Optimization of the Highest Entropy First Scheduling Algorithm for Real-time Systems

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\[ H_{\text{SingleTimeUnit}} = \log_2(\text{period}) \times \frac{c_i}{\text{period}} \]

Entropy of a single time unit:

\[ H_{\text{Task}} = \log_2(\text{period}) \times \frac{c_i}{\text{period}} \]

Entropy of a task:

\[ H_{\text{System}} = \log_2(\text{period}) \times \sum_{i=1}^{n} \frac{c_i}{\text{period}} \]

Total entropy of a system:

- Optimized HEF improved the performance of original HEF for all the test cases.
- Optimized HEF improved the performance of EDF for U ≤ 95%.
- Optimized HEF performance for U = 100% was similar than EDF.
- Future Work: Using entropy in multi-processors

Motivation

Because checking the entropy value of the tasks at each unit of time makes the algorithm not suitable for real implementation, we proposed the following changes:

1) Select the task with the highest entropy for the studied period:
\[ H(x) = H_{\text{SingleTimeUnit}} + \sum_{j=1}^{m} \left( \frac{c_j}{t_j} \right) \times H_{\text{SingleTimeUnit}} > t_i \times H_{\text{SingleTimeUnit}} \]

Then:
\[ c_i + \sum_{j=1}^{m} \left( \frac{c_j}{t_j} \right) > t_i = c_i + t_1 + \sum_{j=1}^{m} \left( \frac{c_j}{t_j} \right) > t_i \]
\[ c_i + \sum_{j=1}^{m} \left( \frac{c_j}{t_j} \right) > 1, \text{then } \sum_{j=1}^{m} \left( \frac{c_j}{t_j} \right) > 1 \]

Non-schedulable by HEF = U > 1

Proposed Optimization

References


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Feasibility

Assuming that we have a task set S with U <= 1 then \( \sum_{i=1}^{m} \frac{c_i}{t_i} \leq 1 \)

If S is not schedulable by HEF, then the entropy of the scheduled tasks for a period \( t \) has to greater than the total entropy present in that particular period:

\[ c_i + \sum_{j=1}^{m} \left( \frac{c_j}{t_j} \right) > t_i = c_i + t_1 + \sum_{j=1}^{m} \left( \frac{c_j}{t_j} \right) > t_i \]
\[ \frac{c_i}{t_i} + \sum_{j=1}^{m} \left( \frac{c_j}{t_j} \right) > 1, \text{then } \sum_{j=1}^{m} \left( \frac{c_j}{t_j} \right) > 1 \]

Optimized HEF improved the performance of the tasks at each unit of time of the scheduling diagram. After a preliminary analysis [2] we found that when the utilization of the task set is higher than 90%, the number of context switches and number of preemptions is higher than EDF [3].

- Hyper-period set at 40
- EDF, Original HEF and Optimized HEF implemented.
- 100 tasks per test file
- 21 Test files
  (Utilization = 70%, 75%, 80%, 85%, 90%, 95% and 100%.
  Tasks per Task set = 3, 4 and 5

Related Work

Acknowledgements: