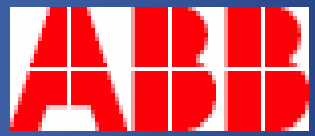
Wireless networked control of a mining ventilation system



University of l'Aquila

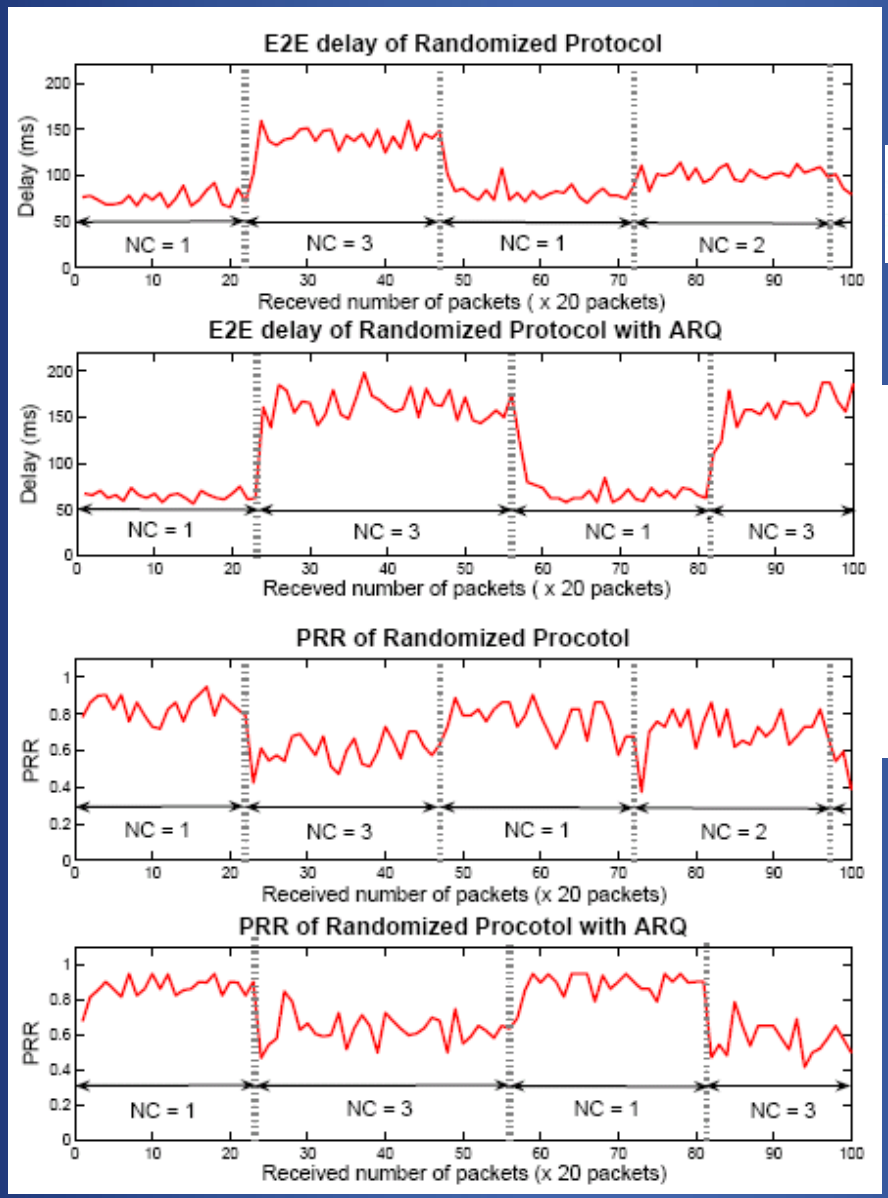
HYCON D4d.5.1: *Definition of extracted control problem for industrial test case on wireless automation*

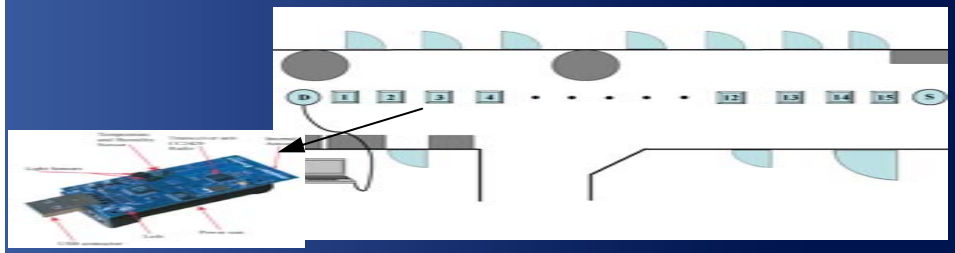
Challenges in control over multi-hop wireless networks

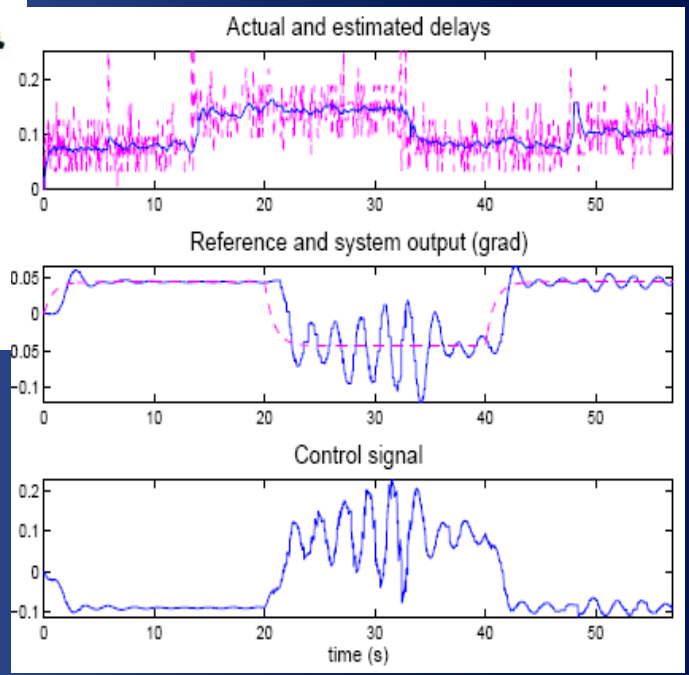
- Innovation:
  - Distributed smart embedded devices
  - Flexibility, deployment in automation
  - Large scale systems with complex dynamics
  - ➢ Integrate computation and communication in distributed control
- Technical issues:
  - Congestion - resource allocation
  - Information availability
  - Control under generalized constraints (physical, transmission…)

i.e. Communication & control

[Witrant & al., CCA 2007]



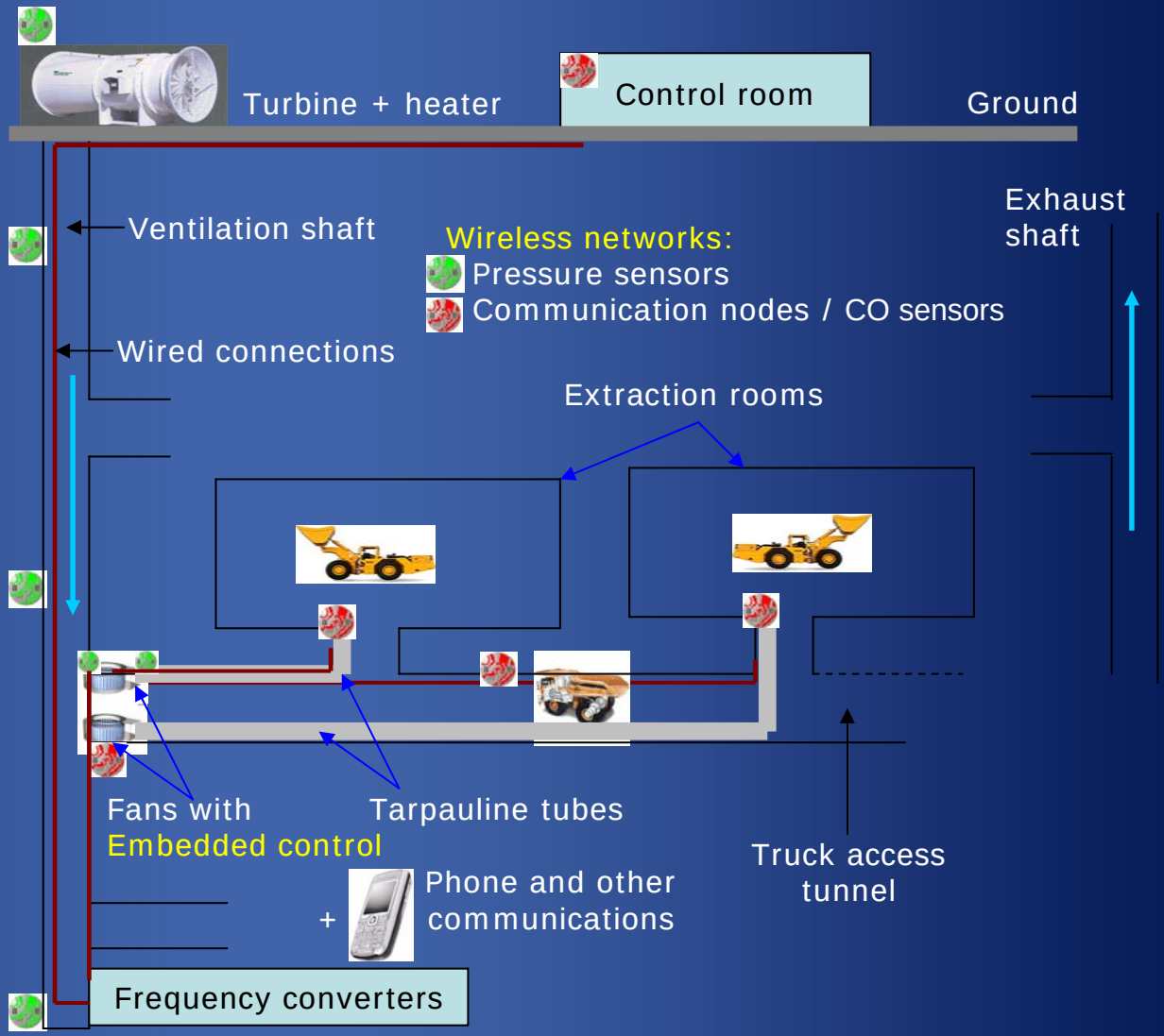




Explicit delay/jitter compensation

⇒ Integrated control approach

Mining ventilation



⇒ Minimize the amount of fresh air to save energy

Control architecture and conceptual design

- Embedded fan control:
  - Hybrid control (threshold) based on average CO values
- Control room:
  - Use distributed measurements to reduce model complexity
  - Model-based control under physical & communication constraints
- Sensors and communication network:
  - Heterogeneous (wired-wireless) architecture
  - Uniform radio technology

$$\tau(t) = n(t)F + \sum_{i=1}^{n(t)} (\alpha_i + \beta_i)$$

Compressible and viscous laminar flow

$$\frac{\partial \rho}{\partial t} + \frac{\partial \rho u}{\partial x} = 0$$

$$\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x}\right) = -\frac{\partial p}{\partial x} + \frac{\partial}{\partial x}\left[(\lambda + 2\mu)\frac{\partial u}{\partial x}\right] + \frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial y}\right)$$

$$\frac{\partial p}{\partial y} = \frac{\partial}{\partial x}\left(\mu\frac{\partial u}{\partial y}\right) + \frac{\partial}{\partial y}\left(\lambda\frac{\partial u}{\partial x}\right)$$

$$\rho c_v\left(\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x}\right) + \left(p + \frac{\rho u}{2} + \rho c_v T\right)\frac{\partial u}{\partial x} = \rho\dot{q} + \frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right) + (\lambda + 2\mu)\left(\frac{\partial u}{\partial x}\right)^2 + \mu\left(\frac{\partial u}{\partial y}\right)^2$$

$$p = \rho R T$$

Distributed pressure sensors

$$\dot{p}(t) = Ap(t) + B\int_{-\tau(t)}^{0} h(\theta)u(t-\theta)d\theta, \quad p(0) = p_0$$

Time-delay system

Conclusion

Motivation

Information technology components are increasingly used in complex engineering systems. The fundamental problems are essential both technologically and economically.

Need

The pervasive infiltration of computer systems (embedded systems and networks) in engineered products and in medicine and biology, requires transformational thinking and ideas in engineering research, education and entrepreneurship.

Our view point

- To use **model-based system integration methodology** combined with **an overall emphasis on compositional design methodology**. NEW DISCIPLINE!
- The first very important step is to find a correct model of the system and its constraints such that it is in the same time **theoretically plausible** and **practically credible.**

HOW to work?

EECI provides the right framework for this new discipline. Its role:

The establishment of the EECI is expected:

- to become a long-term world-wide renowned focal point by stimulating new collaborative (multi-national and multi-disciplinary) research on networked and embedded control

- to break down the barriers between the traditional disciplines
- to be a motor for the dissemination of methods and tools
- to promote the education of students and researchers and to transform engineering education
- to encourage the transfer of methodologies to industry and to learn new ways to enhance the transfer of innovation to products and the creation of an entrepreneurship culture
- to seek financial support from both industry (through industrial projects and teaching) and European and national research foundations

Conclusion

From the 

Network of Excellence
www.ist-hycon.org

to the creation of 

the European Embedded Control Institute
www.eeci-institute.eu

The HYCON NoE and its newly created institute EECI *(under French Association Law 1901),* which offers a legal structure for the Knowledge Community of Networked and Embedded Control, is very interested to contribute to the actions within ARTEMIS, providing methods and tools to reduce the effort for the design, implementation, and maintenance of high-performance embedded control systems.