Embedded Performance Analysis for Organic Computing (EPOC)

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Overview

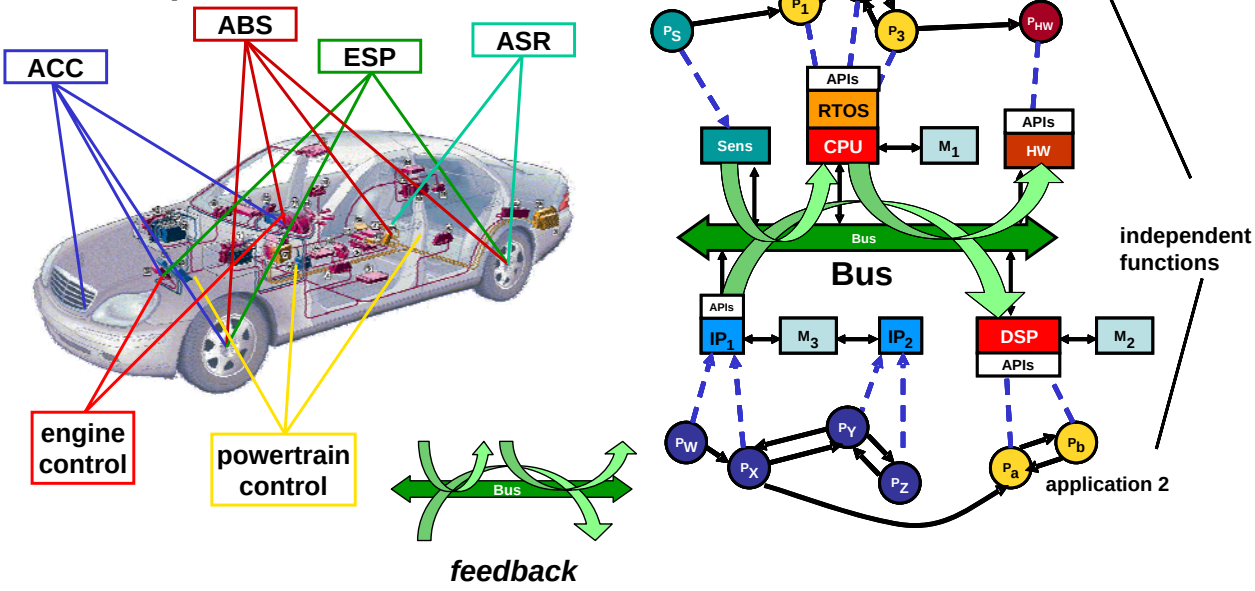
- **introduction**
- **embedded systems performance analysis - status**
- **online performance analysis**
- **towards organic systems**
- **work program**

Motivation

- high dependability requirements in many organic computing system applications
  - particularly in embedded systems (medical, traffic, ...)
- dependability includes performance and real-time (QoS) guarantees
- self protection against loss of performance guarantees needed in organic computing systems
- requires dependable online determination of performance properties

Embedded systems performance analysis - status

- integration of different system functions on a largely static platform
- example: automotive



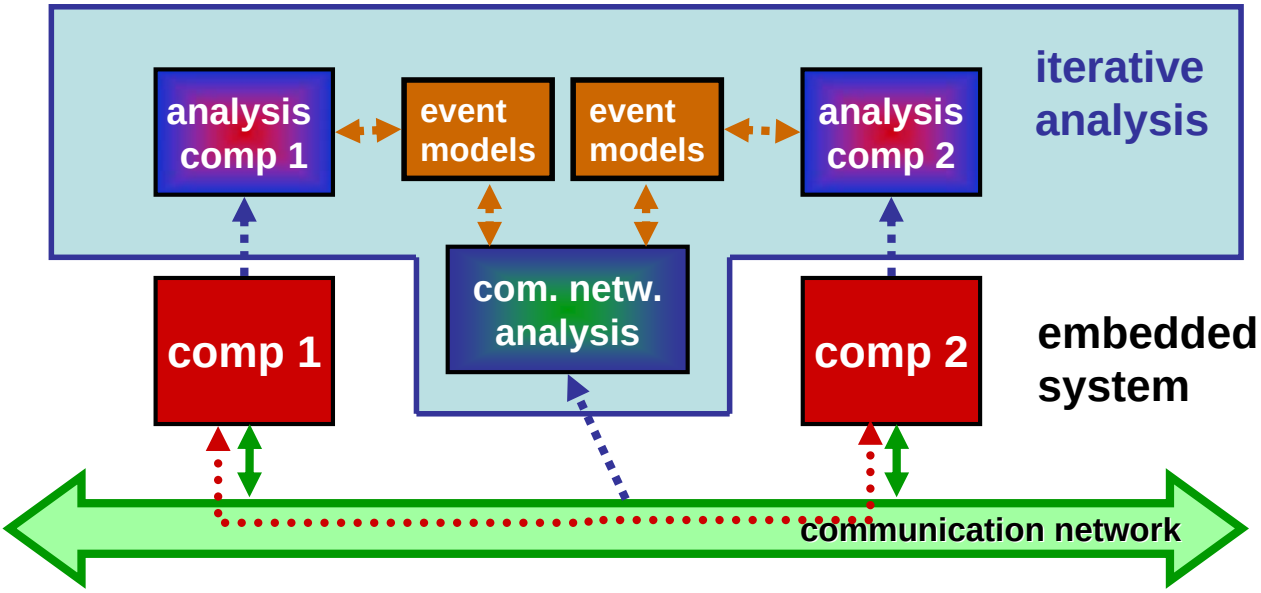
ES Performance Analysis - Status

- complex real time requirements
  - end-to-end deadlines and jitter constraints
  - performance control for low power systems (DVS, power modes)
  - buffer under- and overflow conditions ..
- simulation or measurement (profiling) are most popular to verify system performance
  - time consuming
  - decreasingly reliable for larger systems
- alternatives
  - conservative design styles (e.g. using TDMA for decoupling, see TTP)
    - requires known static properties – not appropriate
  - formal analysis

Formal ES Performance Analysis

- formal real-time analysis approaches have been developed for many years
  - typically limited to components or homogeneously scheduled clusters
  - no scaling to heterogeneous systems
- major advances in formal ES performance analysis in recent years
  - holistic approaches extending traditional analysis to cover different resource sharing strategies
  - compositional analysis combining different local analysis algorithms
    - using network calculus (Thiele, Chakraborty)
    - using parameterized event models (SYMTA/S)

Compositional ES Performance Analysis



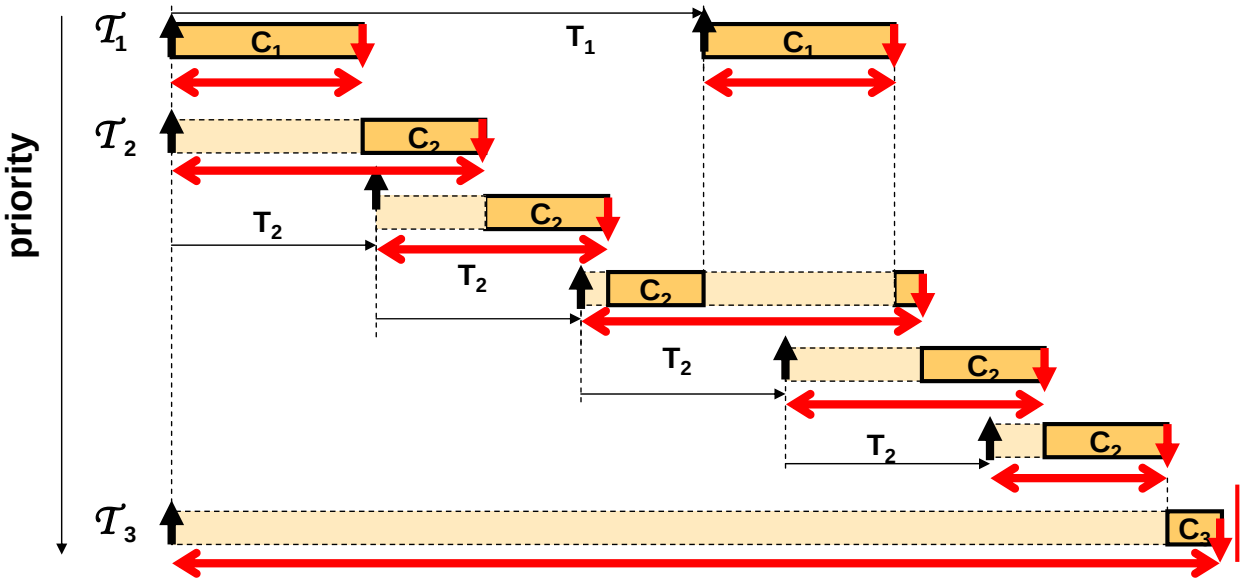
- events are iteratively propagated between local analysis modules
- local analysis solves system of fix point equations

Required Stream Analysis Input

- processes and communication models
  - execution time (interval)
  - communication volume (interval)
  - activation rules (time, event)
  - *dependencies (e.g. task graph, cycles, transactions, ...)*
- component models
  - available performance/bandwidth
  - scheduling strategies (processors and communication)

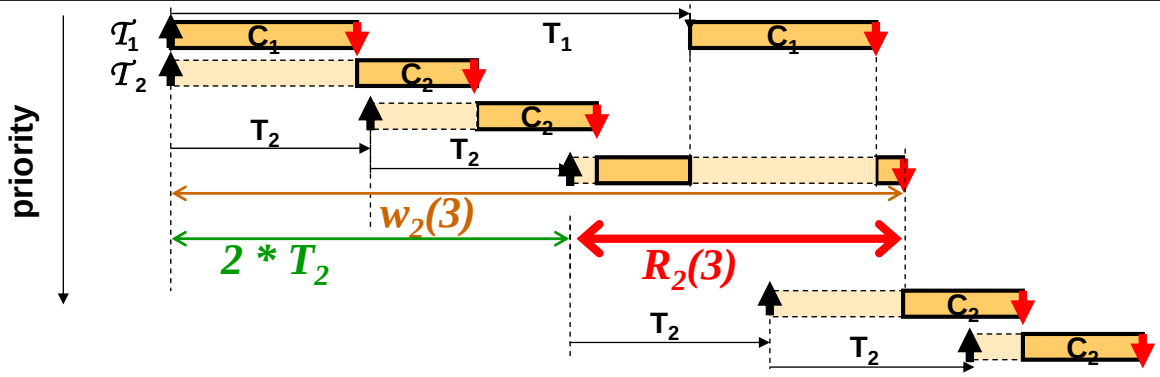
Analysis Example: Formal Analysis by Lehoczky

Assume: system with periods T, static priorities and „core“ execution times C



Find max total execution time, i.e. worst case response time R

Analysis Uses “Busy Window” Approach

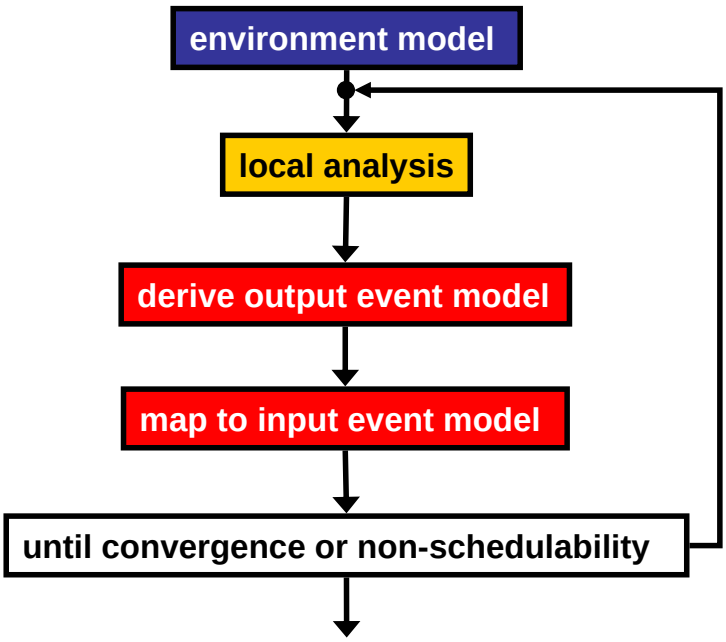


$$w_i(q) = q\,C_i + \sum_{j \in \mathrm{hp}(i)} C_j \left\lceil \frac{w_i(q)}{T_j} \right\rceil$$

find fix point where equations hold!

$$R_i(q) = w_i(q) - (q-1)\,T_i$$

Event Propagation and Analysis Principle

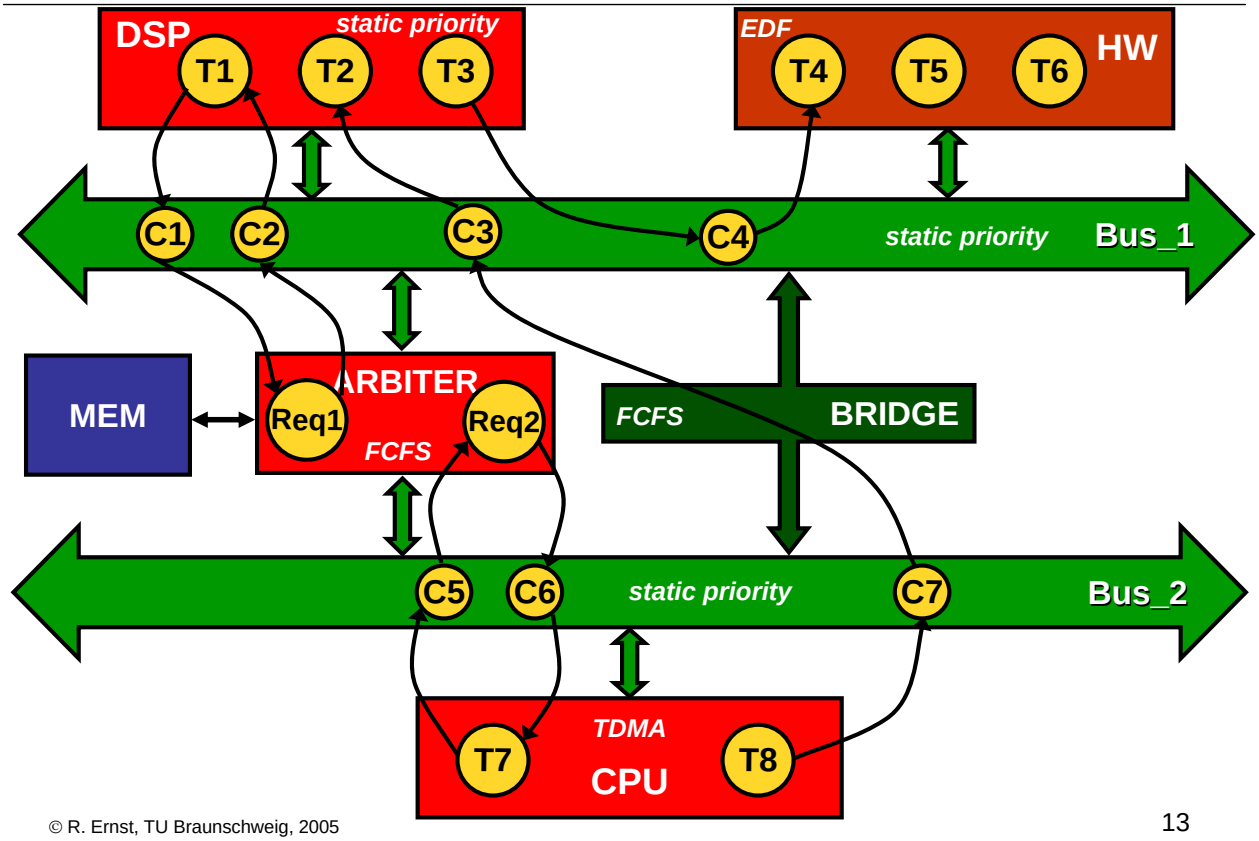


- **very flexible and composable !**

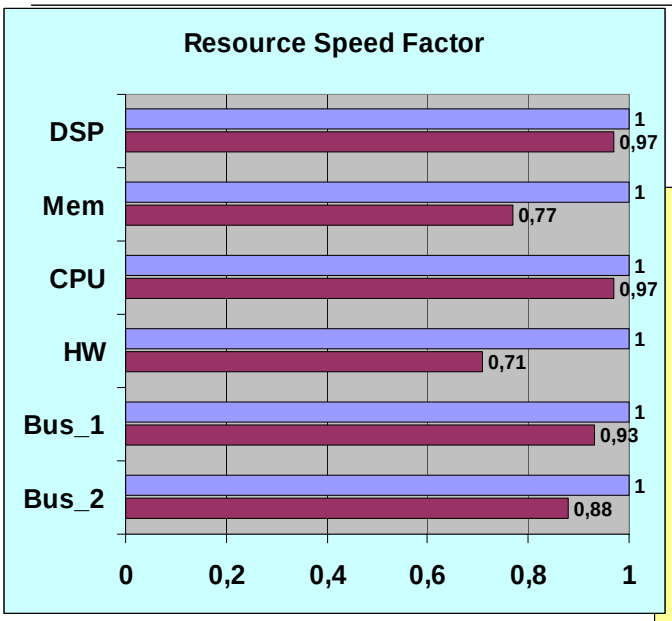
Compositional Performance Analysis - Applications

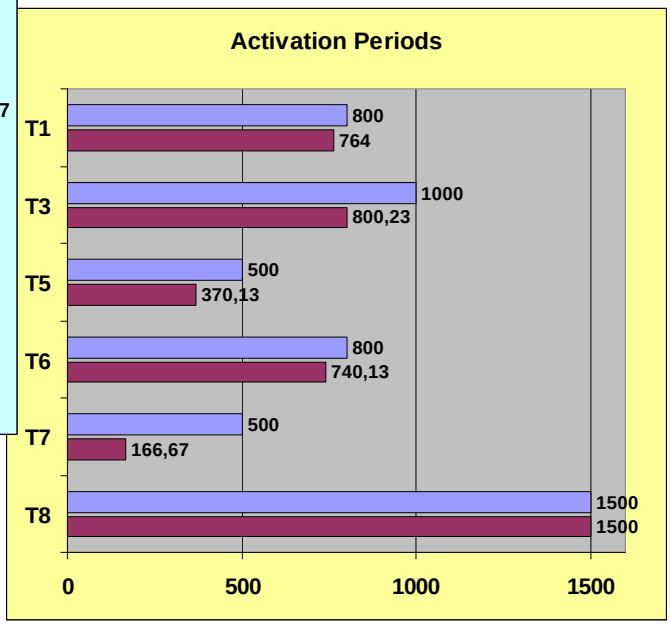
- network processor design
- automotive electronics
- VLSI

Example Application of Compositional Analysis



Sensitivity Analysis Results - Example



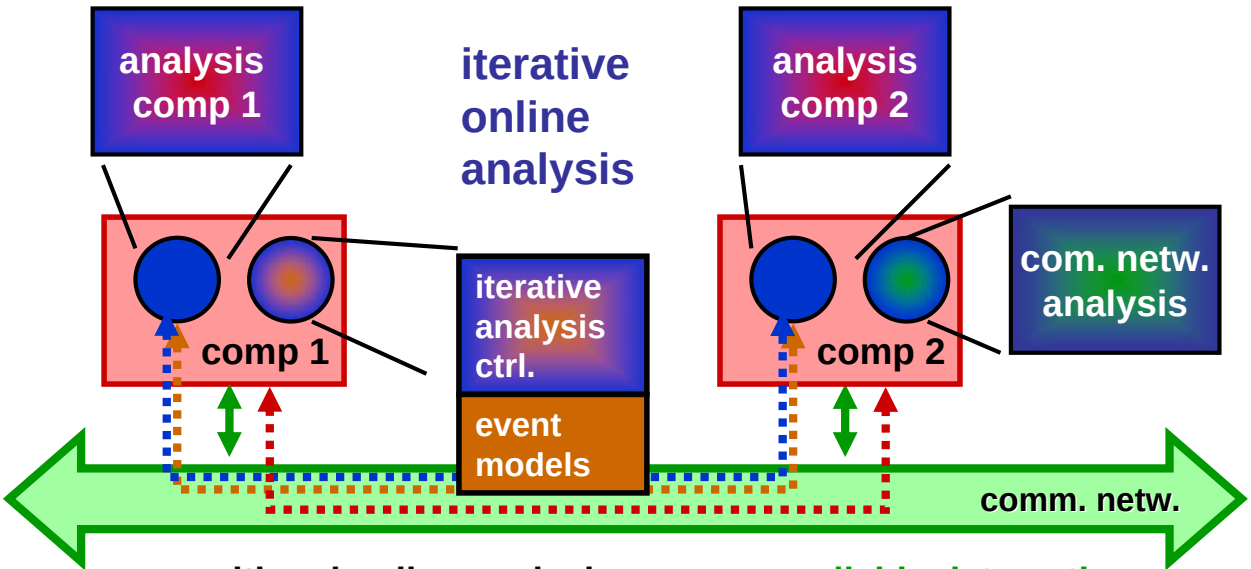


Compositional Performance Analysis - Observations

- fast, versatile and flexible
  - very fast compared to simulation
  - flexible and scalable
  - supports sensitivity analysis – evaluates design robustness
  - enables optimization (e.g. genetic algorithms)
- could be executed online
  - analysis needs access to local data only
  - local analysis could be executed locally
  - compositional analysis could be distributed
    - event propagation corresponds to ES communication

    → event propagation can use existing communication channels
  - open issues in distributed online analysis
    - control
    - dynamics

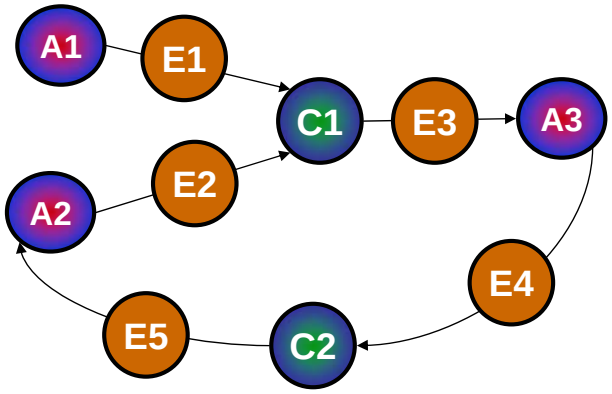
Online Performance Analysis



- compositional online analysis can use available data paths
- requires online capturing of input parameters to analysis
- requires iterative online analysis

Towards organic systems

- dynamic network structure requires distributed, self organizing analysis process
- the analysis flow can be modeled as a data flow graph
  → *analysis network*



Conclusion

- project extends compositional performance analysis to monitor global performance characteristics of OC systems at run time
- evaluates robustness and supports error avoidance
- basis for self protection as key problem of organic systems with dependability requirements
- could be enhanced to support organic system optimization