Evaluation of Response Time in Ethernet-based Automation Systems

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Outlines

- Context and approach

- Model
  - Delays analysis
  - Structure of Generic Model

- Results
  - Simulation of a particular architecture
  - Influence of resources sharing
  - Result interpretation

- Conclusions
Context

- **Ethernet-based automation system**
  - Devices: controllers, RIOM
  - Protocols: Ethernet, TCP/IP
  - Cooperation: Client/Server

- **Response time**
  - Delay between the occurrence of an input event and the occurrence of the corresponding output event

- **Evaluation of response time distribution**
Our approach

- **Simulation of Petri Net models of the systems**
  - Main advantages
    - provides a response time distribution while analytic methods yield only boundaries
    - faster than exhaustive state space analysis
  - Limitations
    - non exhaustive analysis
    - possible long simulation time

- **Modeling formalism: Hierarchical Colored Timed PNs**
  - Colored PNs allow us to build a generic model
  - Hierarchical PNs ease the model design
Delays analysis

- Three delay causes
  - data processing
  - waiting for synchronization
  - waiting for resources
Structure of Generic Model

- **Petri net structure**
  - is derived from the physical architecture

- **Colored tokens**
  - represent resources or data
Simulation of a particular architecture

- **Feature of this architecture**
  - Only switches are shared

- **Simulation**
  - Software: CPNTools
  - Simulation time: 2 hour for computation of 10,000 delays

- **Results**
  - histogram
  - lower bound = 7.5 ms
  - upper bound = 22 ms
Influence of resources sharing

- Architecture Features

  - Only switches are shared
  - Switches and 4 DIODs are shared
  - Switches and all DIODs are shared
Result interpretation

- Small impact of resource sharing on the mean value and the distribution shape of delay

- Significant impact of resource sharing on the upper bound of delay

- With these results, engineer could decide if resource sharing Ethernet architecture is suitable
Conclusions

▪ This paper has presented
  • a Colored Petri Model of Ethernet-based automation system using client/server cooperation
  • simulations to evaluation response time distribution of particular architectures

▪ Main result
  • client/server cooperation could be used in Ethernet-based automation system in conjunction with a technique of analysis to guarantee the response times

▪ Current works
  • response time comparison between architectures using client/server cooperation and architectures using master/slave or producer/consumer cooperation
  • response time evaluation using exhaustive analysis based on model-checking approach