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## Real-time communications in distributed control systems

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# Real-Time Communications in Distributed Control Systems

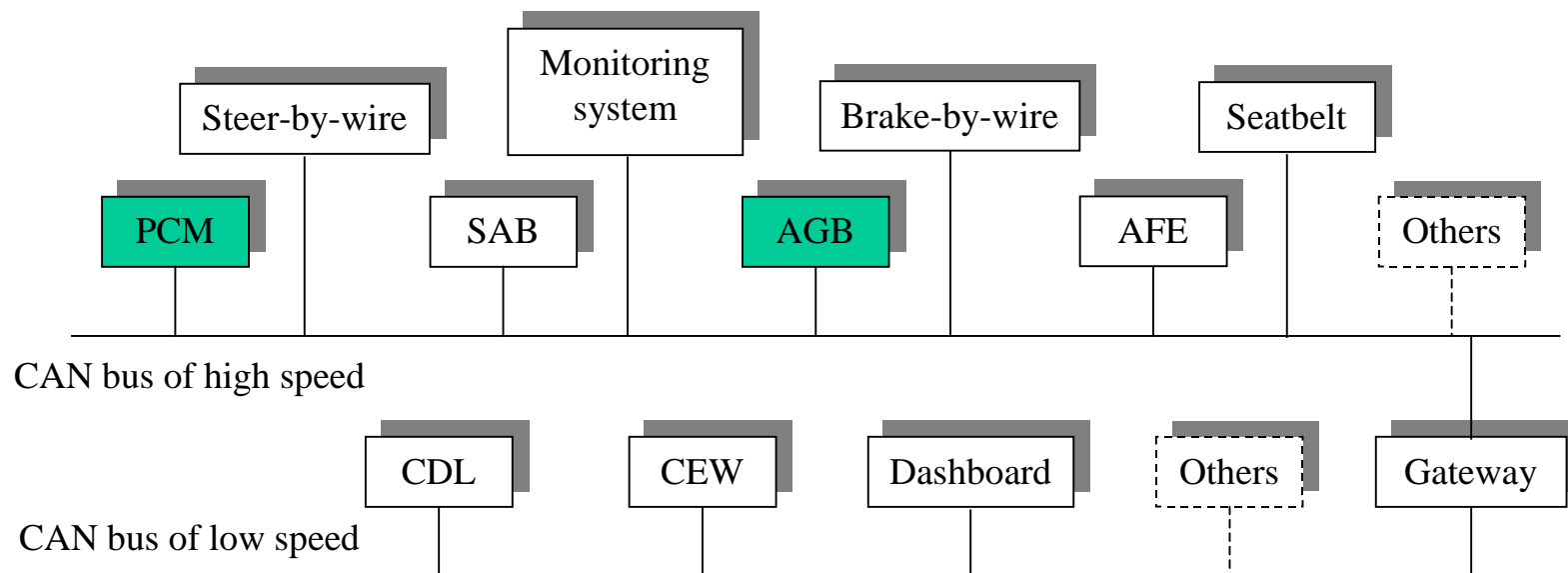
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TRIO Project at LORIA – UHP Nancy 1 - INRIA*

1. PRA SI99-04: In-vehicle embedded systems using CAN (*with WHUT, Li Gangyan*)
2. PRA SI01-04: Factory automation using fieldbus and switched industrial Ethernet (*with Zhejiang Univ., Sun Youxian, Wang Zhi*)

# PRA SI99-04: Objective

- Extend existing CAN-based embedded systems for including more functions
  - Defining new functional architecture
  - Performance evaluation to validate new operational architecture (functional architecture mapped on to a support architecture)
  - Dependability evaluation to validate the safety

# PRA SI99-04: Results



**PCM: Power Control Module**

**AGB: Automatic Gear Box**

**SAB: Safety Air Bag**

**AFE: Automatic Fire Extinction**

**CDL: Car Central Door Locking**

**CEW: Car Electric-Windows**

# PRA SI99-04: Results

- - [1] G. Y. Li, Y. Q. Song, H. S. Jin, “CAN (Controller Area Network) and its Application to Car Central Control System”. *Journal of Wuhan Automotive Polytechnic University*, Vol.22, N°1, pp.6-9, 2000 (In chinese)
- - [2] G.Y. Li, Y.Q. Song, P. Xiao and H.S. Jin, “Monitoring System of Car Information Central Control System”, *4th IFAC International Conference on Fieldbus Systems and their Applications*, pp135-137, Nov.15-16, 2001, Nancy (France), Elsevier Science Publisher

# PRA SI99-04: mutual exchanges

- Chinese in France
  - LI Gangyan, 4 months
  - YANG Mingzhong, 3 weeks
  - CHENG Sencheng, 3 weeks
  - JIN Haisong, 2 months
- French in China
  - SONG Yeqiong, 3 weeks
  - SIMONOT-LION Françoise, 1 week

# PRA SI99-04: Extended impact

- Internship of Ms. Lu Liping of WHUT at LORIA during one year, financed by the two labs. Her PhD thesis in « cotutelage » between INPL and WHUT will be soon set
- Y.Q. Song is invited prof at WHUT
- In china: Wuhan City International Cooperation Project: “Research of the Car Information Central Control Network Technology and its Application”. No. 13 20017010121
- In France: a PhD thesis (CIFRE) with PSA on « dependability of X-by-Wire »

# PRA SI99-04: Anecdotal history

- The idea of this PRA project was born in a pub (bistro du Vélodrome) during the first sojourn of Prof. LI in Nancy (as part of an exchange program between Lorraine and Hubei province), a big amateur of beers
- LORIA was working on in-vehicle embedded systems
- WHUT knows well the electronic control units in a vehicle





# PRA SI99-04: future cooperations

- Informal exchanges via emails for supervising the PhD thesis of Ms. JIN Haisong
- PhD thesis of Ms. LU Liping in « co-tutelage » (hope she will get a French Embassy PhD grant in 2003)
- Proposal of another PRA project in 2002

# PRA SI99-04: Concluding remarks

- Fruitful pluridisciplinary cooperation within PRA SI99-04 (LORIA in distributed real-time systems and WHUT in automotive)
- More Chinese in France than French in China
- Willing to perpetuate our cooperation. **In which better ways (EU Projects) ?**
- ... *(to be completed by Prof. LI Gangyan)*

# Now fly to Zhejiang University



# PRA SI01-04: History

- Before PRA, PhD thesis of Wang Zhi in Shenyang Institute of Automation, then his postdoc in Zhejiang University followed by his sojourn at LORIA (Postdoctoral Grant of French Embassy)
- Common research topic: fieldbus (Nancy is the birth place of WorldFIP fieldbus)
- Complementary:
  - **System:** TRIO of LORIA in design, modeling and validation of distributed real-time systems
  - **Application:** NLECT of Zhejiang Univ. in process control and factory automation

# PRA SI01-04: Objective

- Study real-time guarantee when replacing traditional fieldbus by switched industrial Ethernet
- Research problems:
  - Performance evaluation
  - Dynamic real-time QoS guarantees
    - admission control mechanisms
    - message scheduling algorithms

# PRA SI01-04: Interests for partners

- For France:
  - Higher manpower in this research topic
  - More experimentations of industrial Ethernet in Chinese industry (no past fieldbus history to manage)
- For China:
  - Enhancement of research (against development) in factory communication
  - More opportunities for industrial deployment of research results, as China wants to become the world center of advanced manufacturing (CIMS) and Chinese industry has not past fieldbus history to manage

# Real-time guarantees in Switched Ethernet

- HRT (Hard Real-Time)
- SRT (Soft Real-Time)
- *WHRT (Weakly-Hard Real-Time) or  $(m,k)$ -firm* : we obtained very interesting results

Just a little bit more  
technical presentation

## In the future

- Implementation of Matrix-DBP for Switched Industrial Ethernet to provide  $(m,k)$ -firm real-time guarantee
- Response time evaluation methods (based on network calculus) for factory communication systems involving both Fieldbus and Ethernet
- More theoretic study on  $(m,k)$ -firm [a LIAMA project is proposed in 2002]