta and M.-Y. Chow, "Overview of Time Sensitive Network Control Systems," in *Networked Control Systems: Theory and Applications*, Fei-Yue Wang and D. Liu, Eds.: Springer-Verlag, 2007.
2. Hongbo Li, Zengqi Sun, Mo-Yuen Chow, and Huaping Liu, "Output Feedback Control for a Class of Networked Control Systems," accepted for publication in *Asian Journal of Control*, October, 2007.
3. Y. Tipsuwan, and M.-Y. Chow, "Gain scheduler middleware: A methodology to enable existing controllers for networked control and teleoperation: PART I: Networked control," *IEEE Transactions on Industrial Electronics*, Vol. 51, No. 6, December, 2004.
4. Y. Tipsuwan, and M.-Y. Chow, "Gain scheduler middleware: A methodology to enable existing controllers for networked control and teleoperation: PART II: teleoperations," *IEEE Transactions on Industrial Electronics*, Vol. 51, No. 6, December, 2004.
5. M. Chow, "Guest Editorial on The Special Section on Distributed Network-Based Control Systems and Applications," *IEEE Transactions on Industrial Electronics*, Vol. 51, No. 6, 2004, pp. 1-2.
6. H. Li, Z. Sun, M.-Y. Chow, and B. Chen, "State feedback controller design of networked control systems with time delay and packet dropout," *Proceedings of IFAC WC 2008 (the 17th IFAC World Congress)*, Seoul, Korea, July 6-11, 2008.
7. H. Li, Z. Sun, M.-Y. Chow, and B. Chen, "A simple state feedback controller design method of networked control systems with time delay and packet dropout," *Proceedings of IFAC WC 2008 (the 17th IFAC World Congress)*, Seoul, Korea, July 6-11, 2008.
8. R. A. Gupta, A. K. Agarwal, M.-Y. Chow, and Wenye Wang, "Information security with real-time operation: performance assessment for next generation wireless distributed networked-control-systems," *Proceedings of IEEE IECON07 Taipei, Taiwan*, 2007.
9. R. A. Gupta, M.-Y. Chow, A. Agarwal, and W. Wang, "Characterization of data-sensitive wireless distributed networked-control-systems," *Proceedings of IEEE/ASME International conference on Advanced Intelligent Mechatronics ETH Zürich, Switzerland*, September 4-7, 2007.

10. Z. Li and M.-Y. Chow, "Sampling Rate Scheduling and Digital Filter Co-design of Networked Supervisory Control System," Proceedings of IEEE ISIE07, Vigo, Spain, June 4 - 7, 2007
11. Z. Li, M.-Y. Chow, "Adaptive Multiple Sampling Rate Scheduling of Real-time Networked Supervisory Control System – Part I" Proceeding of IEEE IECON06, Paris, Nov. 6-10, 2006.
12. Z. Li, M.-Y. Chow, "Adaptive Multiple Sampling Rate Scheduling of Real-time Networked Supervisory Control System – Part II" Proceeding of IEEE IECON06, Paris, Nov. 6-10, 2006.

5. Intended audience

This tutorial is intended for researchers and students who want to learn the basic of NCS and D-NCS technologies and their applications in industrial electronics areas.

6. List of topics to be covered

- Introduction to Network Control Systems
- Introduction to Distributed Network Control Systems
- Challenges and solutions of Distributed Network Control Systems
  - Packet delay
  - Packet drop
  - Security
  - Resource allocation
- Technologies in NCS and D-NCS
  - Gain Scheduling Middleware
  - Optimal State Feedback Stabilizing Gain Selection
  - Adaptive Resource Allocation
- Examples
  - iSpace at ADAC Lab, North Carolina State University
  - Networked Dc motor control
  - Network-based integrated navigation system