

Protokolle zur internen Uhrensynchronisation in sicherheitskritischen Echtzeitsystemen

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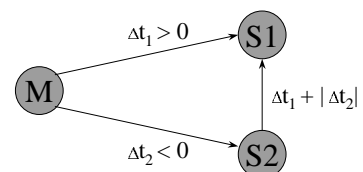
Melody Environment

- distributed real-time safety-critical operating system MELODY
- global deadlines
- no external clock synchronization
- unicast / hardware supported broadcast communication
- hardware / software: 100 Mbps Ethernet LAN of Pentium III, 500 MHz, 128 MB, HD 13 GB, Linux Suse 6.2, kernel 2.2.12



Problem

- use of internal clock synchronization for global deadline support
- master / slave mechanism
- potential disharmonious behavior with unicast communication

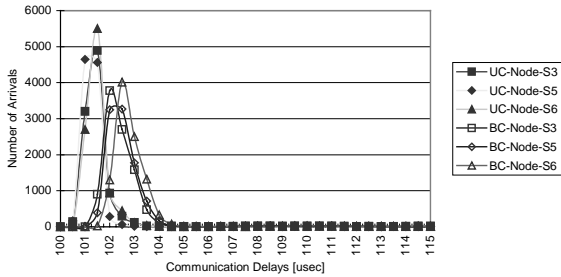


→ verified by experimental evaluation



Measuring Clock Deviations

- roundtrip message:
master → slave → master
- communication delays (10.000 measurements)



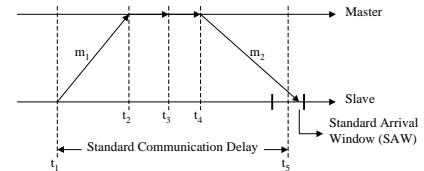
Properties:

1. standard communication delay
2. standard / minimum com. delay differ at most 2 μsec
3. unicast / broadcast messages differs at most 2 μsec
4. symmetry
5. time stamp overhead at most 200 nsec



Real-Time Network Protocol (RTNP)

- Broadcast message from the master invokes the slaves to start the synchronization procedure.
- unicast roundtrip synchronization message

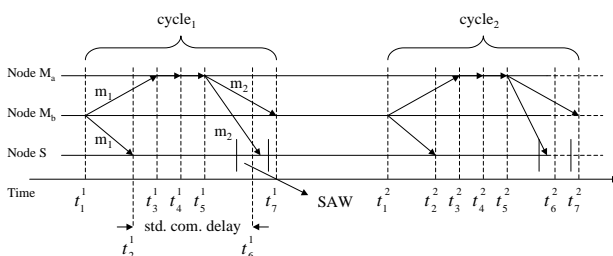


- m_2 includes master time stamp.
- If m_2 fails to fit into this window, it will be ignored, and another attempt has to be made.
- local update for clock drift correction



Real-Time Duplex Protocol (RTDP)

- start-master, synchronization-master
- protocol timing

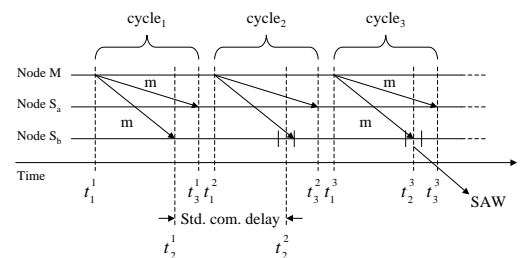


- sync. phase (MELODY): cycle₁, ..., cycle₁₂ [1.5 ms]
- m_2 includes master time stamp.
- If m_2 fails to fit into one of the windows, it will be ignored, and another cycle must be used.
- local update for clock drift correction



Real-Time Burst Protocol (RTBP)

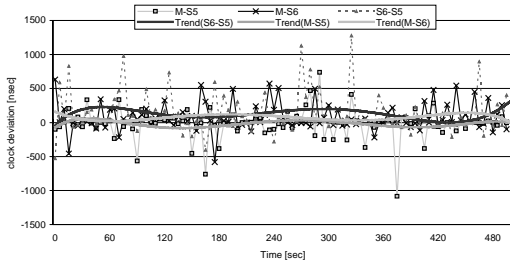
- protocol timing



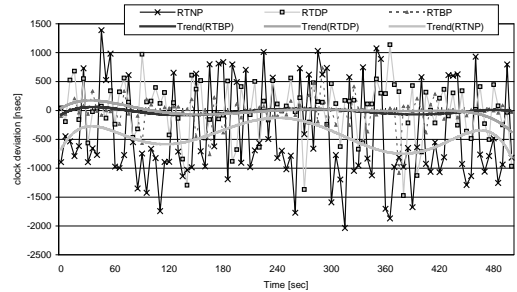
- sync. phase (MELODY): cycle₁, cycle₂, ..., cycle₁₂ [360 μs]
- m includes master time stamp.
- If m fails to fit into one of the windows, it will be ignored, and another cycle must be used.
- local update for clock drift correction



RTBP Evaluation



Accuracy of Master-Slave Synchronization



Conclusions and Future Work

- more details:
 - 12th Euromicro Conference on Real-Time Systems, Stockholm, Sweden, June 19 - 21, 2000
- disharmonious RTNP
- novel broadcast protocols RTDP and RTBP
 - harmonious behavior
 - higher accuracy than unicast
 - higher fault tolerance capability
- future work
 - installing the new protocols as MELODY functions
 - protocol overhead evaluation
 - fault tolerance studies