Karlsruhe Institute of Technology

Technology for Pervasive Computing

WoR-MAC: Combining Wake-on-Radio with Quality-of-Service for Intelligent Environments

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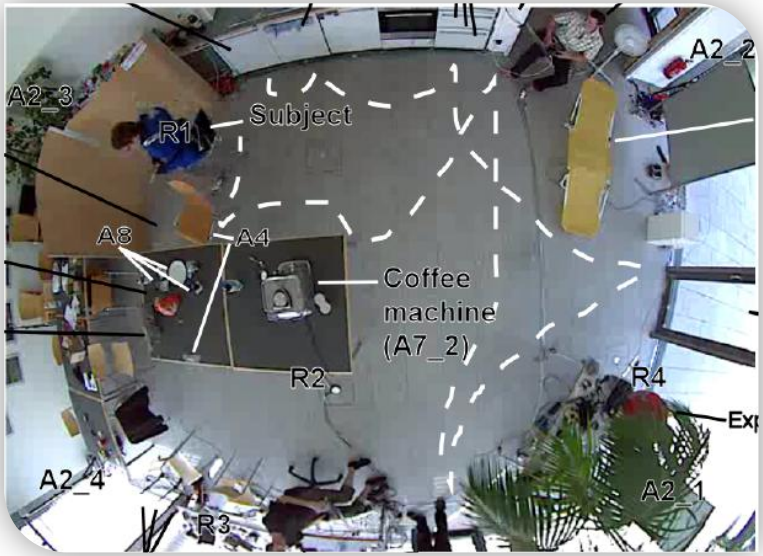
Motivation – Intelligent Environments

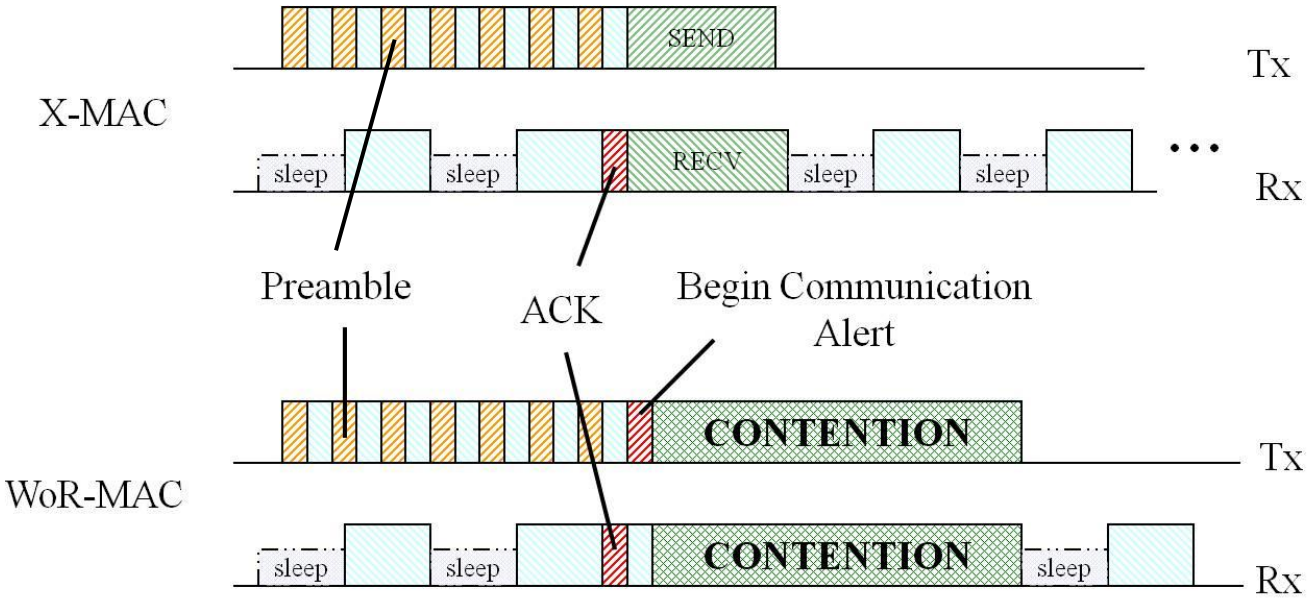
- Heterogeneous mobile/non-mobile devices
  - Power consumption – lifetime critical aspect
- Various human-centric applications
  - Different communication modalities
  - Different QoS requirements
- Wireless communication necessary
  - Reduce energy consumption w/o sacrificing QoS?



WoR-MAC – Protocol Design

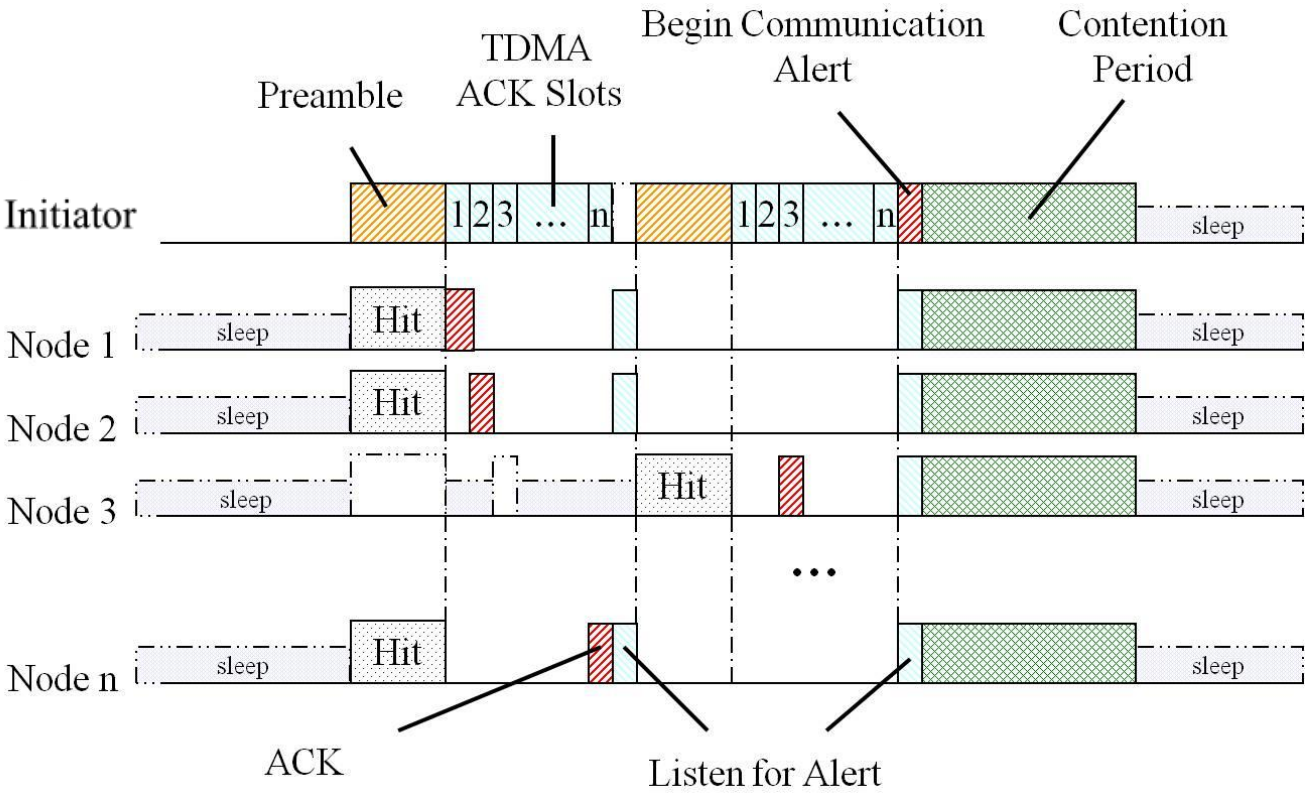
- X-MAC – targeted wake-ups using strobed, addressed preambles
  - Low power consumption
  - Static QoS properties
  - High overhead for each packet

  How can we combine power consumption of X-MAC with QoS of other protocols?
- WoR-MAC – allow nodes to wake to contention



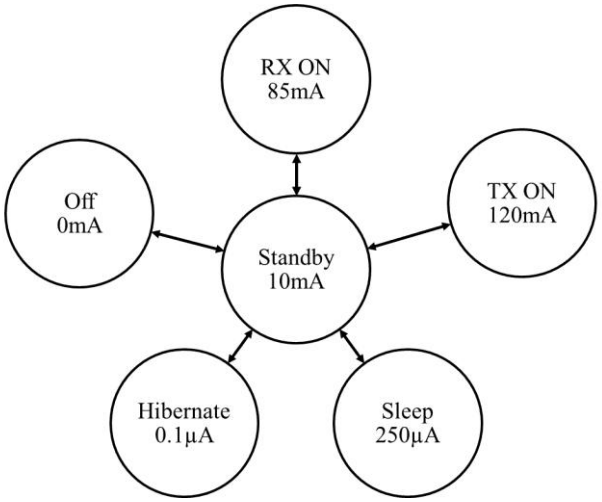
WoR-MAC – Protocol Design

- Group-addressed wake-ups
- Parameterized ACKs



Simulation Environment

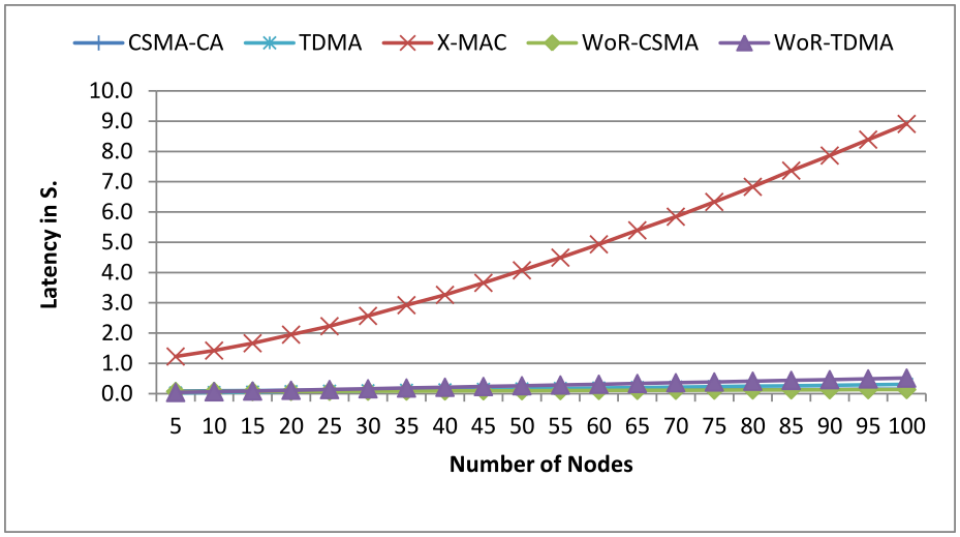
- Modeled using OPNET simulator
- Evaluated using CSMA-CA and TDMA
- Generic IE application modeled
- Test “subject” enters room every 10 mins
- Stays for 5 mins, repeated over 12 hrs
- Communication period initiated every 5s
  - Initiation done by user
- Each node generates 1 - 5 packets
- Each packet addressed to 1 - 5 receiver nodes
- 2m x 3m area, 5 – 100 nodes step 5
- Monitored:
- QoS: latency, packet loss
- energy consumption

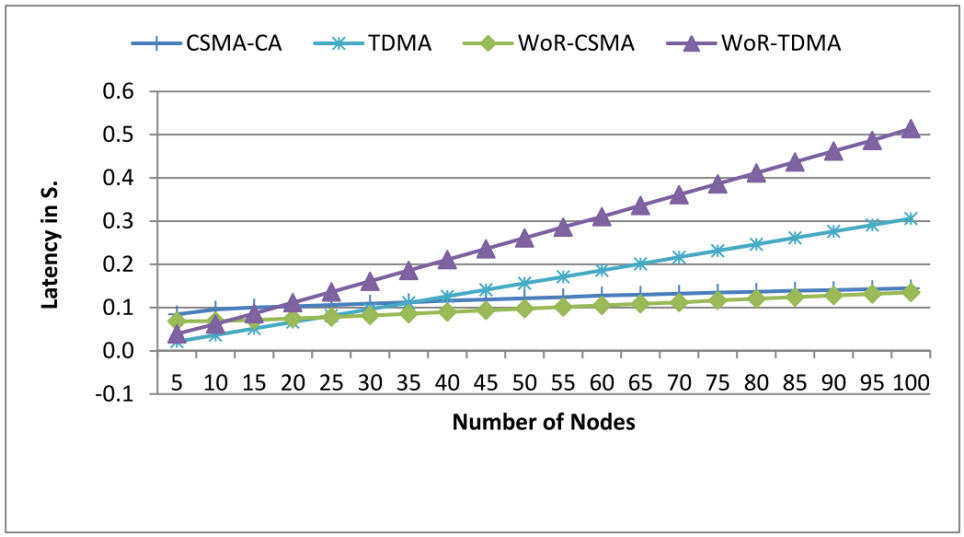


States of CC2420

Results - Latency

- X-MAC latency order of magnitude higher
- WoR increases dependence on # of nodes
- WoR-TDMA shows expected offset
- WoR-CSMA improves latency over CSMA-CA
  - Due to discarding packets at end of period
  - Affects packet loss

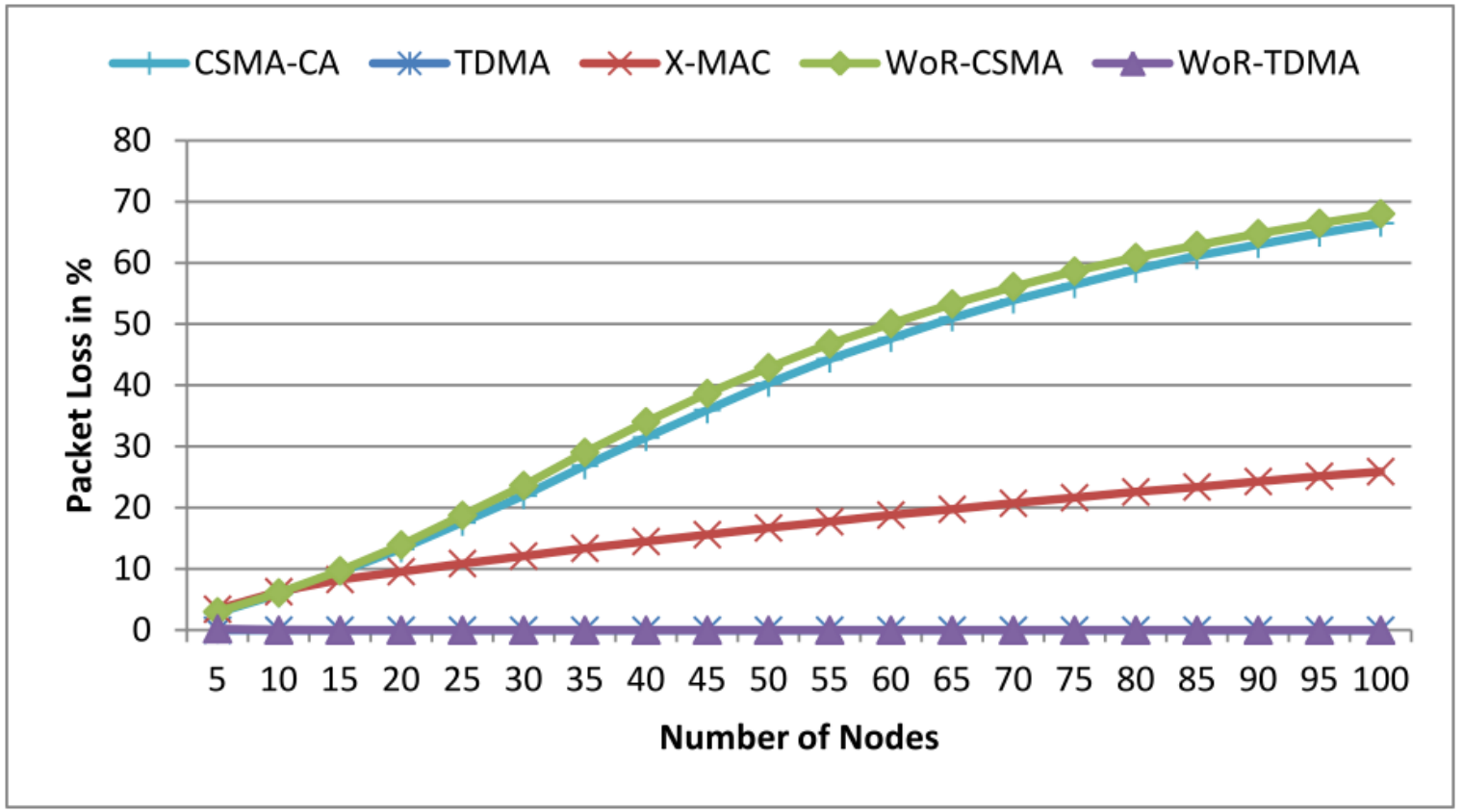




WoR-MAC maintains latency, accounting for initial delay

Results – Packet Loss

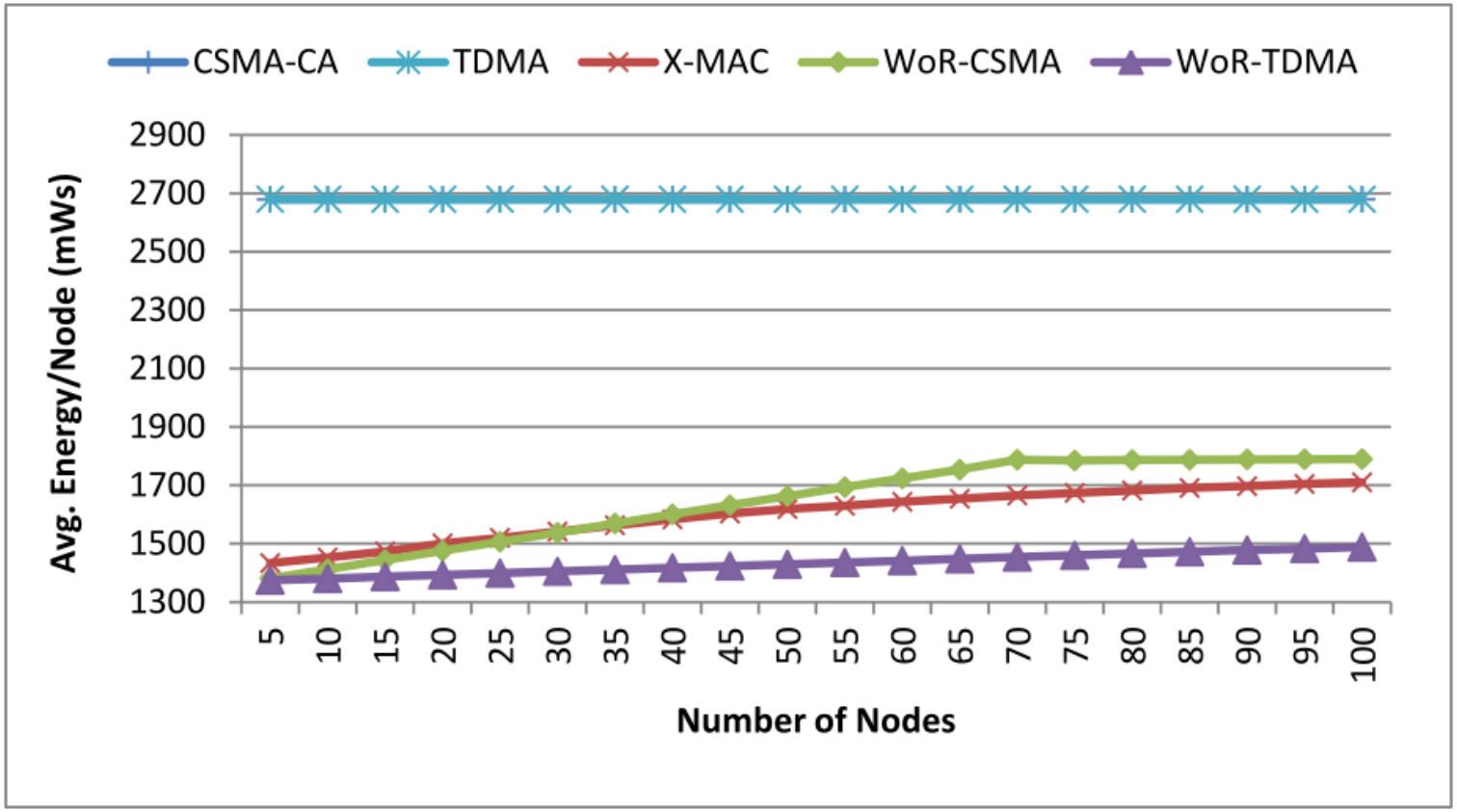
- Average packet loss



WoR-MAC maintains packet loss across embedding

Results – Energy Consumption

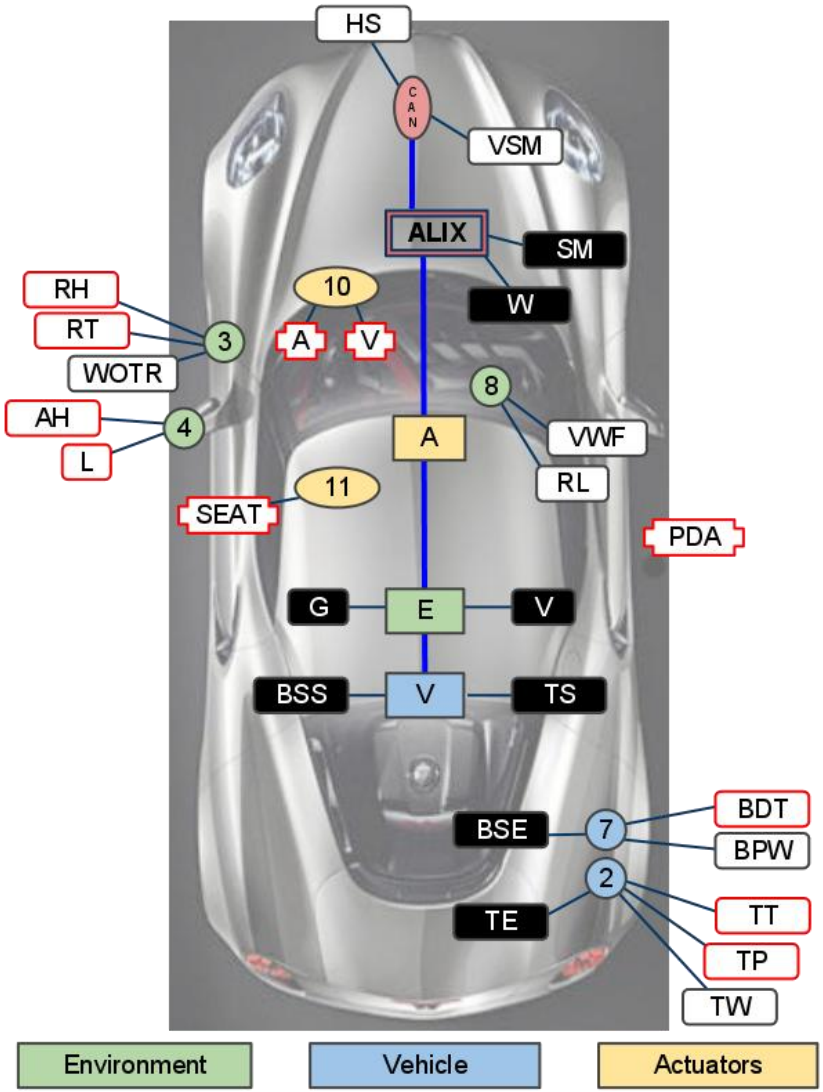
Average energy consumed per node



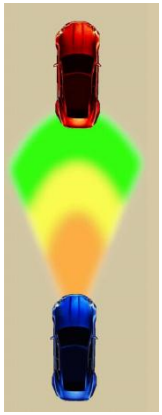
WoR-MAC reduces energy, sometimes surpassing X-MAC

OTHER APPLICATIONS

Automotive Sensing/Actuation(CRF)



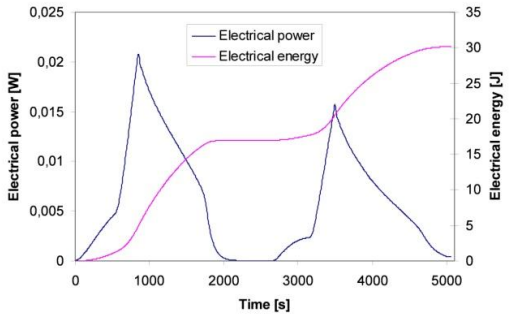
- Sensor-actuator network to reduce cable-tree
  - Increase redundant communication pathways
- 3 different levels of danger
- Each level with different QoS-energy consumption trade-off
- WoR-MAC switches embedded MAC to meet warning level requirements

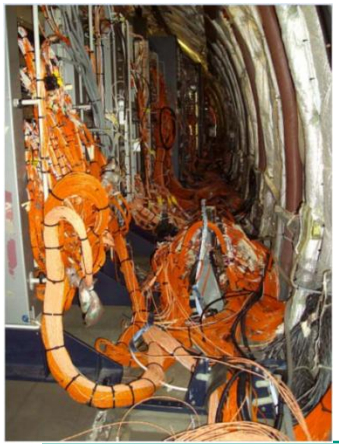


3 WARNING LEVELS
None
Warning
Alarm

Aeronautic structural monitoring

- Structural monitoring in airplanes
  - Door surrounding impact detection
  - Fuselage structural health monitoring
- Weight is crucial
- Reduce cables, increase maintainability
- Constant sensor measurements
  - Temperature differential harvesting
- Data communication on tarmac





Conclusion

- IE's have special requirements
  - Low power for mobile devices / post-hoc
  - App dependent QoS
- WoR-MAC – WoR-CSMA and WoR-TDMA
  - Low activity => low power consumption
  - High activity => QoS of embedded protocol
- Applications outside of IE

THANK YOU!

QUESTIONS?!