APPROXIMATE BANDWIDTH ALLOCATION FOR COMPOSITIONAL REAL-TIME SYSTEMS

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Problem and Objective

Problem:
- Allocation of bandwidth among components of a compositional real-time systems
- State-of-the-art algorithms for bandwidth allocation use either pseudo-polynomial-time techniques for exact allocation [2], or linear-time, utilization-based techniques [1] which may over-provision bandwidth.

Goal:
- Minimize the bandwidth allocated to each component and simultaneously guarantee component schedulability.
- Provide system designer an option to choose accuracy ε to trade bandwidth with computational efficiency.

Solution: An Approximation Scheme

Develop a Polynomial-Time Parametric Approximation Scheme for capacity determination

Setting:
- Compositional RTS with sporadic tasks as component
- Fixed priority (e.g., deadline monotonic) scheduler
- Explicit-Deadline Periodic (EDP) resource

Solution: Challenge #1

✓ Reduce the number of points in testing set to polynomial in the size of τ and 1/ε [3]

\[ \text{Cumulative Approx. Request-Bound Function} \]

Solution: Challenge #2

✓ Determine how to set minimum capacity Θi for each testing set point t

Our Algorithm [4]

- FPMinimumCapacity (Π, Δ, τ, ε)
  - Initialize Θ(0) with \( U(τ) \).
  - For each Θi ∈ Θ:
    - For each point in the Approximate Testing set
      - Initialize line segment
    - For the four values of \( \ell \)
      - Find Θi s.t. line segment falls below that \( \ell \)-th step
    - Set Θi to be the minimum of these s.t. line segment is beneath some \( \ell \)-th step
    - Set Θ(∞) to be maximum of all Θ over tasks

Complexity: \( O(n^2 \log n/ε) \)

Comparison

  - Significant reduction in relative error
  - Only 5% error for approximation algorithms
  - 30-95% for sufficient algorithms
  - 95% confidence interval are shown

  - Runtime for approximate algorithm shows improvement than the exact case

References


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