Appendix To Reducing Tardiness Under Global Scheduling by Splitting Jobs

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A G-FL Lateness Bounds

Because job deadlines are not used directly to determine job priorities under G-FL (unlike under G-EDF), the computations for tardiness bounds are more complex for G-FL than the computations described in Sec. 3.1. Here we summarize the analysis from [1] as applied to split tasks. We first assume the absence of critical sections and then describe how our analysis is modified to account for critical sections. Each task is given a relative priority point $Y_i^{split} = T_i^{split} - \frac{m-1}{m} C_i^{split}$. We then define, for each τ_i,

$$S_i^{split} = C_i^{split} \cdot \max\left\{0, 1 - \frac{Y_i^{split} - \min_{\tau_j \in \tau} Y_j^{split}}{T_i^{split}}\right\}. \quad \text{(A.1)}$$

We also define

$$G(\vec{x}) = \sum_{m-1 \text{ largest}} (x_j U_j^{split} + C_j^{split} - S_j^{split}), \quad \text{(A.2)}$$

$$x_i = \frac{G(\vec{x}) + \sum_{\tau_j \in \tau} S_j^{split} - C_i^{split}}{m}. \quad \text{(A.3)}$$

The algorithm provided in [2] for computing $\vec{x}$ continues to apply to G-FL as described here, as explained in [1]. Each task τ_i has under G-FL a *response time bound* of $x_i + C_i^{split} + Y_i^{split} - \min_{\tau_j \in \tau} Y_j^{split}$, a lateness bound of $x_i + C_i^{split} - T_i^{split} + Y_i^{split} - \min_{\tau_j \in \tau} Y_j^{split}$, and a tardiness bound of $\max\{0, x_i - C_i^{split} - T_i^{split} + Y_i^{split} - \min \tau_j \in \tau Y_j^{split}\}$.

When we account for critical sections, a single subjob $J_{i,j}$ can run for as long as $C_{i,j}^{split} + b_i$ time units. Nonetheless, τ_i's processor share over the long term is not affected, because the total execution of all subjobs must be the execution of the base job. Intuitively, $\gamma_i(t)$ can lag behind $y_i(t)$ with respect to $e_i(t)$ (rather than t) for the bounded amount of at most b_i units of execution of the base job.

Using $C_{i_j}^{split} + b_i$ in the sporadic task model would be overly pessimistic, because it would unnecessarily increase the long-term utilization used in the analysis. Therefore, we extend the sporadic task model to reduce this pessimism. We use the function $DBF(\tau_i^{split}, t)$, defined as the maximum demand of jobs from τ_i that have both release times and absolute priority points in any interval of length t. The following theorem, proved in [2], uses S_i^{split} from (A.1) to bound $DBF(\tau_i^{split}, t)$:

Theorem 1. $DBF(\tau_i^{split}, t) \leq U_i^{split} t + S_i^{split}$.

We now extend this theorem to our task model for split jobs where each split can be delayed at most b_i time units. We now define $Y_i^{split} = T_i^{split} - \frac{m-1}{m}(C_{i,j}^{split} + b_i)$. We still define $U_i^{split} = C_i^{split}/T_i^{split}$ and $S_i^{split} = C_i^{split} \cdot \max\left\{0, 1 - \frac{Y_i^{split} - \min_{\tau_j \in \tau} Y_j^{split}}{T_i^{split}}\right\}$ (see (A.1)) but allow a job to run for as long as $C_i^{split} + b_i$ time units.

Theorem 2. $DBF(\tau_i^{split}, t) \leq U_i^{split} t + S_i^{split} + b_i$.

Proof. Let I be a worst-case interval of length t, i.e., such that jobs of τ_i^{split} with releases and absolute priority points in I demand $DBF(\tau_i^{split}, t)$ units of execution. If we assume $b_i = 0$, then by Thm. 1, there are at most $U_i^{split} t + S_i^{split}$ units of execution demanded in I. By our mechanism for handling critical sections, allowing $b_i > 0$ can only cause demand to move to the left. Also by our definition of worst-case demand, the most demand that can enter I would be b_i units of demand added to the last subjob. The theorem follows. □

Because we created a new task model rather than using the sporadic task model, directly using the work described above requires using a worst case of $C_i^{split} + b_i$ even when computing utilizations, resulting in a loss of system capacity. Fortunately, with only minor modifications it can be applied without such a loss of capacity.

The numerator in (A.3) measures the competing work remaining at the priority point of a job under analysis. When applied to τ_i^{split}, it is based on analyzing the $DBF(\tau_i^{split}, t)$ over a particular interval for

each τ_i^{split} using Thm. 1. By comparing Thm. 1 and Thm. 2, we see that adding $\sum_{\tau_j \in \tau} b_j$ to the numerator in (A.3) accounts for the additional demand. In addition, because a job of τ_i^{split} can run for $C_i^{split} + b_i$ time units, each C_i or C_j should be replaced with $C_i^{split} + b_i$ or $C_j^{split} + b_j$, respectively. We now have:

$$G(\vec{x}) = \sum_{m-1 \text{ largest}} (x_j U_j^{split} + C_j^{split} + b_j - S_j^{split}) \quad \text{(A.4)}$$

$$x_i = \frac{G(\vec{x}) + \sum_{\tau_j \in \tau} (S_j^{split} + b_j) - (C_i^{split} + b_i)}{m} \quad \text{(A.5)}$$

and, for each task τ_i^{split}, a lateness bound of $x_i + C_i^{split} + b_i - T_i^{split} + Y_i^{split} - \min_{\tau_j \in \tau} Y_j^{split}$. Observe that while we needed to inflate C_i^{split} values, we did not need to inflate U_i^{split} values. Because utilization values rather than execution time values are used to determine whether tardiness bounds exist, no capacity loss occurs.

Task Ordering in Heuristic Algorithm In the heuristic algorithm described in Sec. 8, the ordering of tasks within a cluster is not explicitly specified. Before tasks are ordered, the G-FL tardiness bound computation algorithm is run. The tasks that contribute to $G(\vec{x})$ are ranked above all other tasks, in order of their decreasing contribution to $G(\vec{x})$. The remaining tasks are then ranked in order of decreasing S_i^{split}.

References

[1] J. P. Erickson and J. H. Anderson. Fair lateness scheduling: Reducing maximum lateness in g-edf-like scheduling. In *ECRTS*, pages 3–12, 2012.

[2] J. P. Erickson, N. Guan, and S. K. Baruah. Tardiness bounds for global EDF with deadlines different from periods. In *OPODIS*, pages 286–301, 2010. Revised version at `http://cs.unc.edu/~jerickso/opodis2010-tardiness.pdf`.

B Graphs

In this appendix, we present a more complete set of graphs than presented in the paper. We first present graphs for systems that do not include critical sections, and we then present graphs that include critical sections and are scheduled using the MX-Q locking protocol.

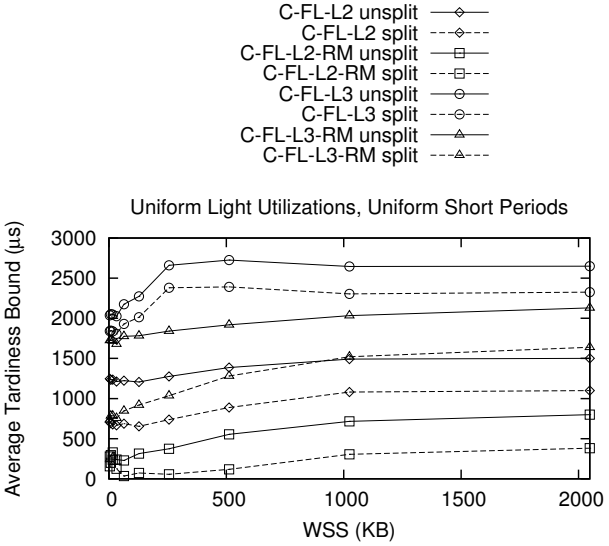

Figure B.1: By WSS: Uniform Light Utilizations, Uniform Short Periods

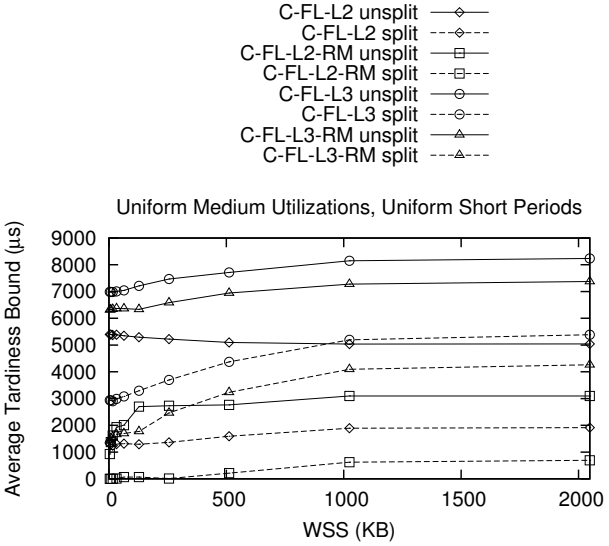

Figure B.3: By WSS: Uniform Medium Utilizations, Uniform Short Periods

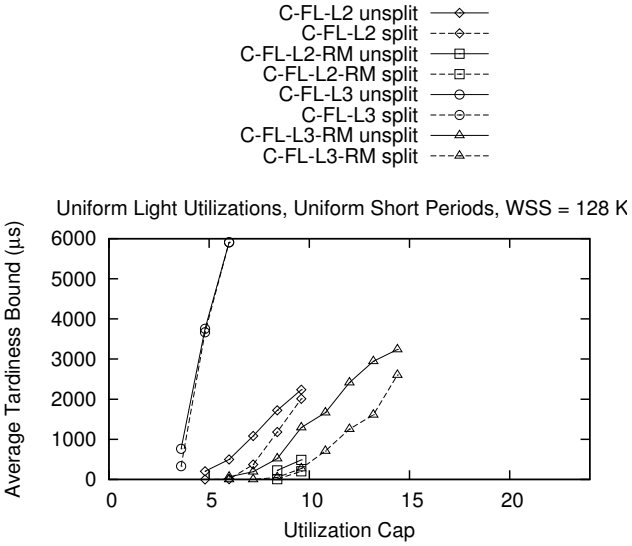

Figure B.2: By Utilization Cap: Uniform Light Utilizations, Uniform Short Periods

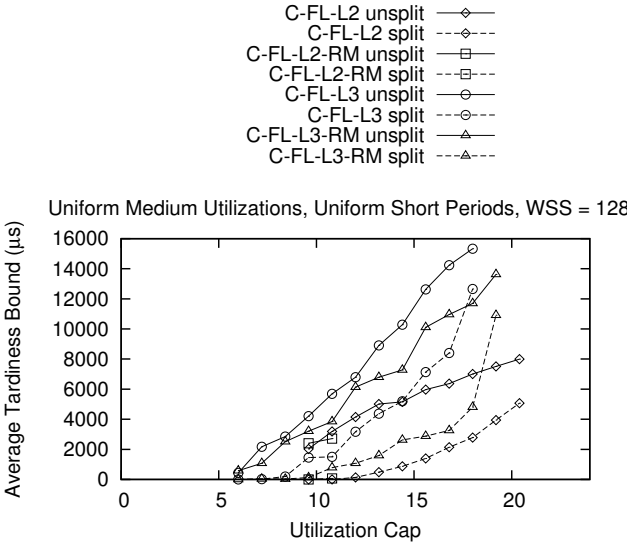

Figure B.4: By Utilization Cap: Uniform Medium Utilizations, Uniform Short Periods

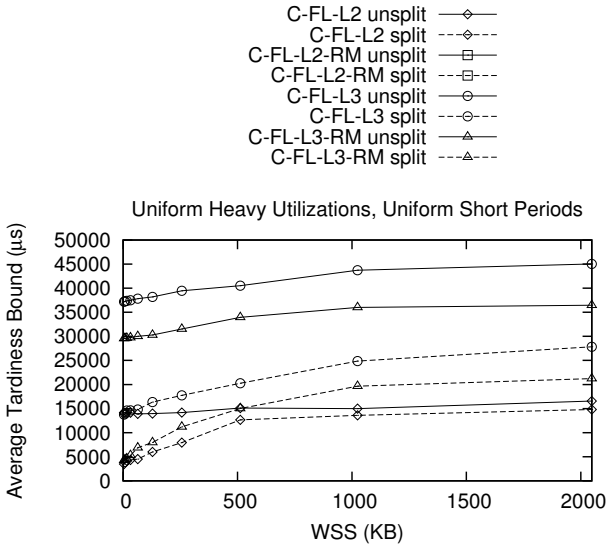

Figure B.5: By WSS: Uniform Heavy Utilizations, Uniform Short Periods

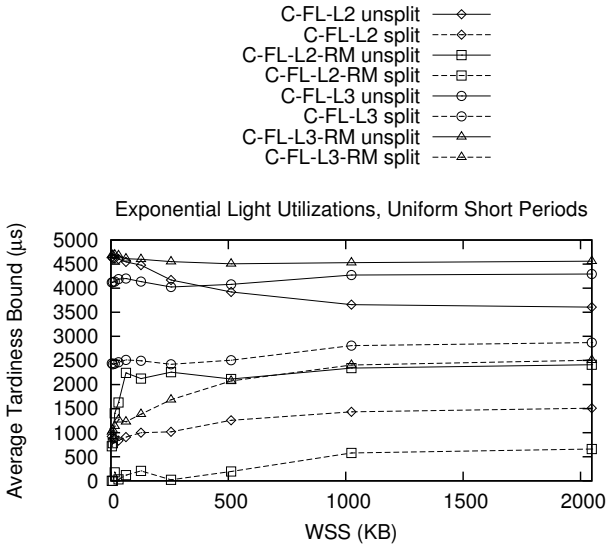

Figure B.7: By WSS: Exponential Light Utilizations, Uniform Short Periods

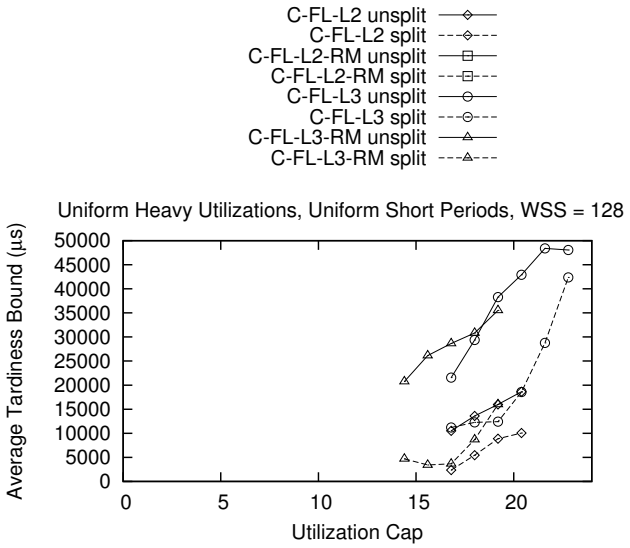

Figure B.6: By Utilization Cap: Uniform Heavy Utilizations, Uniform Short Periods

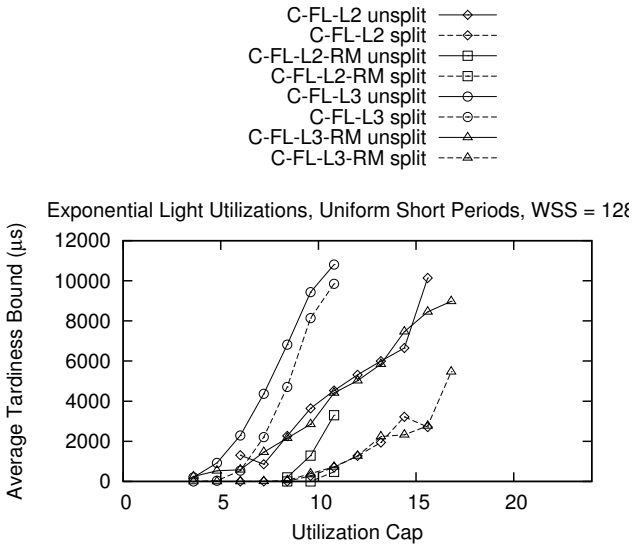

Figure B.8: By Utilization Cap: Exponential Light Utilizations, Uniform Short Periods

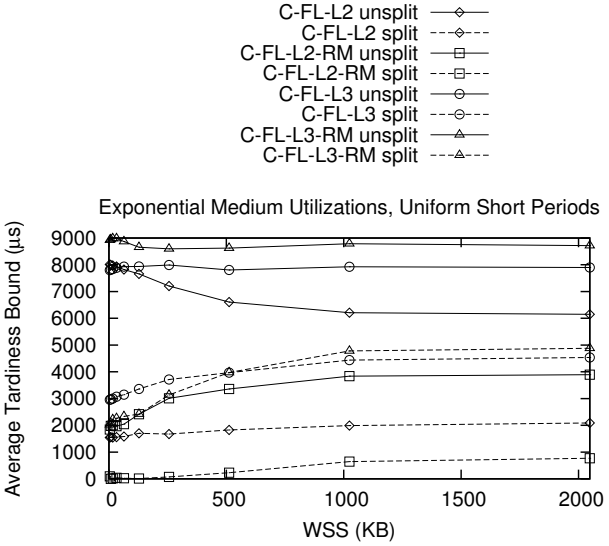

Figure B.9: By WSS: Exponential Medium Utilizations, Uniform Short Periods

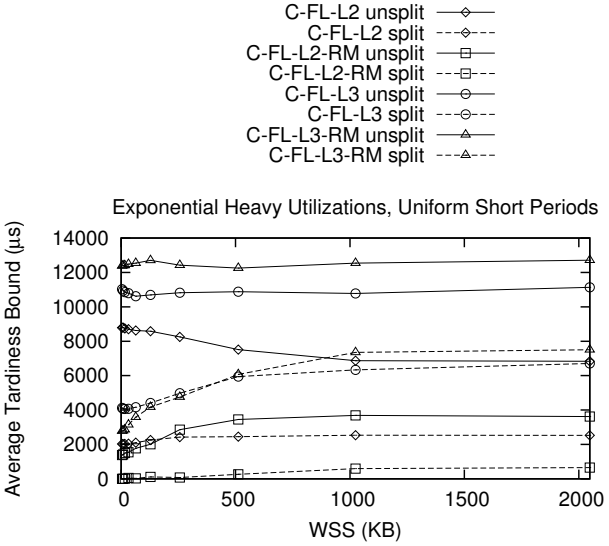

Figure B.11: By WSS: Exponential Heavy Utilizations, Uniform Short Periods

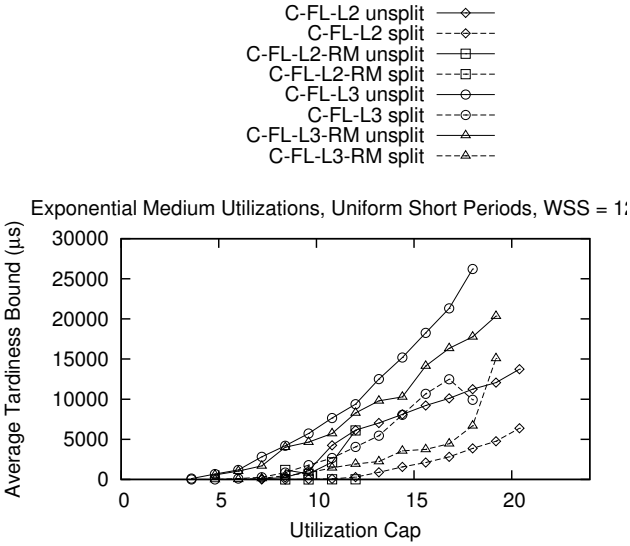

Figure B.10: By Utilization Cap: Exponential Medium Utilizations, Uniform Short Periods

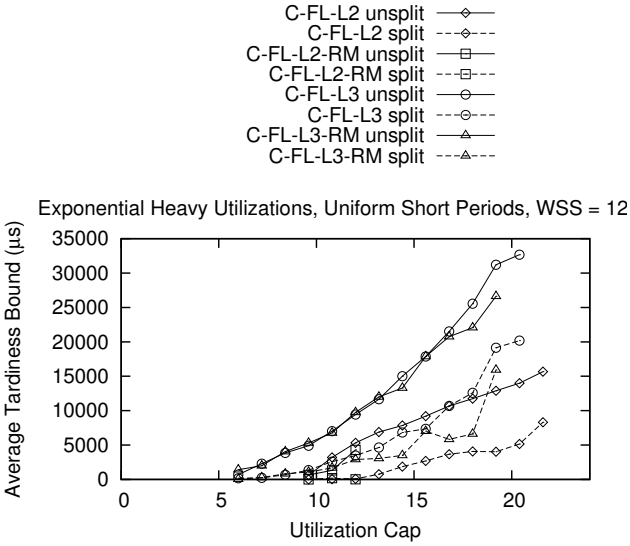

Figure B.12: By Utilization Cap: Exponential Heavy Utilizations, Uniform Short Periods

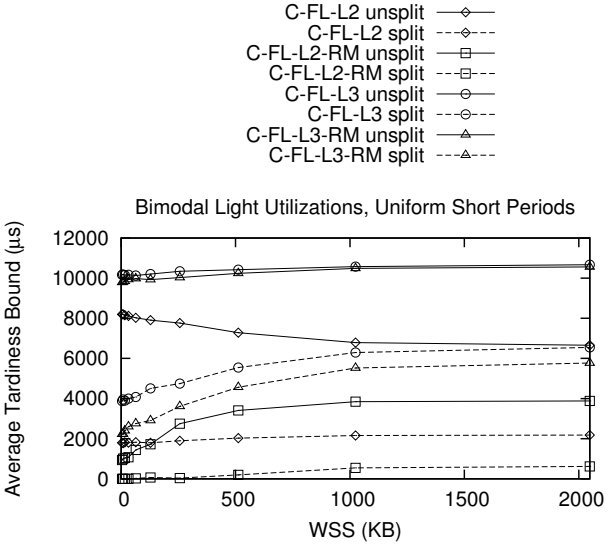

Figure B.13: By WSS: Bimodal Light Utilizations, Uniform Short Periods

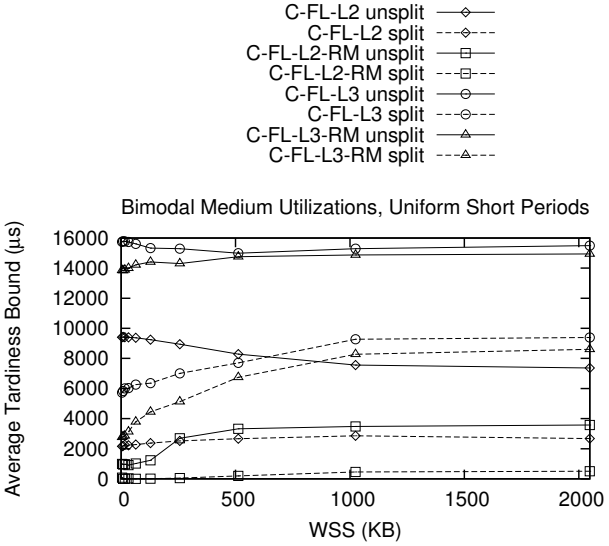

Figure B.15: By WSS: Bimodal Medium Utilizations, Uniform Short Periods

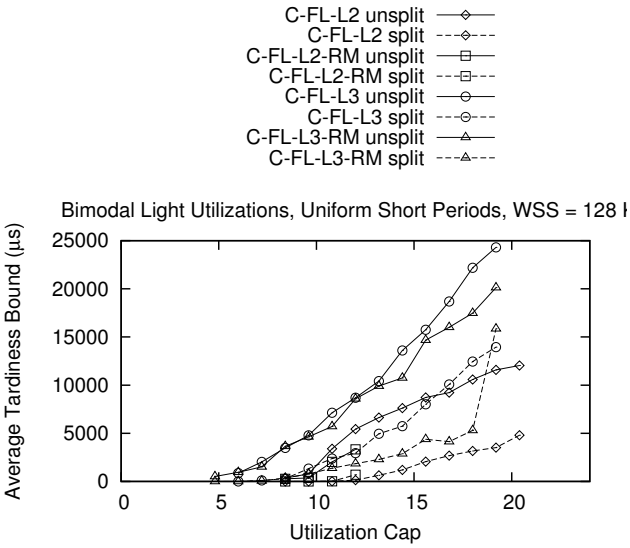

Figure B.14: By Utilization Cap: Bimodal Light Utilizations, Uniform Short Periods

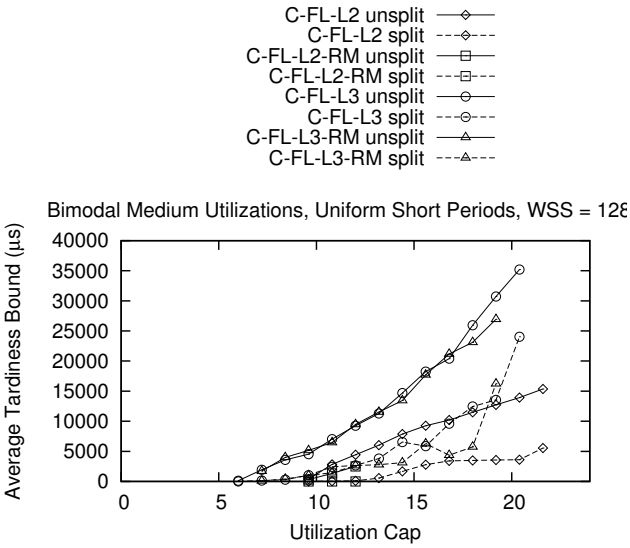

Figure B.16: By Utilization Cap: Bimodal Medium Utilizations, Uniform Short Periods

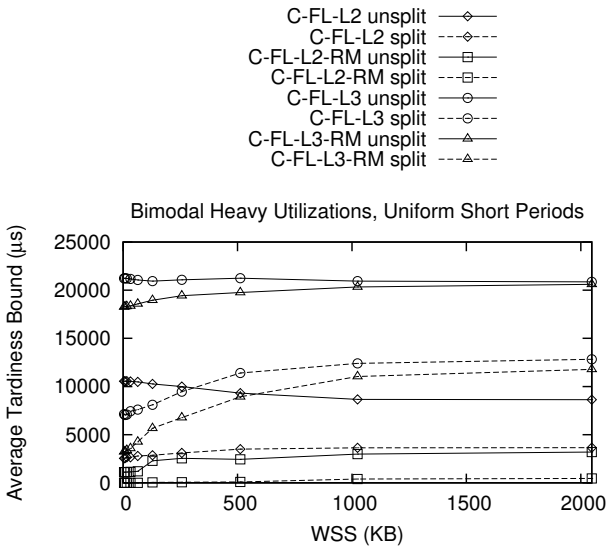

Figure B.17: By WSS: Bimodal Heavy Utilizations, Uniform Short Periods

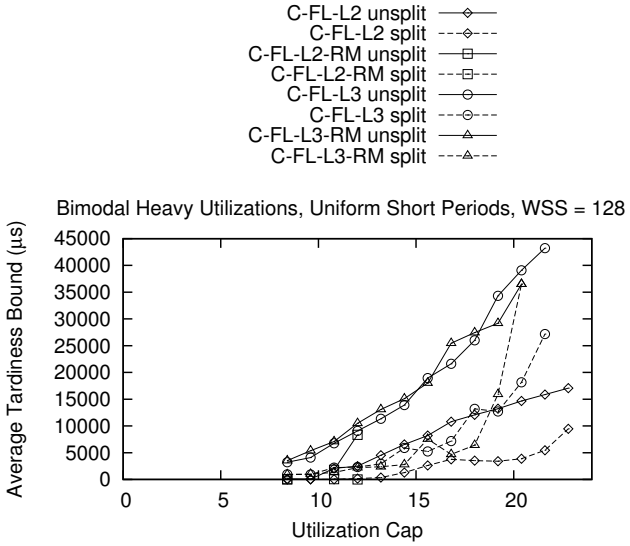

Figure B.18: By Utilization Cap: Bimodal Heavy Utilizations, Uniform Short Periods

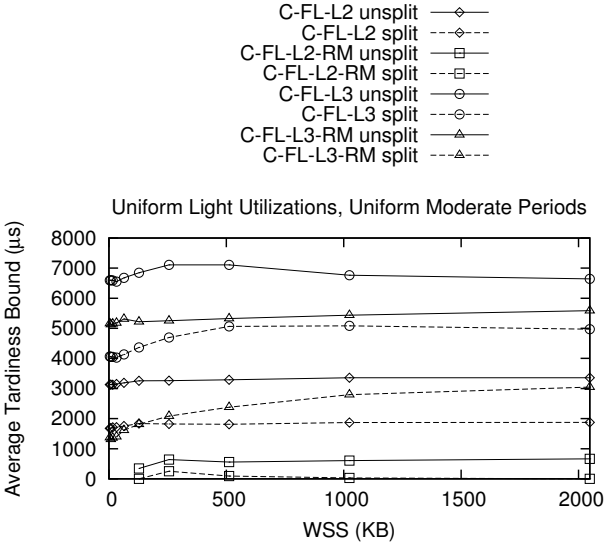

Figure B.19: By WSS: Uniform Light Utilizations, Uniform Moderate Periods

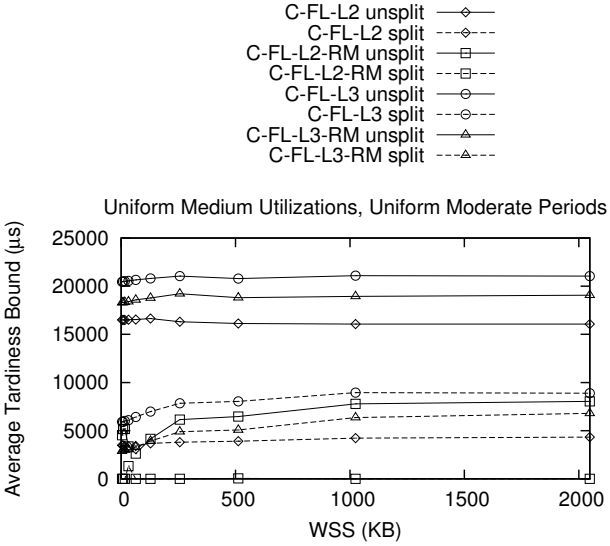

Figure B.21: By WSS: Uniform Medium Utilizations, Uniform Moderate Periods

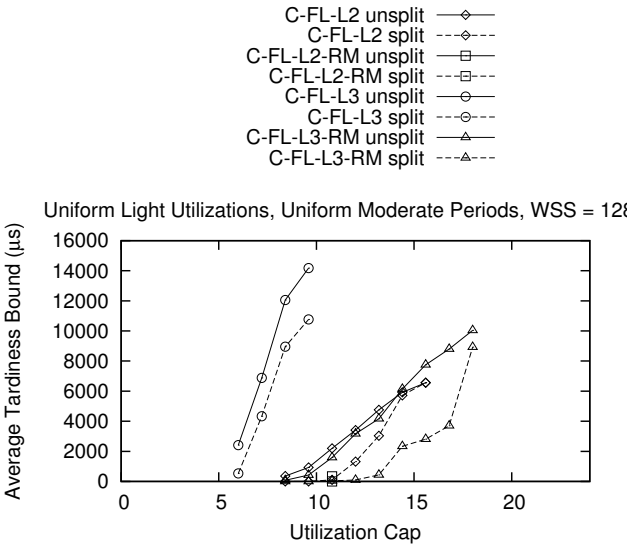

Figure B.20: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods

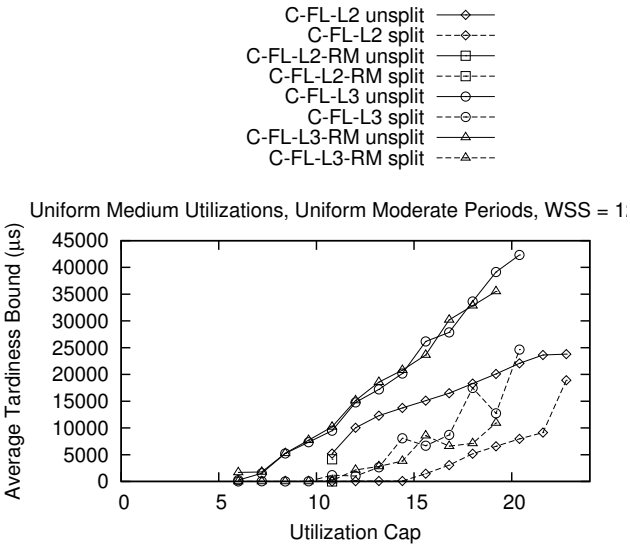

Figure B.22: By Utilization Cap: Uniform Medium Utilizations, Uniform Moderate Periods

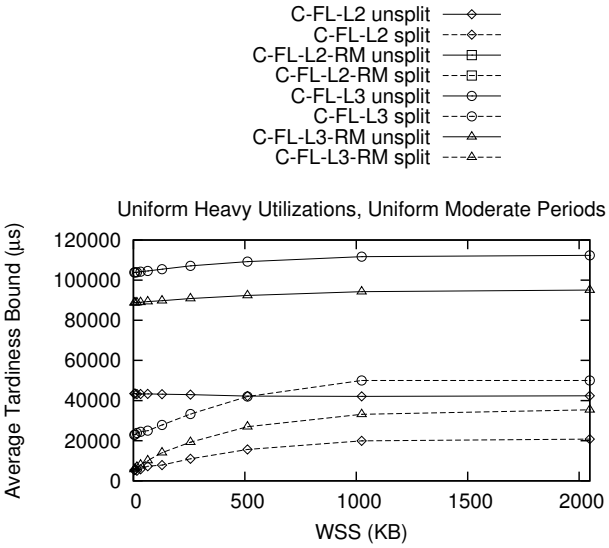

Figure B.23: By WSS: Uniform Heavy Utilizations, Uniform Moderate Periods

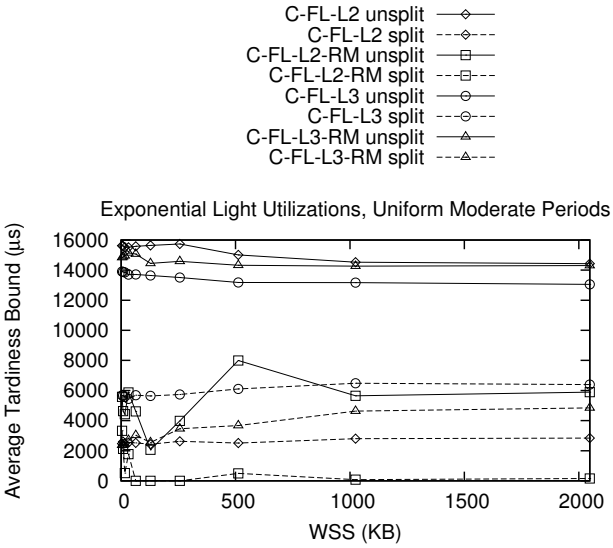

Figure B.25: By WSS: Exponential Light Utilizations, Uniform Moderate Periods

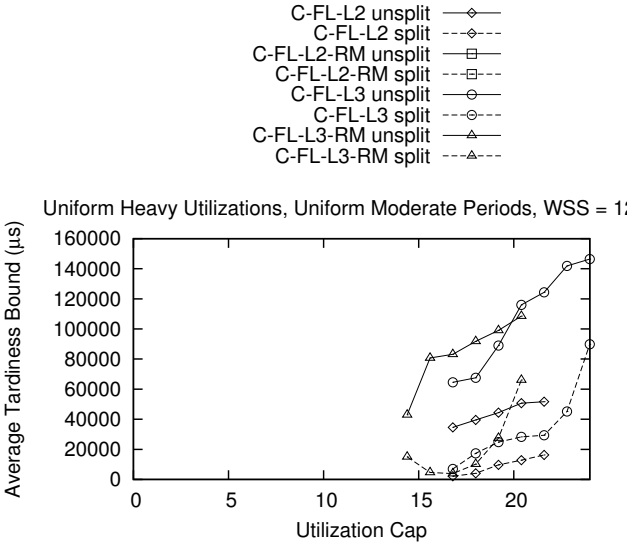

Figure B.24: By Utilization Cap: Uniform Heavy Utilizations, Uniform Moderate Periods

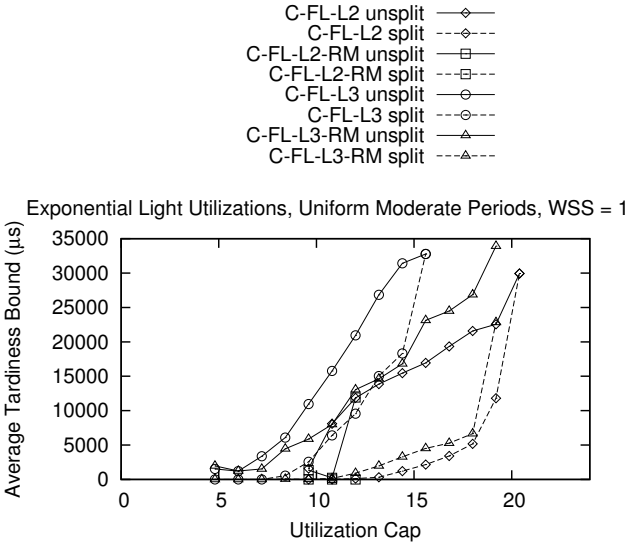

Figure B.26: By Utilization Cap: Exponential Light Utilizations, Uniform Moderate Periods

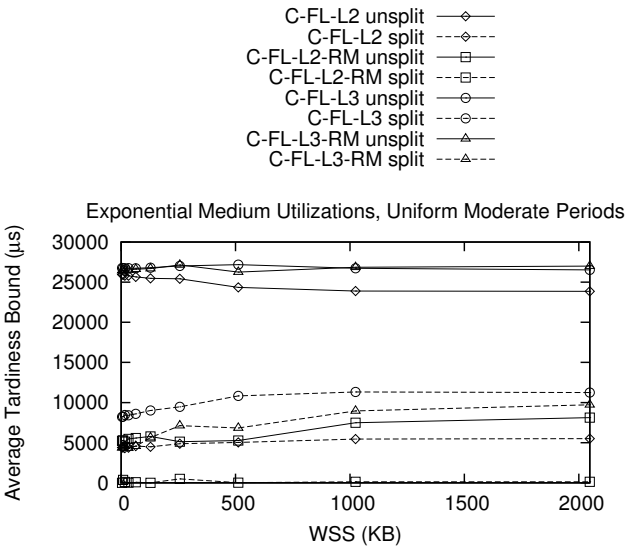

Figure B.27: By WSS: Exponential Medium Utilizations, Uniform Moderate Periods

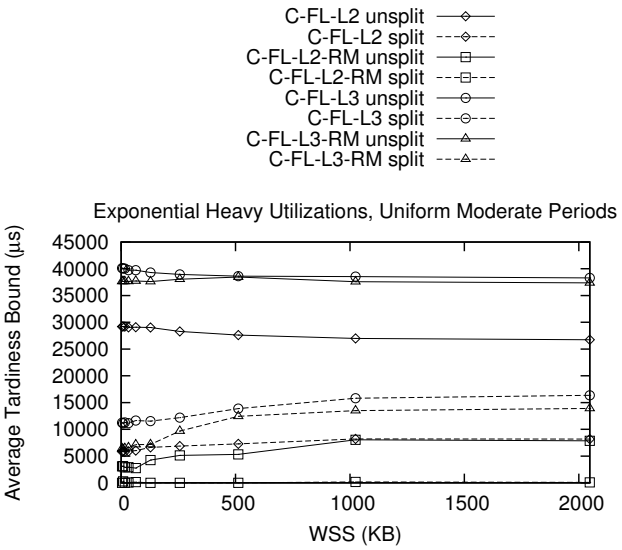

Figure B.29: By WSS: Exponential Heavy Utilizations, Uniform Moderate Periods

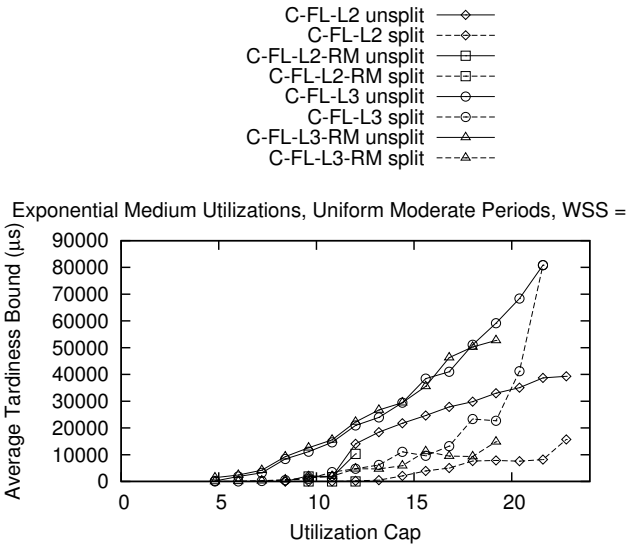

Figure B.28: By Utilization Cap: Exponential Medium Utilizations, Uniform Moderate Periods

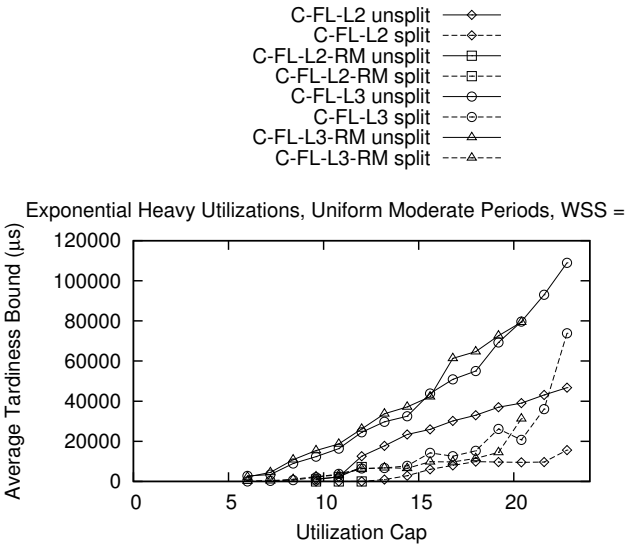

Figure B.30: By Utilization Cap: Exponential Heavy Utilizations, Uniform Moderate Periods

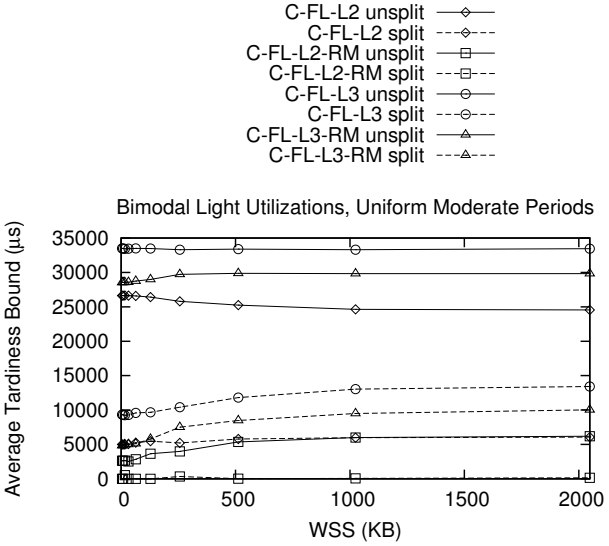

Figure B.31: By WSS: Bimodal Light Utilizations, Uniform Moderate Periods

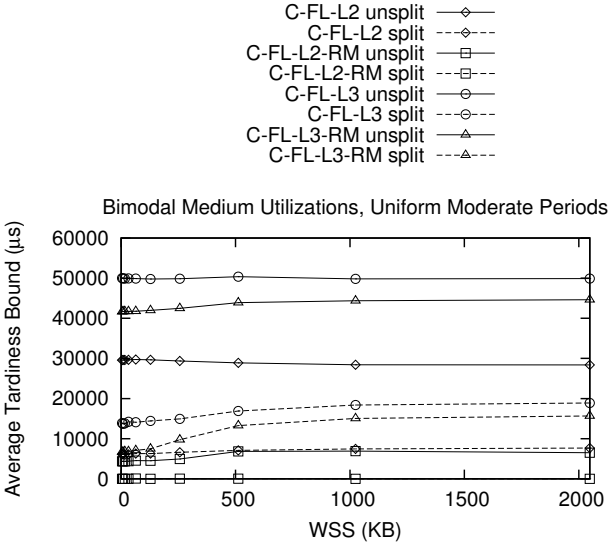

Figure B.33: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods

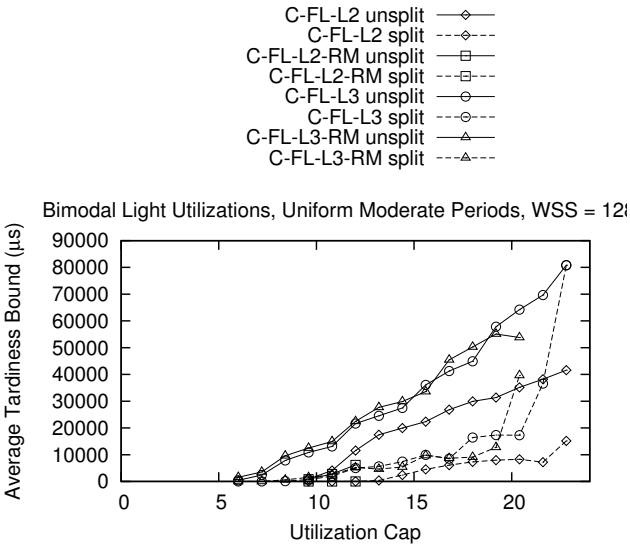

Figure B.32: By Utilization Cap: Bimodal Light Utilizations, Uniform Moderate Periods

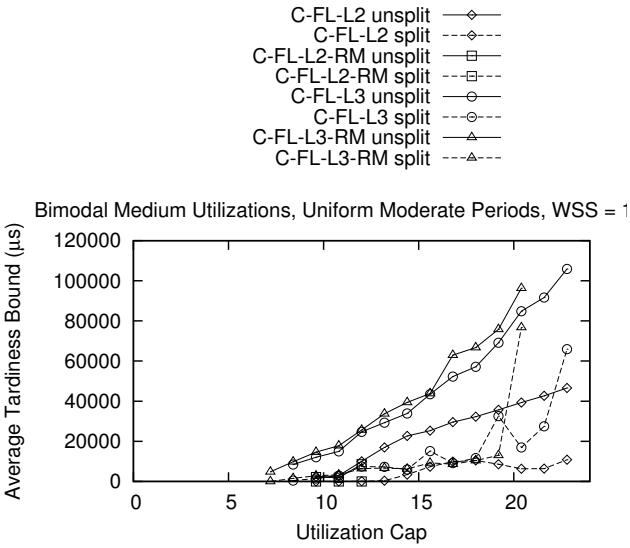

Figure B.34: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods

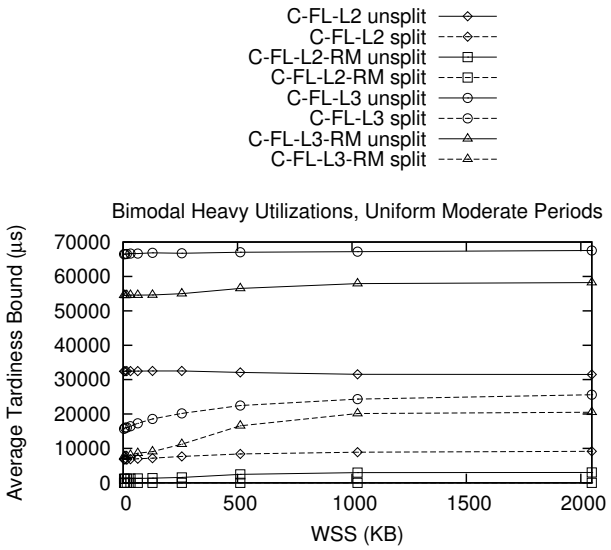

Figure B.35: By WSS: Bimodal Heavy Utilizations, Uniform Moderate Periods

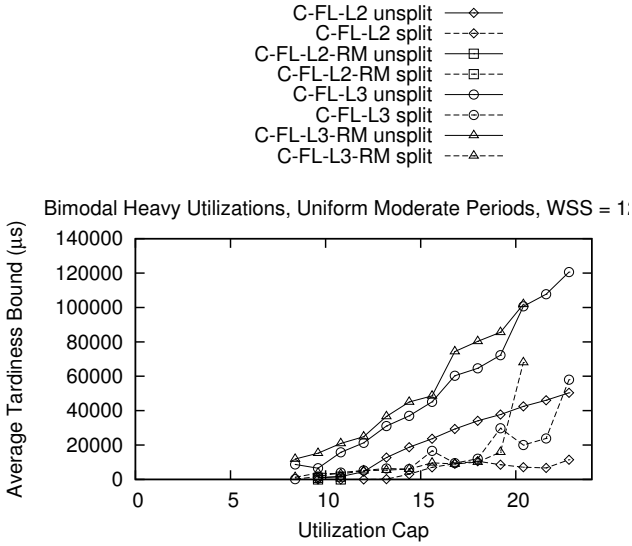

Figure B.36: By Utilization Cap: Bimodal Heavy Utilizations, Uniform Moderate Periods

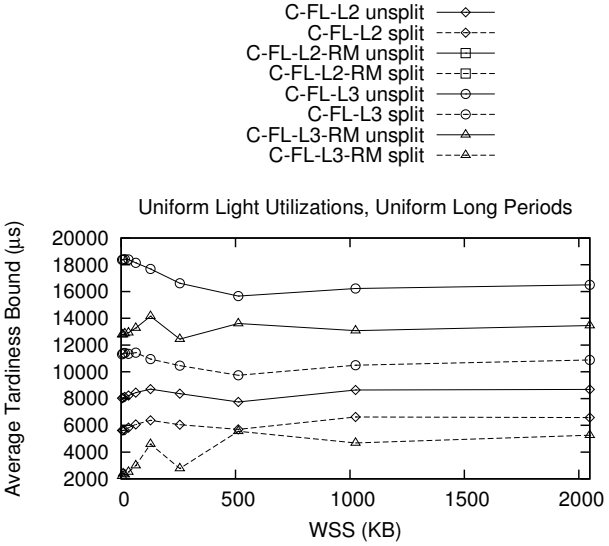

Figure B.37: By WSS: Uniform Light Utilizations, Uniform Long Periods

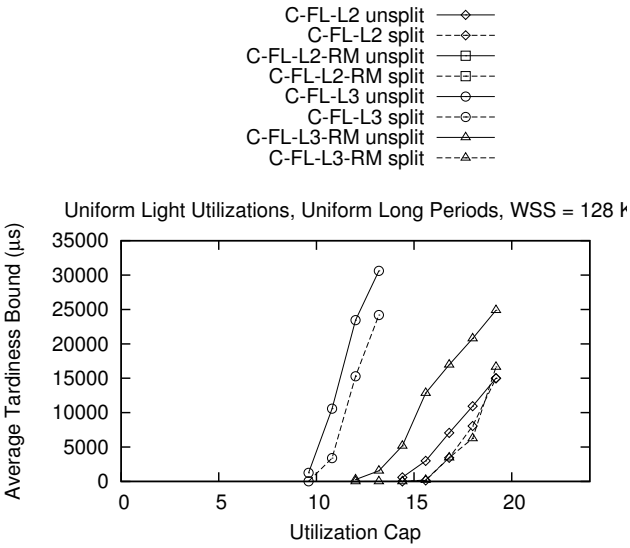

Figure B.38: By Utilization Cap: Uniform Light Utilizations, Uniform Long Periods

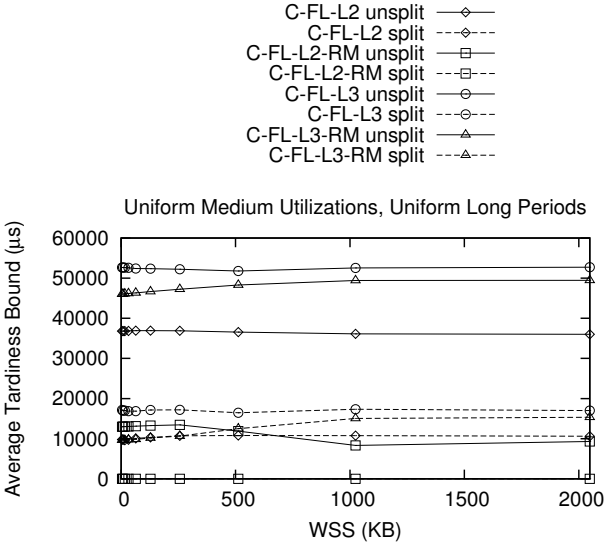

Figure B.39: By WSS: Uniform Medium Utilizations, Uniform Long Periods

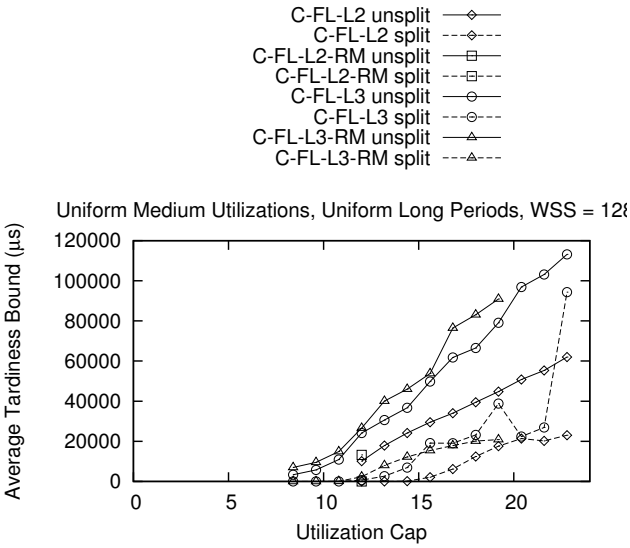

Figure B.40: By Utilization Cap: Uniform Medium Utilizations, Uniform Long Periods

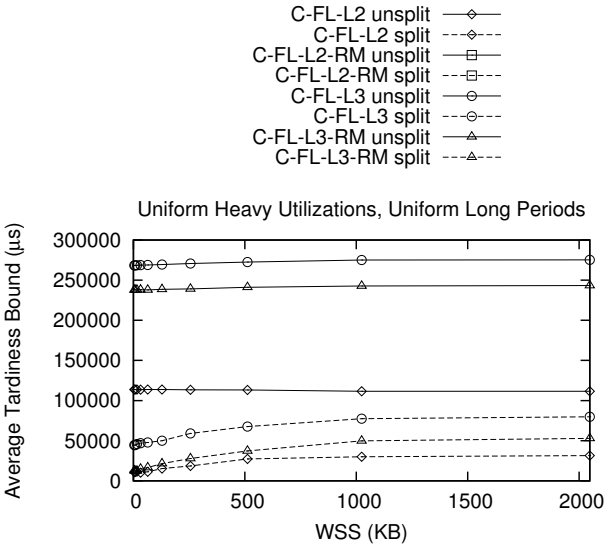

Figure B.41: By WSS: Uniform Heavy Utilizations, Uniform Long Periods

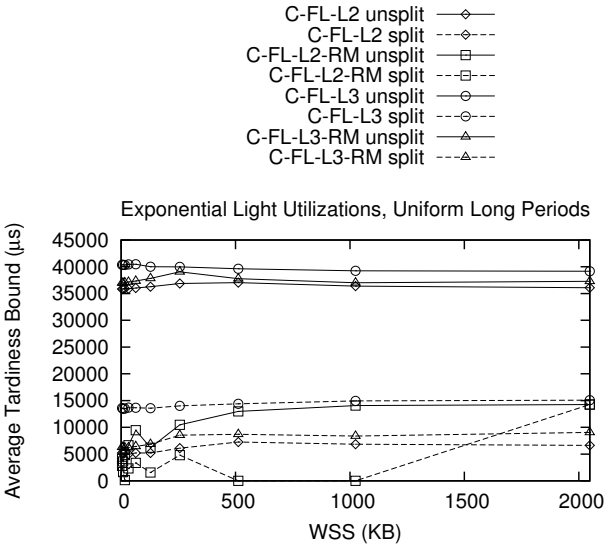

Figure B.43: By WSS: Exponential Light Utilizations, Uniform Long Periods

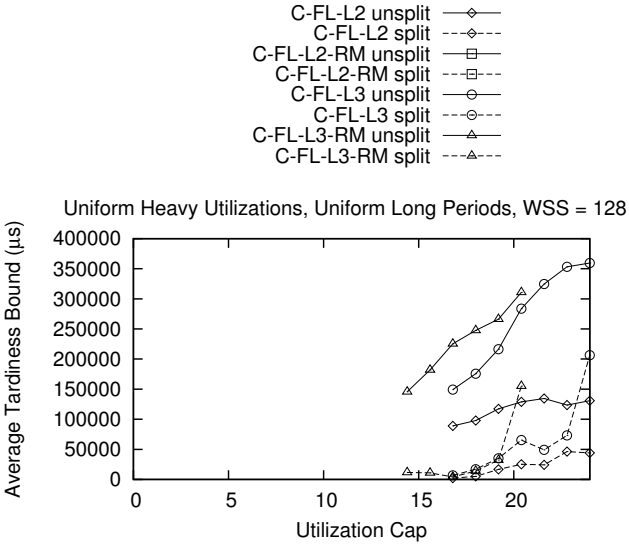

Figure B.42: By Utilization Cap: Uniform Heavy Utilizations, Uniform Long Periods

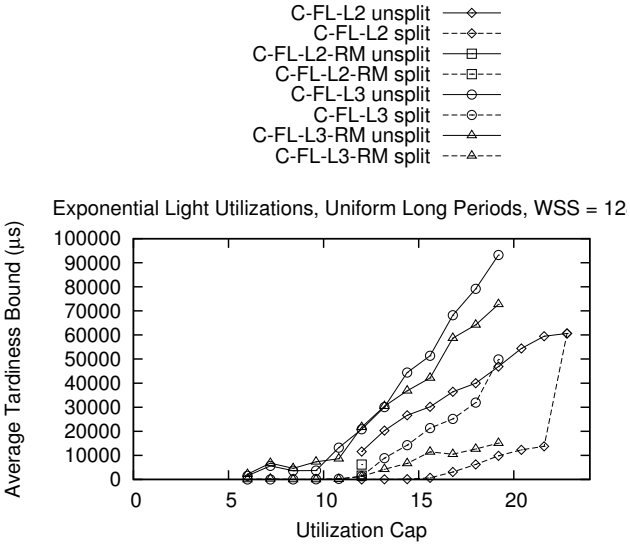

Figure B.44: By Utilization Cap: Exponential Light Utilizations, Uniform Long Periods

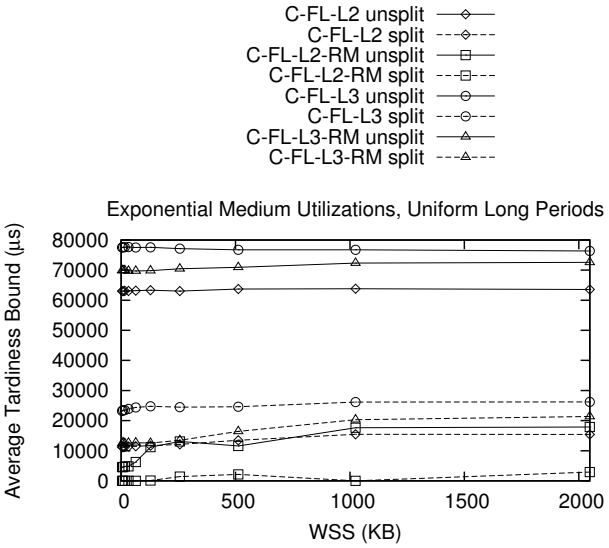

Figure B.45: By WSS: Exponential Medium Utilizations, Uniform Long Periods

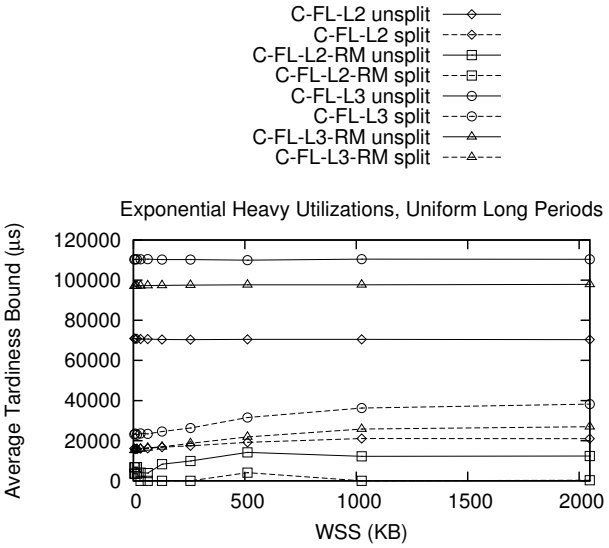

Figure B.47: By WSS: Exponential Heavy Utilizations, Uniform Long Periods

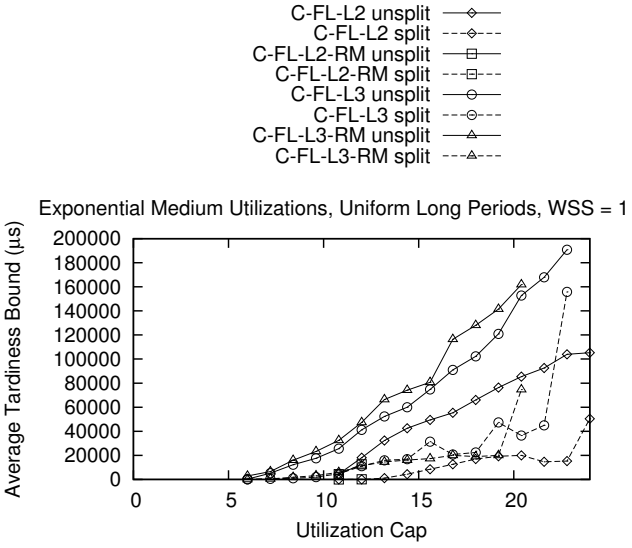

Figure B.46: By Utilization Cap: Exponential Medium Utilizations, Uniform Long Periods

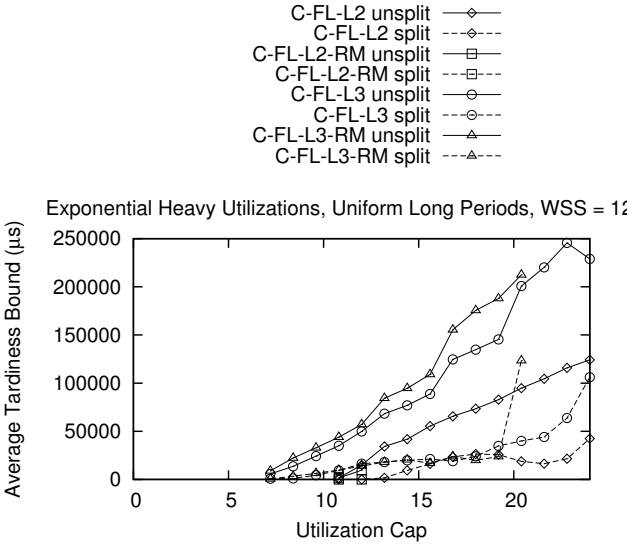

Figure B.48: By Utilization Cap: Exponential Heavy Utilizations, Uniform Long Periods

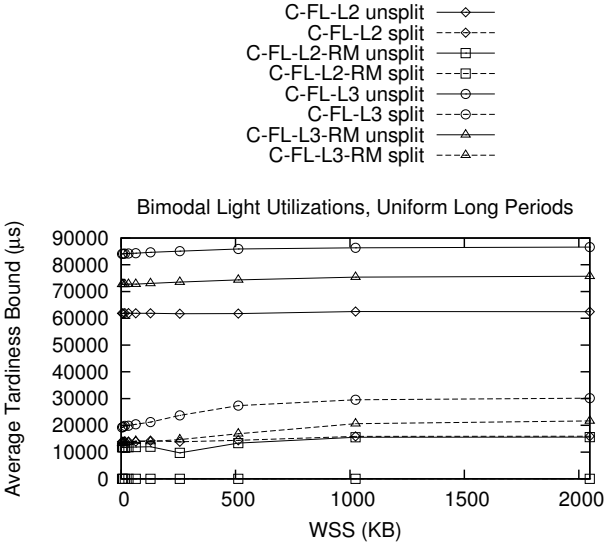

Figure B.49: By WSS: Bimodal Light Utilizations, Uniform Long Periods

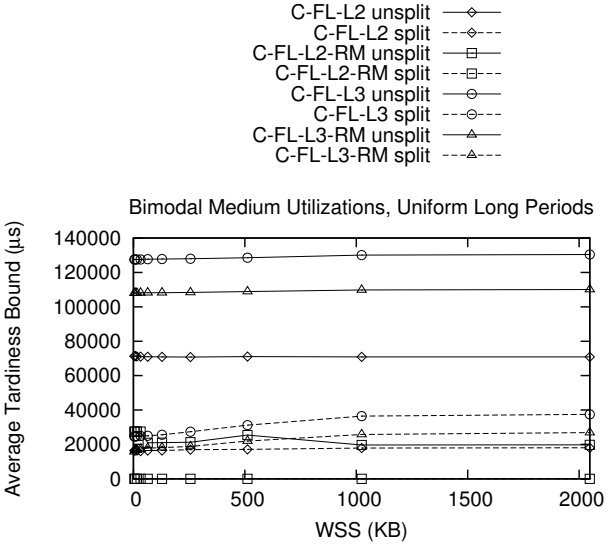

Figure B.51: By WSS: Bimodal Medium Utilizations, Uniform Long Periods

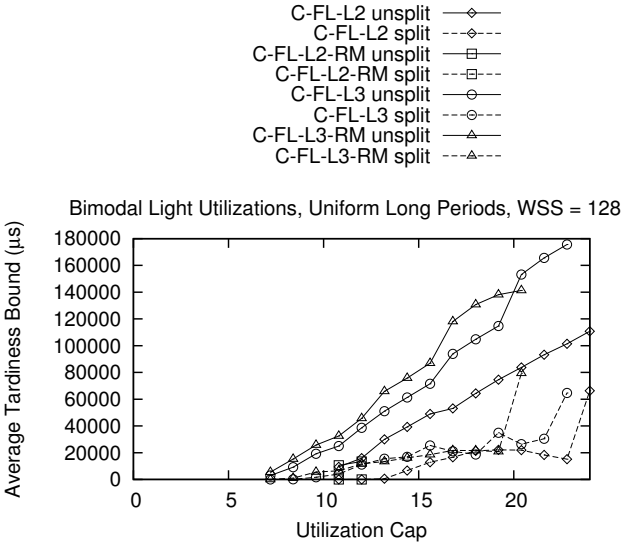

Figure B.50: By Utilization Cap: Bimodal Light Utilizations, Uniform Long Periods

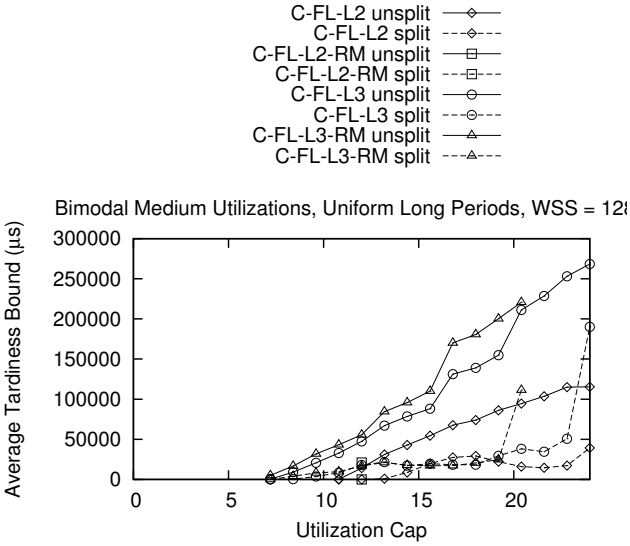

Figure B.52: By Utilization Cap: Bimodal Medium Utilizations, Uniform Long Periods

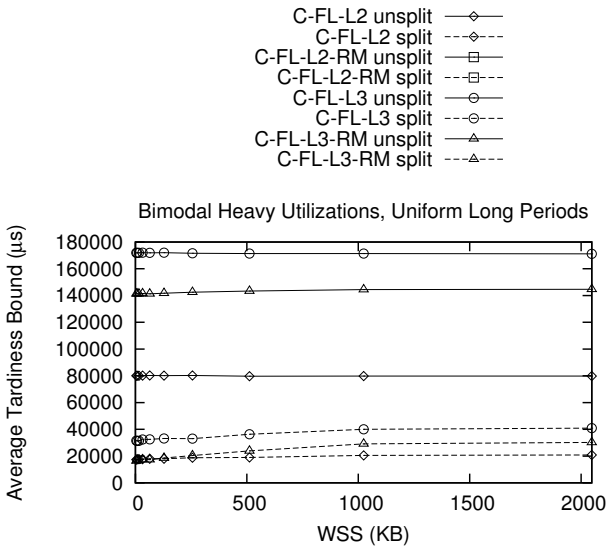

Figure B.53: By WSS: Bimodal Heavy Utilizations, Uniform Long Periods

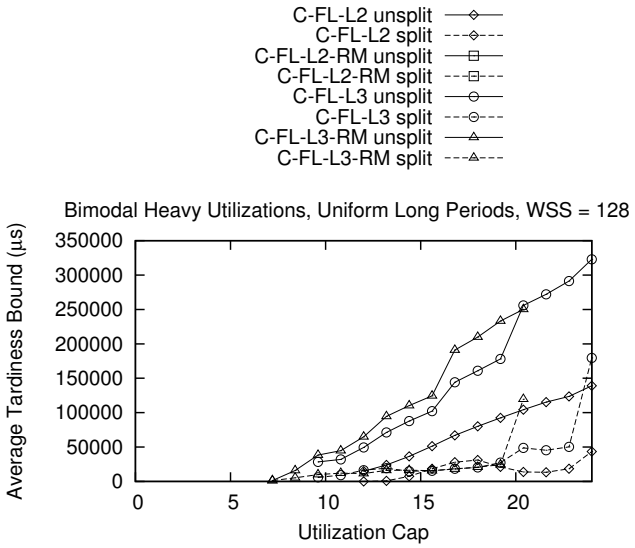

Figure B.54: By Utilization Cap: Bimodal Heavy Utilizations, Uniform Long Periods

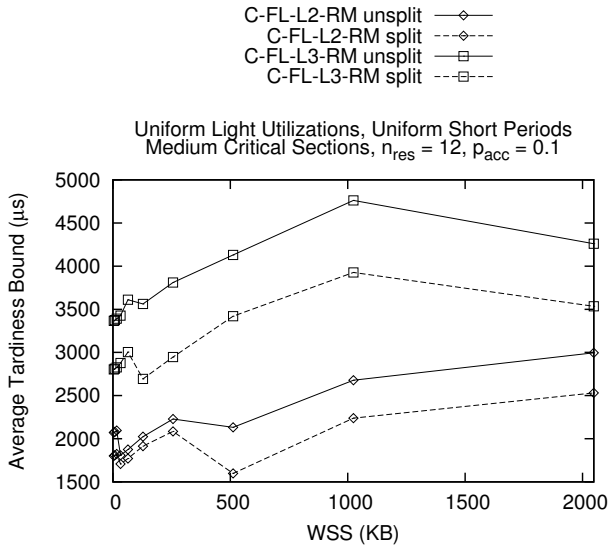

Figure B.55: By WSS: Uniform Light Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

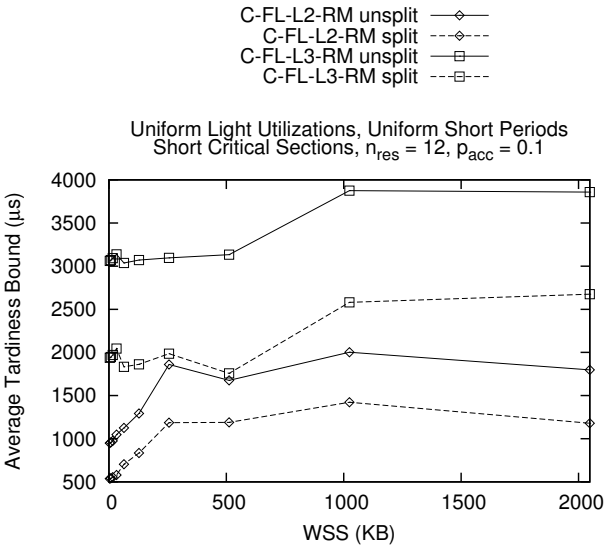

Figure B.57: By WSS: Uniform Light Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

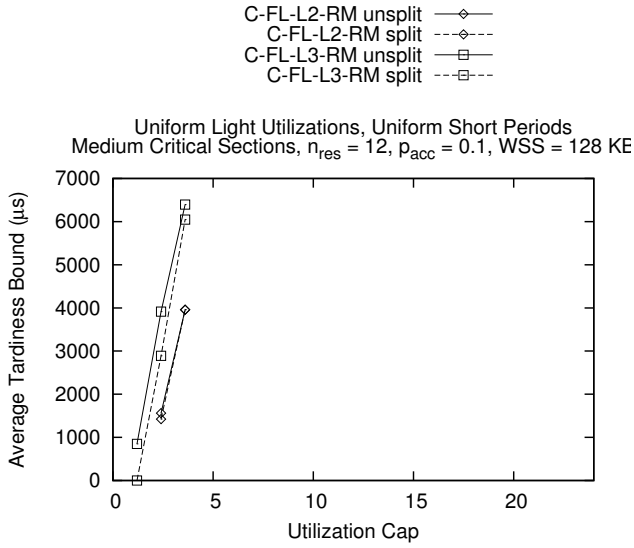

Figure B.56: By Utilization Cap: Uniform Light Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

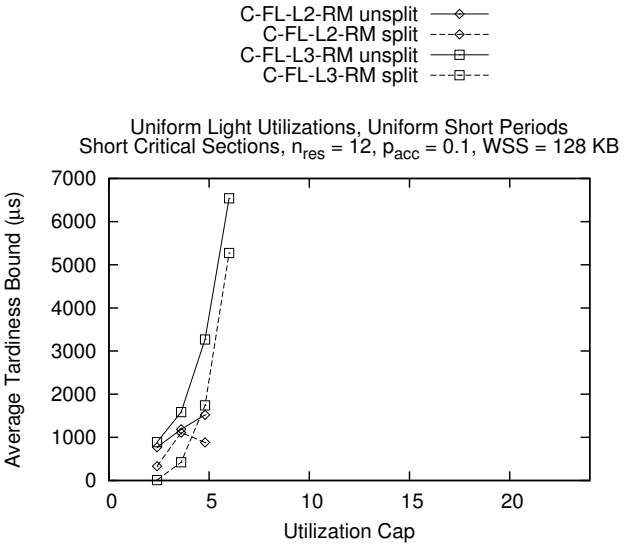

Figure B.58: By Utilization Cap: Uniform Light Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

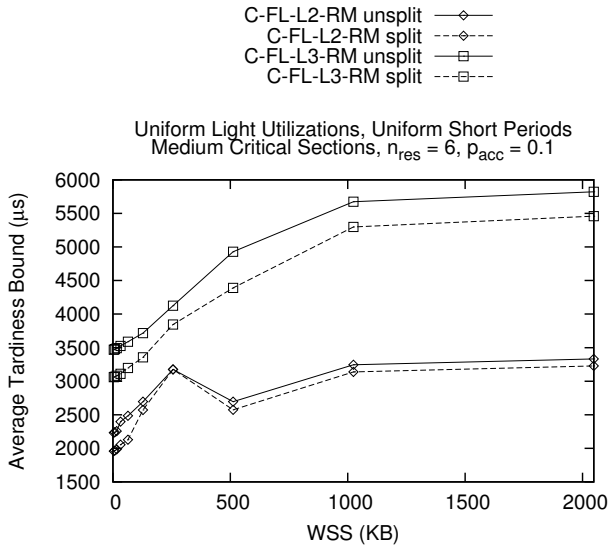

Figure B.59: By WSS: Uniform Light Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

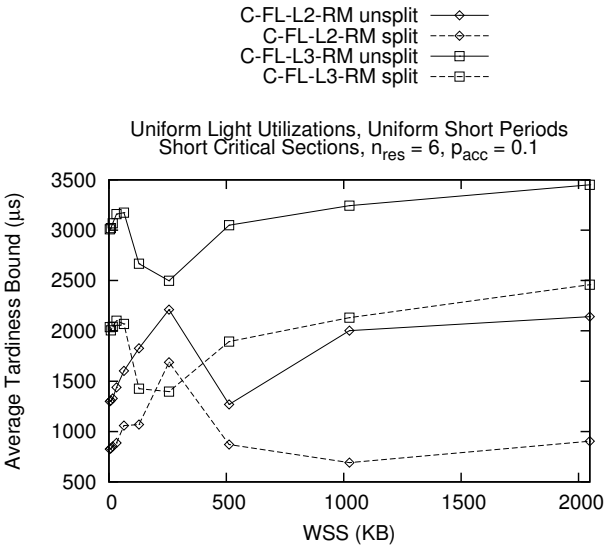

Figure B.61: By WSS: Uniform Light Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

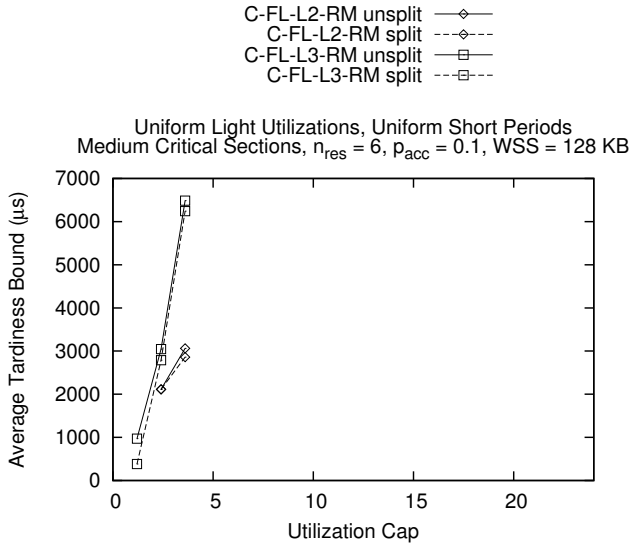

Figure B.60: By Utilization Cap: Uniform Light Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

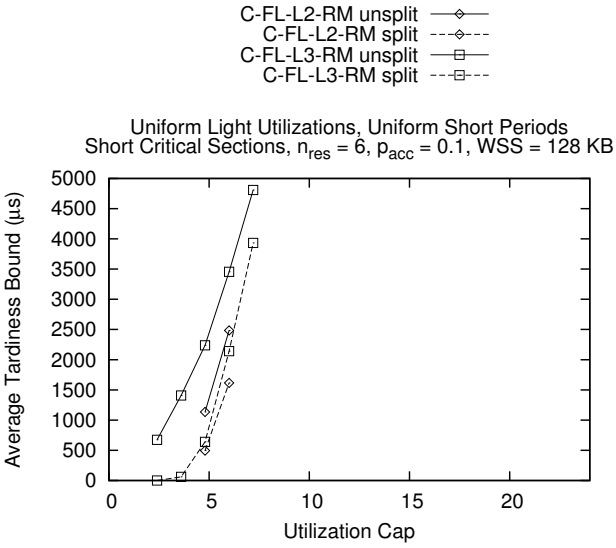

Figure B.62: By Utilization Cap: Uniform Light Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

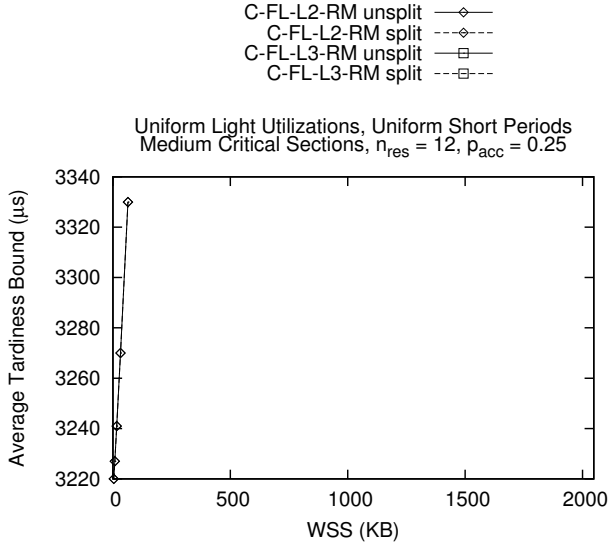

Figure B.63: By WSS: Uniform Light Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

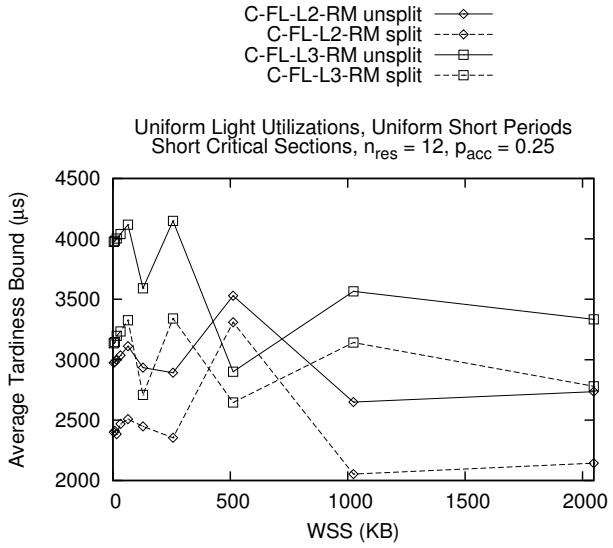

Figure B.64: By WSS: Uniform Light Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

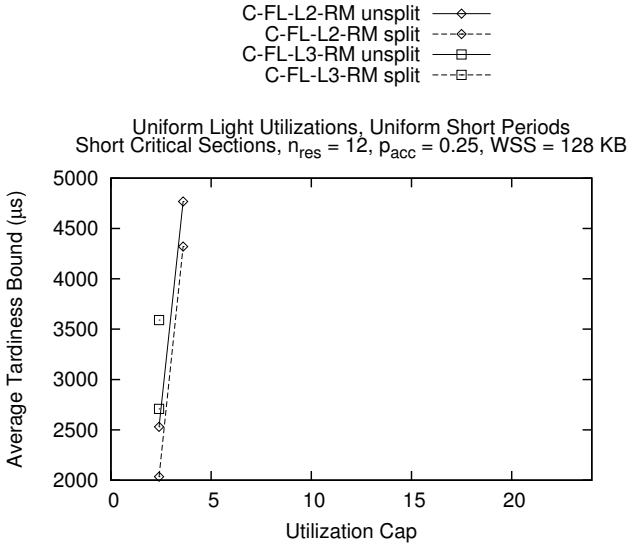

Figure B.65: By Utilization Cap: Uniform Light Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

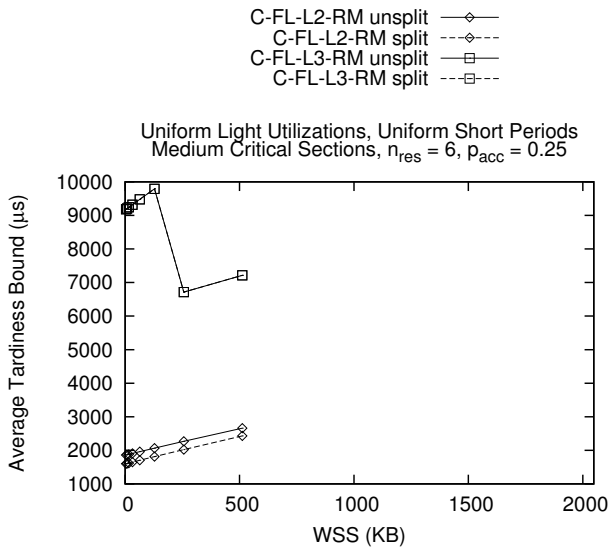

Figure B.66: By WSS: Uniform Light Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

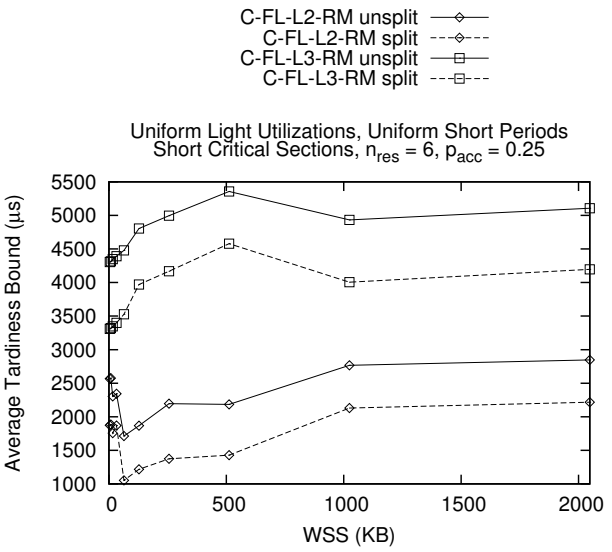

Figure B.68: By WSS: Uniform Light Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

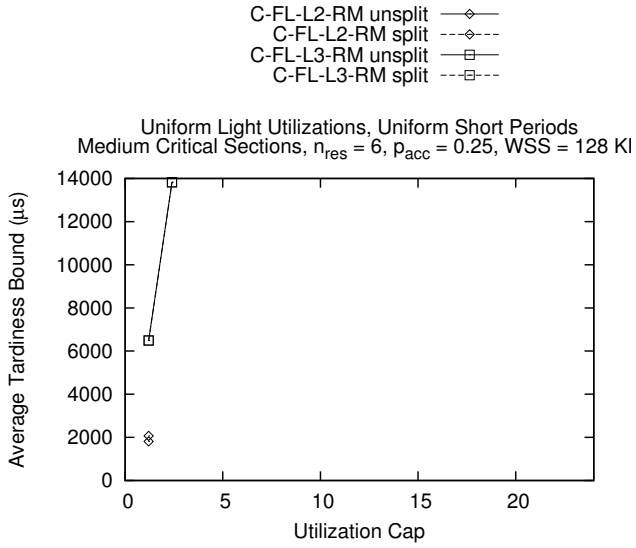

Figure B.67: By Utilization Cap: Uniform Light Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

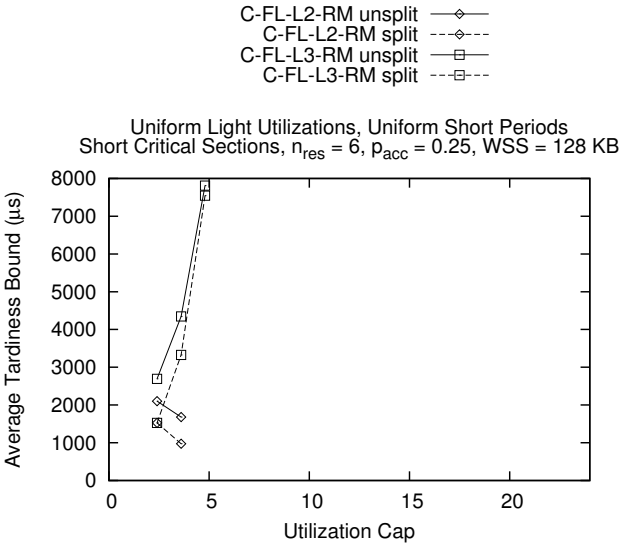

Figure B.69: By Utilization Cap: Uniform Light Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

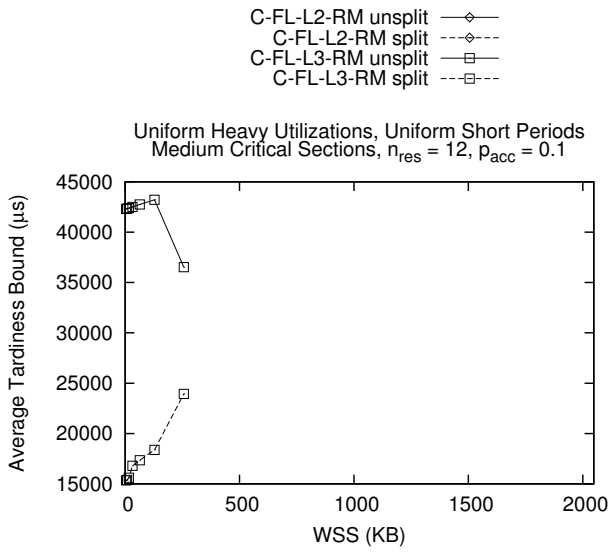

Figure B.70: By WSS: Uniform Heavy Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

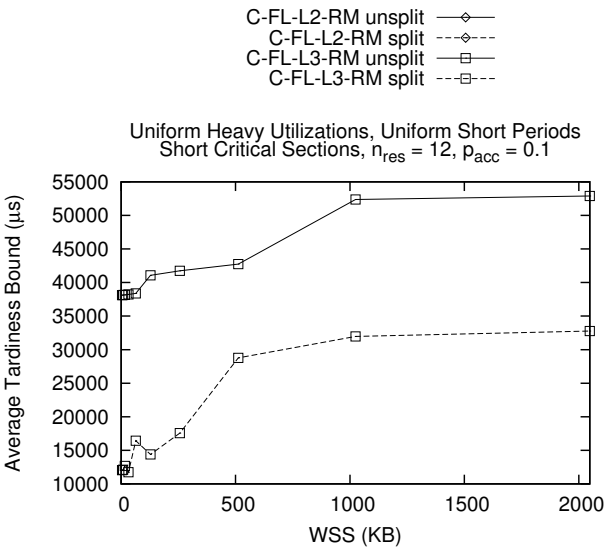

Figure B.72: By WSS: Uniform Heavy Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

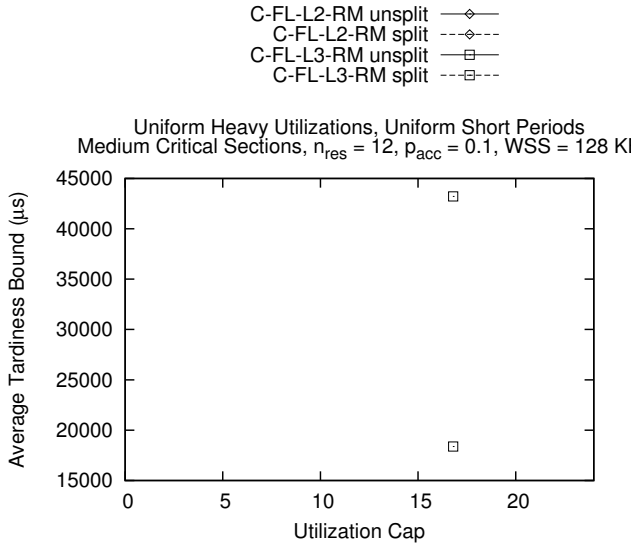

Figure B.71: By Utilization Cap: Uniform Heavy Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

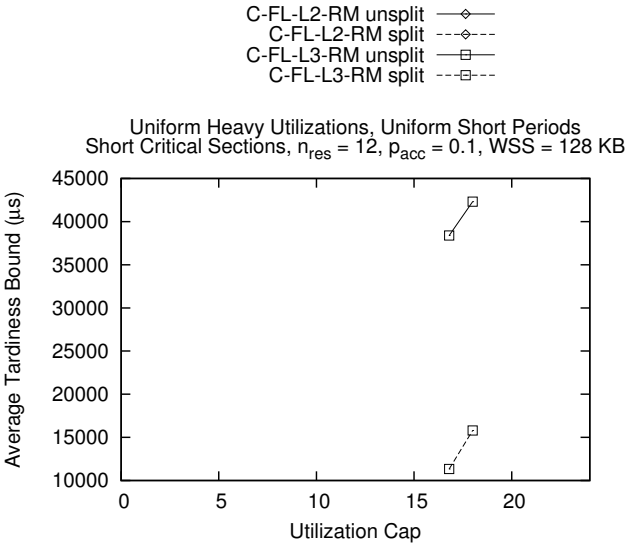

Figure B.73: By Utilization Cap: Uniform Heavy Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

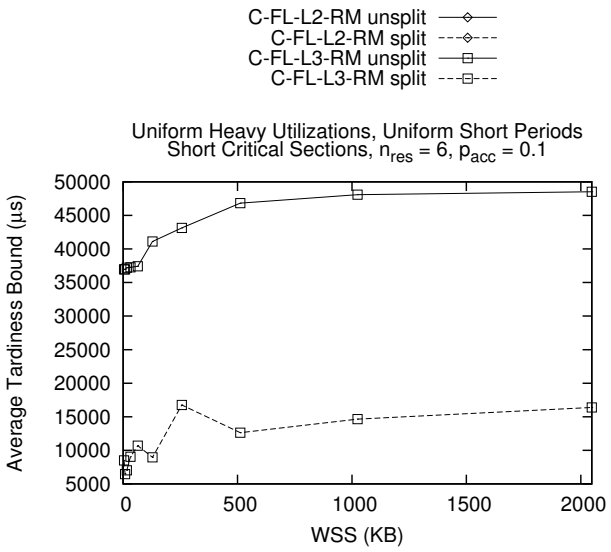

Figure B.74: By WSS: Uniform Heavy Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

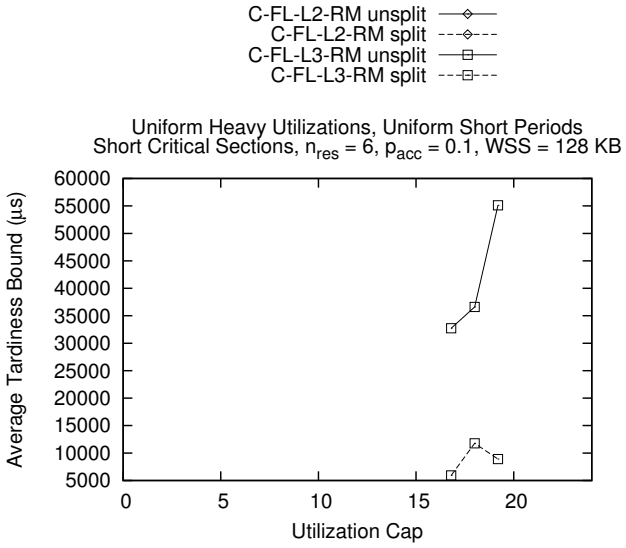

Figure B.75: By Utilization Cap: Uniform Heavy Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

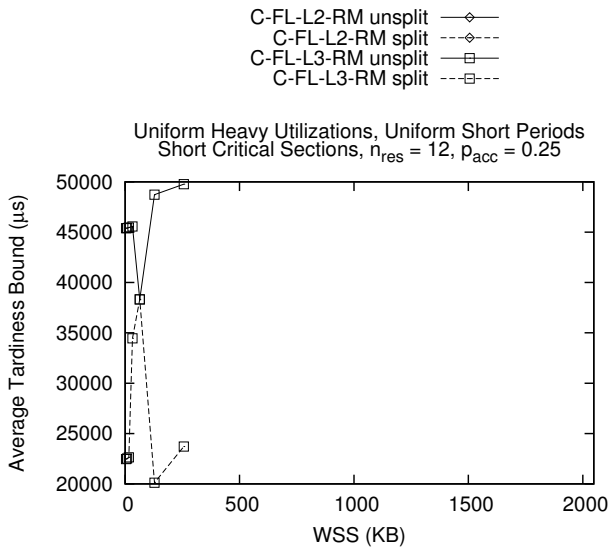

Figure B.76: By WSS: Uniform Heavy Utilizations, Uniform Short Periods, Short Critical Sections, n_{res} = 12, p_{acc} = 0.25

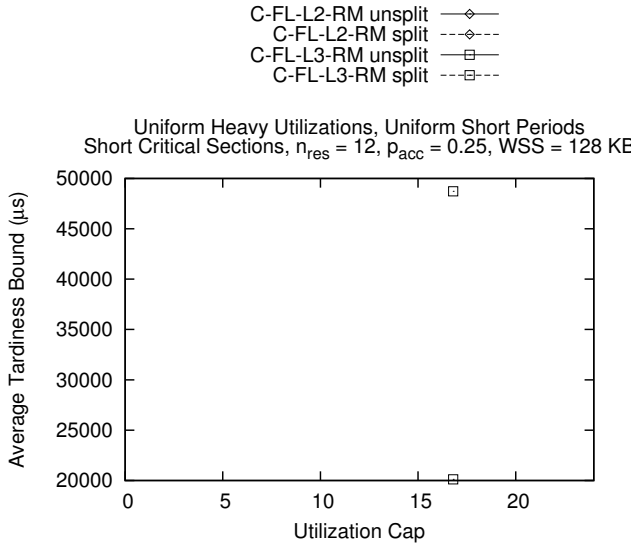

Figure B.77: By Utilization Cap: Uniform Heavy Utilizations, Uniform Short Periods, Short Critical Sections, n_{res} = 12, p_{acc} = 0.25

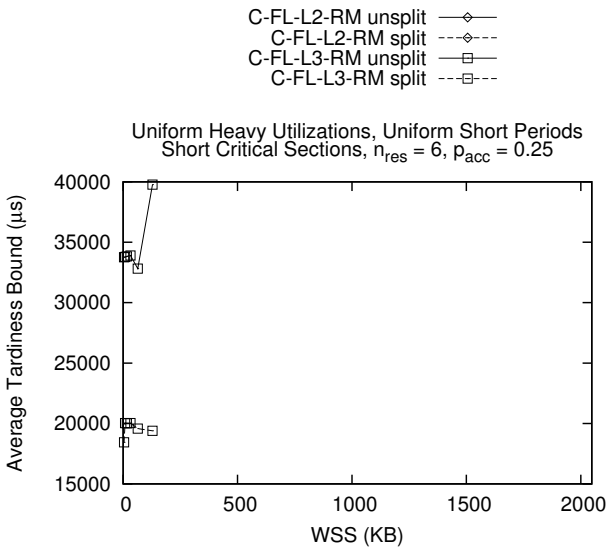

Figure B.78: By WSS: Uniform Heavy Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

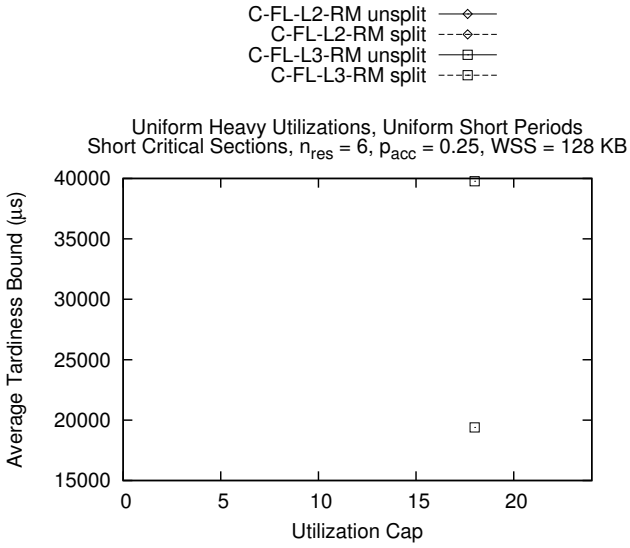

Figure B.79: By Utilization Cap: Uniform Heavy Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

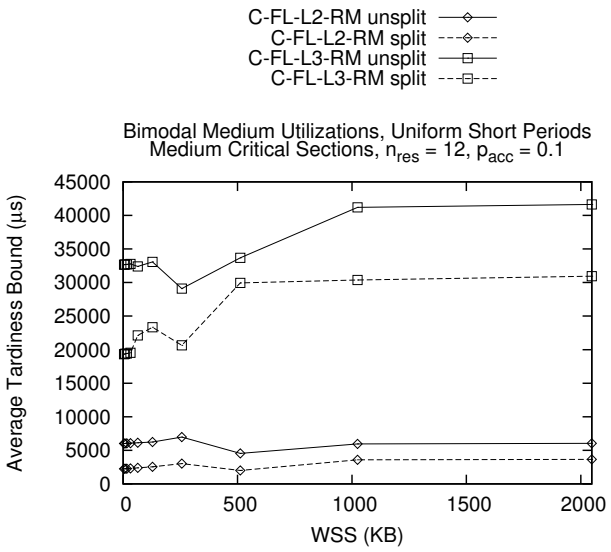

Figure B.80: By WSS: Bimodal Medium Utilizations, Uniform Short Periods, Medium Critical Sections, n_{res} = 12, $p_{acc} = 0.1$

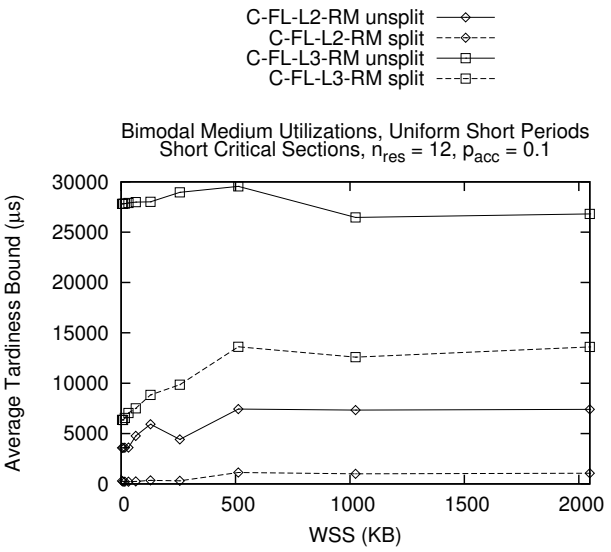

Figure B.82: By WSS: Bimodal Medium Utilizations, Uniform Short Periods, Short Critical Sections, n_{res} = 12, $p_{acc} = 0.1$

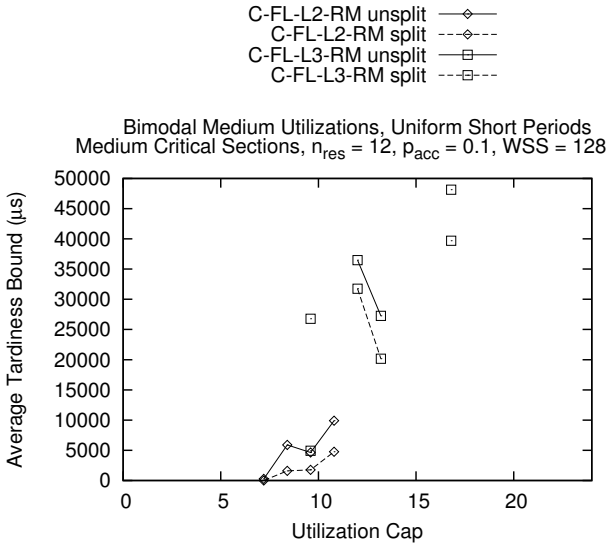

Figure B.81: By Utilization Cap: Bimodal Medium Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

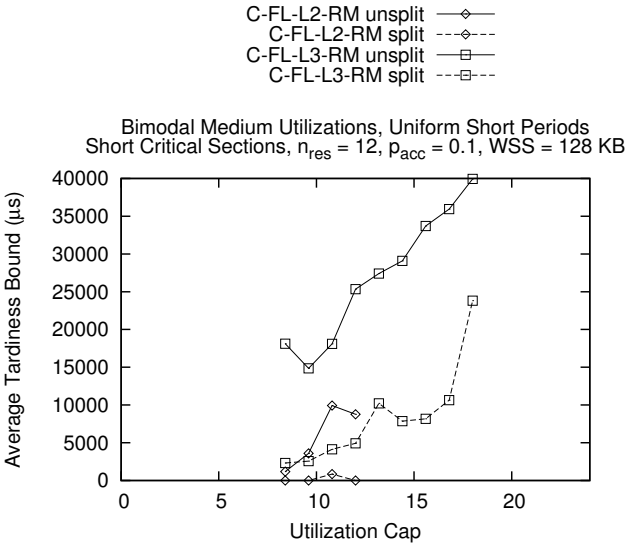

Figure B.83: By Utilization Cap: Bimodal Medium Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

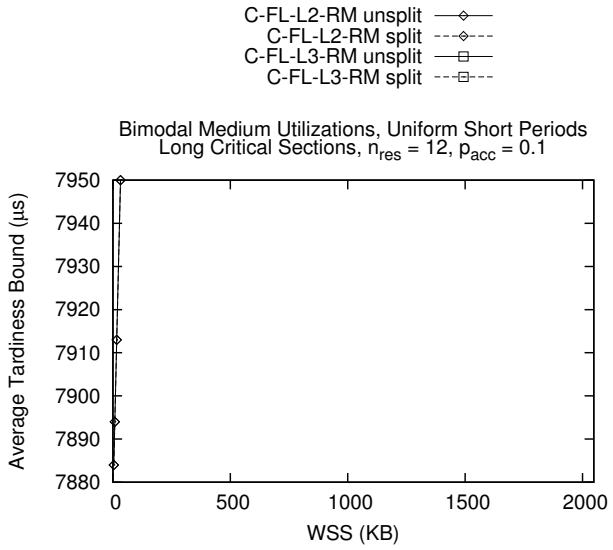

Figure B.84: By WSS: Bimodal Medium Utilizations, Uniform Short Periods, Long Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

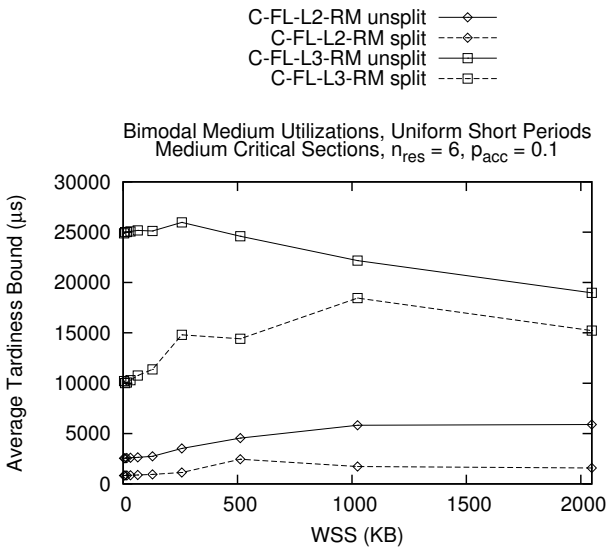

Figure B.85: By WSS: Bimodal Medium Utilizations, Uniform Short Periods, Medium Critical Sections, n_{res} = 6, $p_{acc} = 0.1$

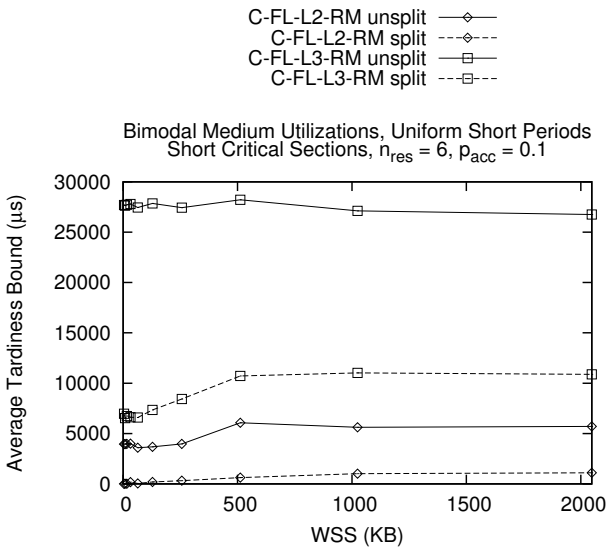

Figure B.87: By WSS: Bimodal Medium Utilizations, Uniform Short Periods, Short Critical Sections, n_{res} = 6, $p_{acc} = 0.1$

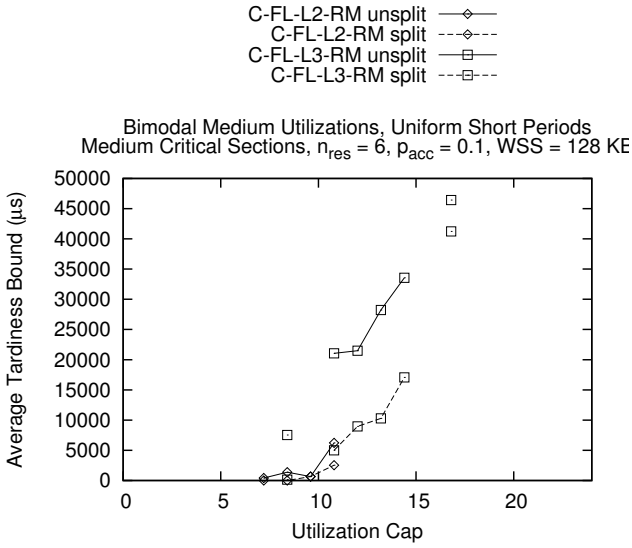

Figure B.86: By Utilization Cap: Bimodal Medium Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

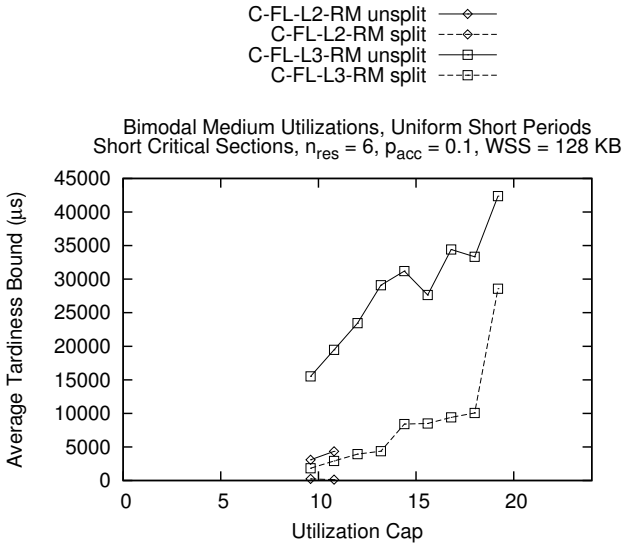

Figure B.88: By Utilization Cap: Bimodal Medium Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

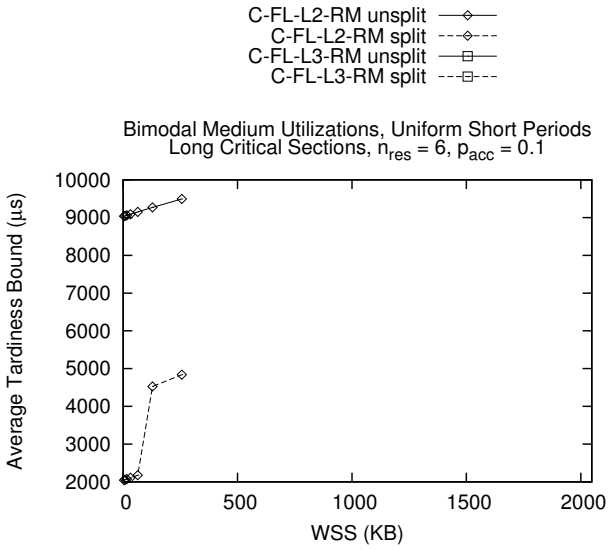

Figure B.89: By WSS: Bimodal Medium Utilizations, Uniform Short Periods, Long Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

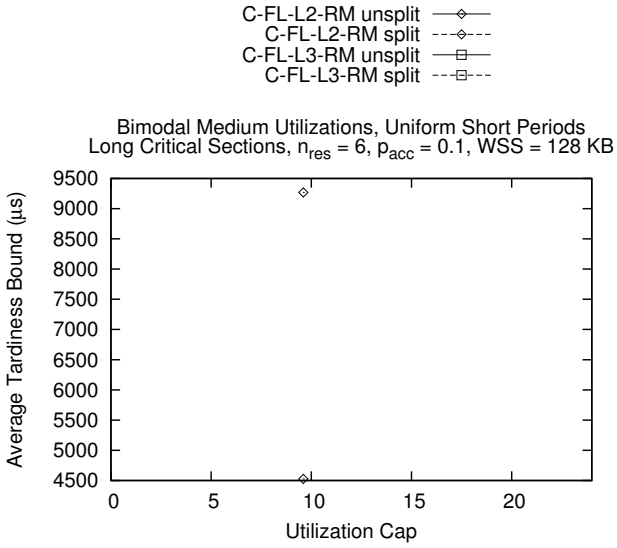

Figure B.90: By Utilization Cap: Bimodal Medium Utilizations, Uniform Short Periods, Long Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

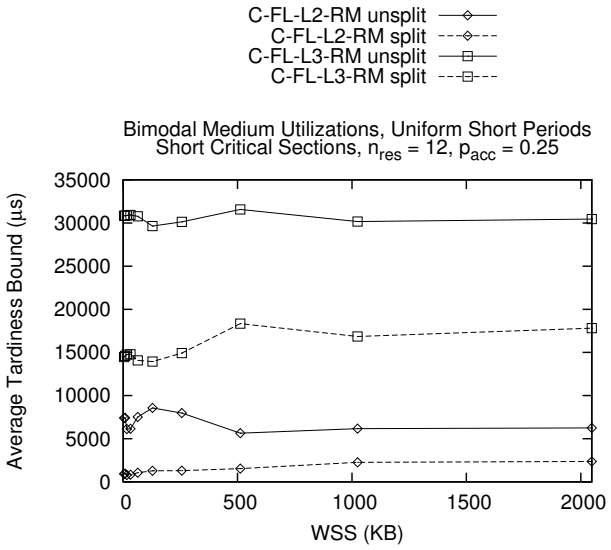

Figure B.91: By WSS: Bimodal Medium Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

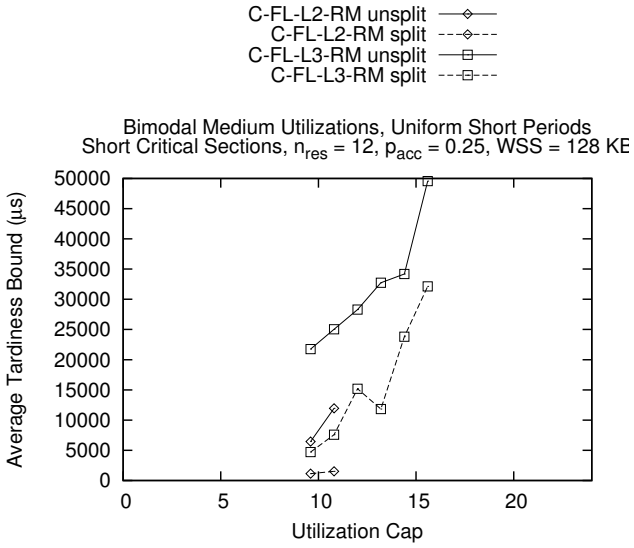

Figure B.92: By Utilization Cap: Bimodal Medium Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

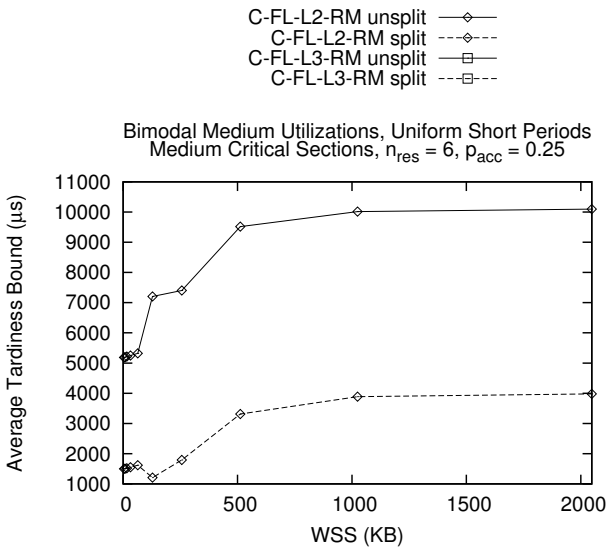

Figure B.93: By WSS: Bimodal Medium Utilizations, Uniform Short Periods, Medium Critical Sections, n_{res} = 6, $p_{acc} = 0.25$

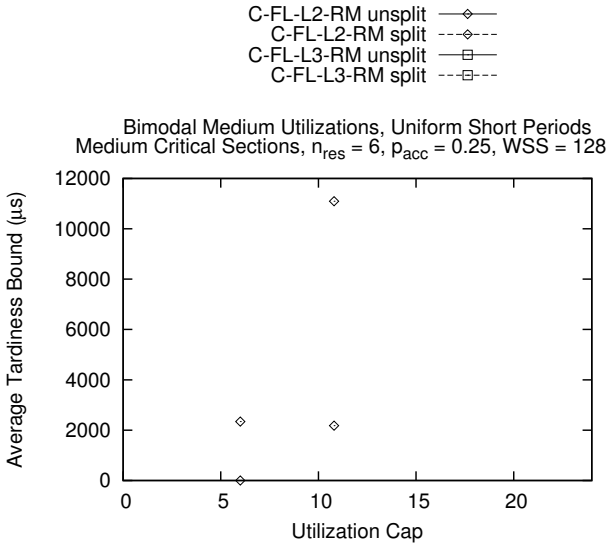

Figure B.94: By Utilization Cap: Bimodal Medium Utilizations, Uniform Short Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

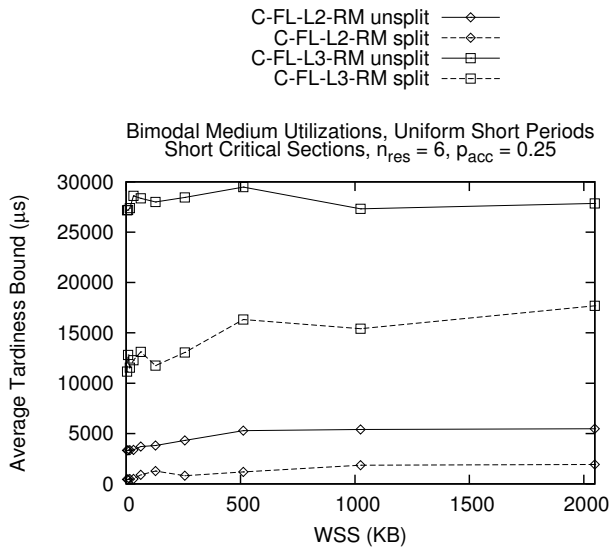

Figure B.95: By WSS: Bimodal Medium Utilizations, Uniform Short Periods, Short Critical Sections, n_{res} = 6, $p_{acc} = 0.25$

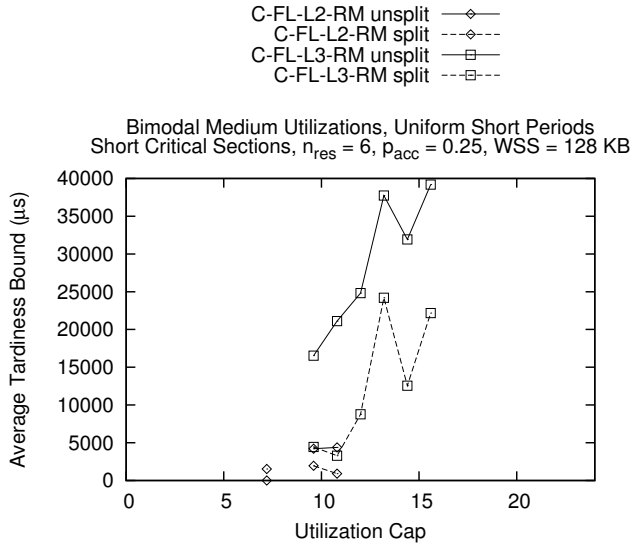

Figure B.96: By Utilization Cap: Bimodal Medium Utilizations, Uniform Short Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

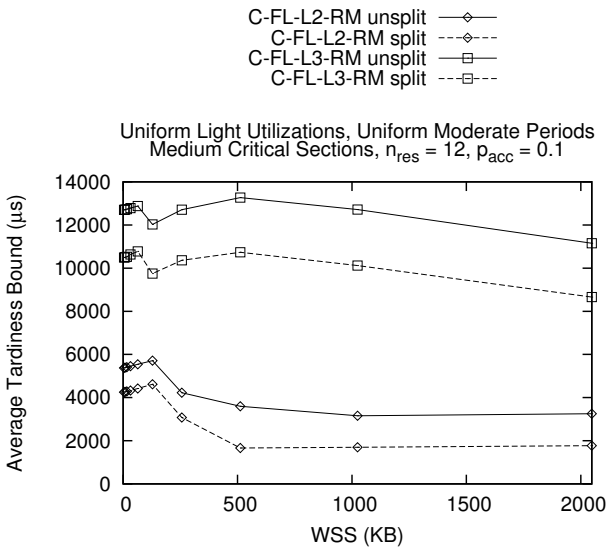

Figure B.97: By WSS: Uniform Light Utilizations, Uniform Moderate Periods, Medium Critical Sections, n_{res} = 12, p_{acc} = 0.1

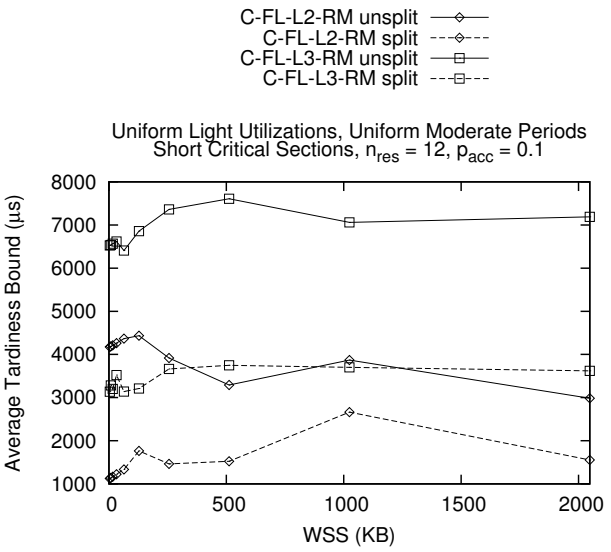

Figure B.99: By WSS: Uniform Light Utilizations, Uniform Moderate Periods, Short Critical Sections, n_{res} = 12, p_{acc} = 0.1

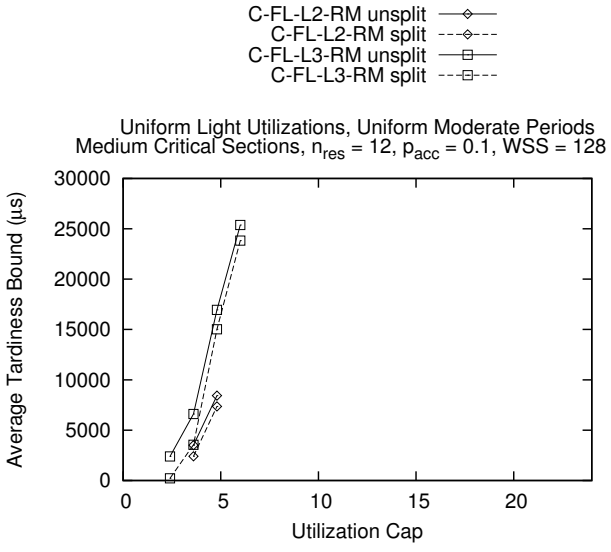

Figure B.98: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods, Medium Critical Sections, n_{res} = 12, p_{acc} = 0.1

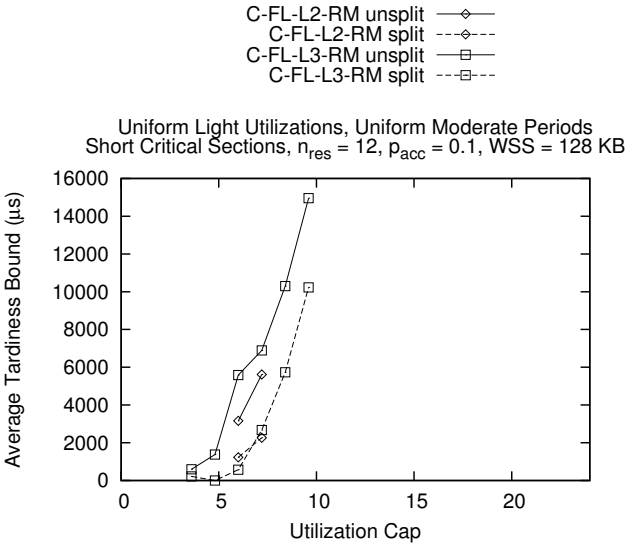

Figure B.100: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods, Short Critical Sections, n_{res} = 12, p_{acc} = 0.1

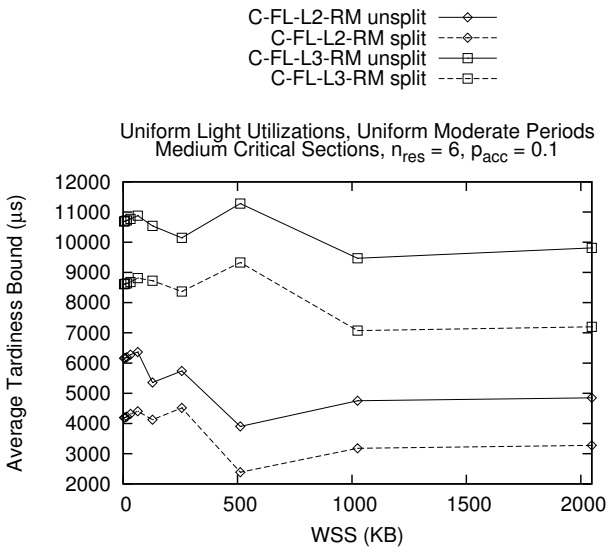

Figure B.101: By WSS: Uniform Light Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

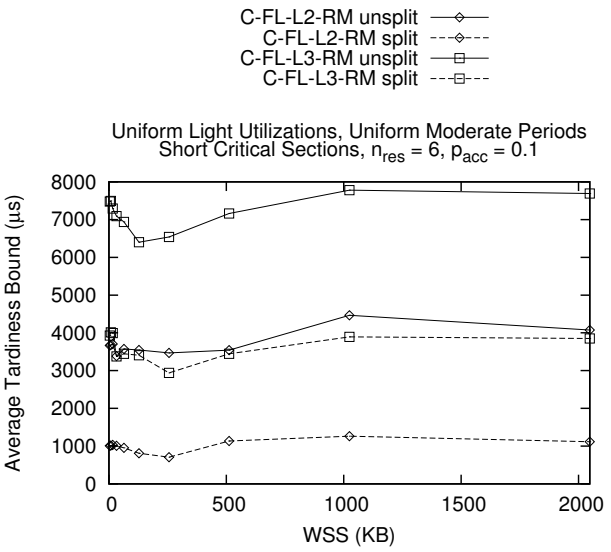

Figure B.103: By WSS: Uniform Light Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

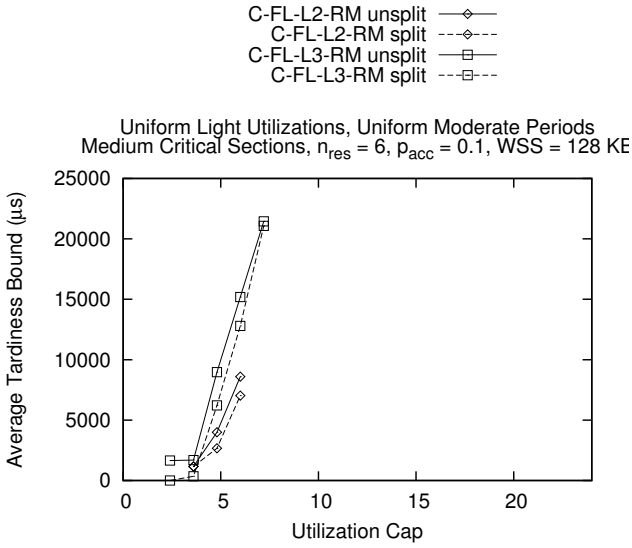

Figure B.102: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

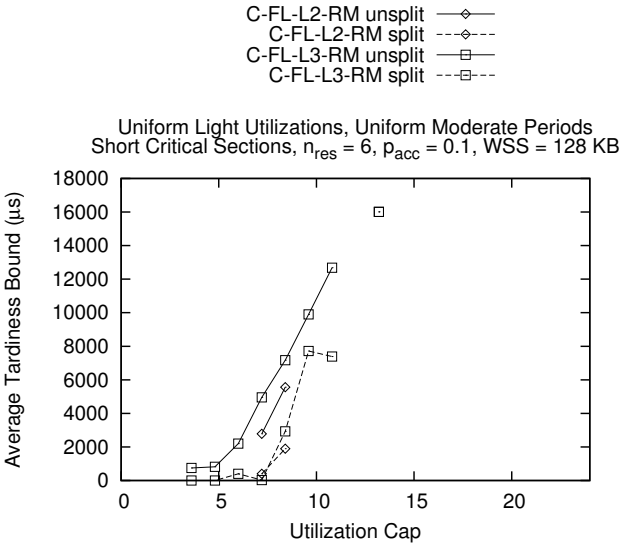

Figure B.104: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

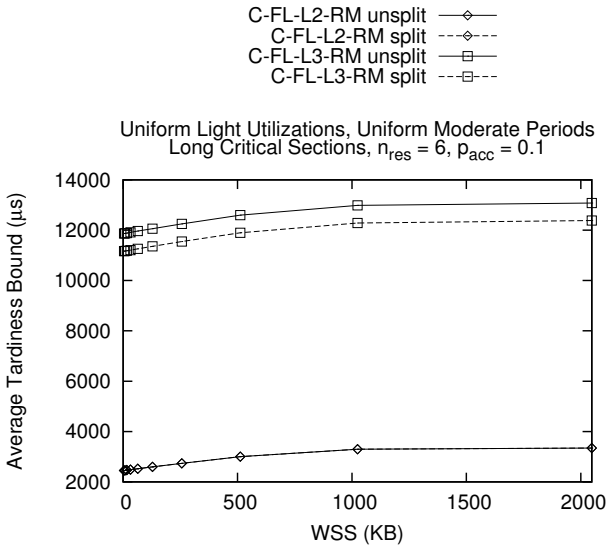

Figure B.105: By WSS: Uniform Light Utilizations, Uniform Moderate Periods, Long Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

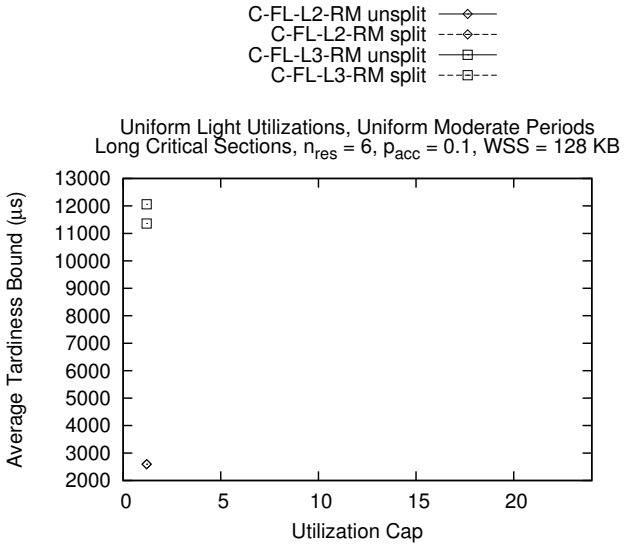

Figure B.106: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods, Long Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

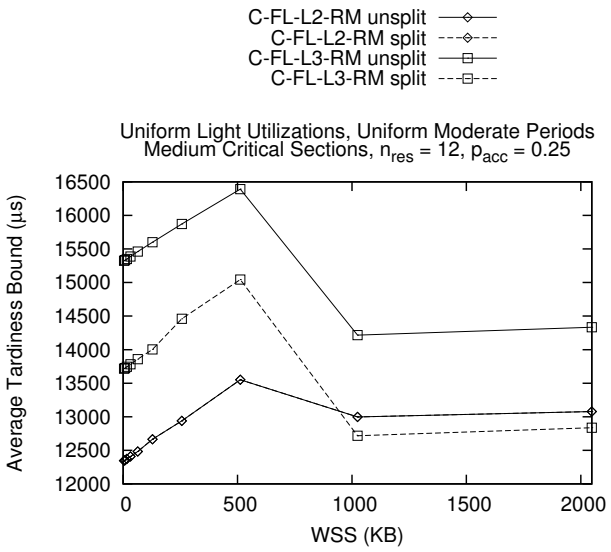

Figure B.107: By WSS: Uniform Light Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

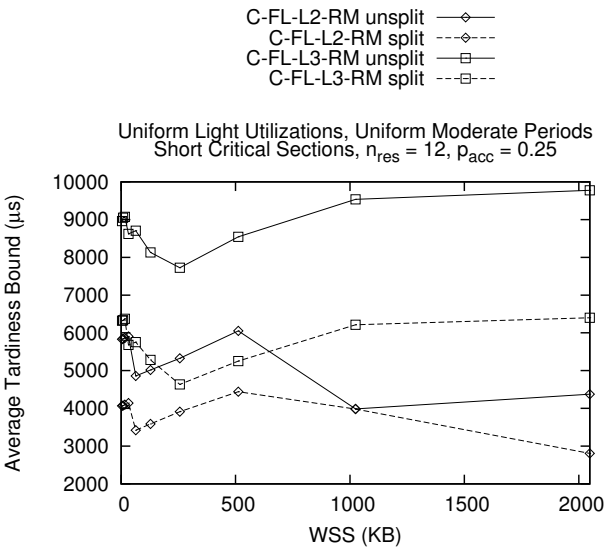

Figure B.109: By WSS: Uniform Light Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

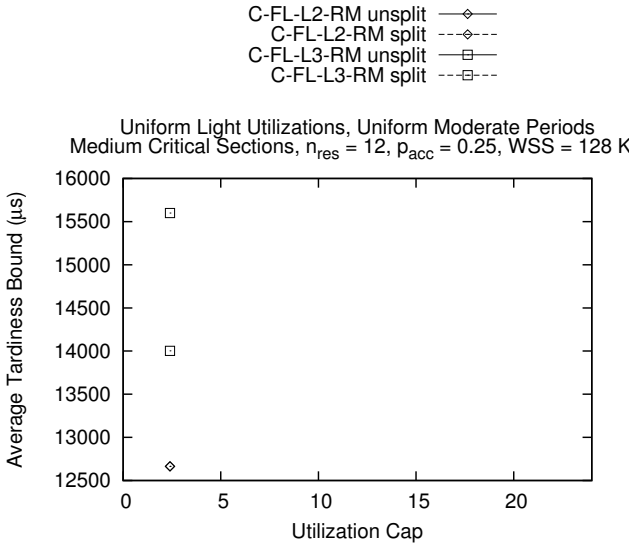

Figure B.108: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

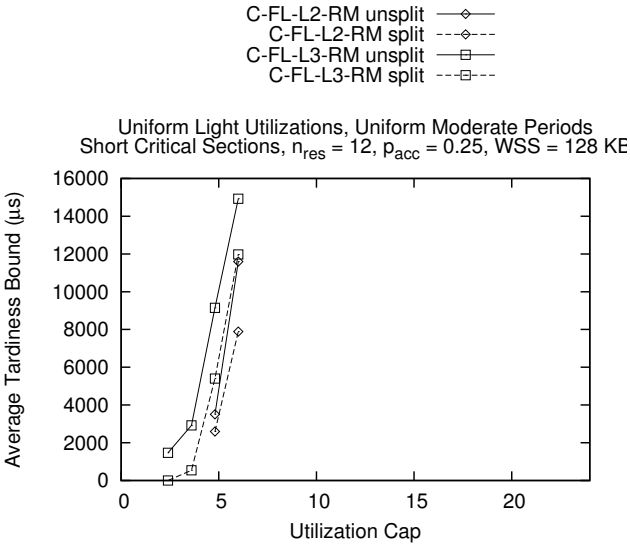

Figure B.110: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

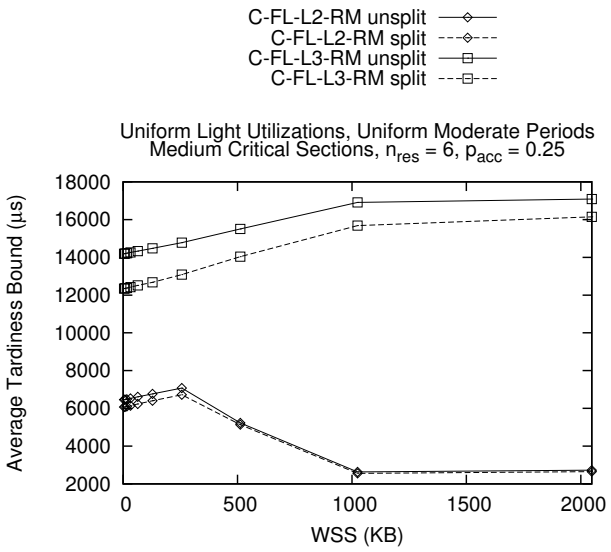

Figure B.111: By WSS: Uniform Light Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

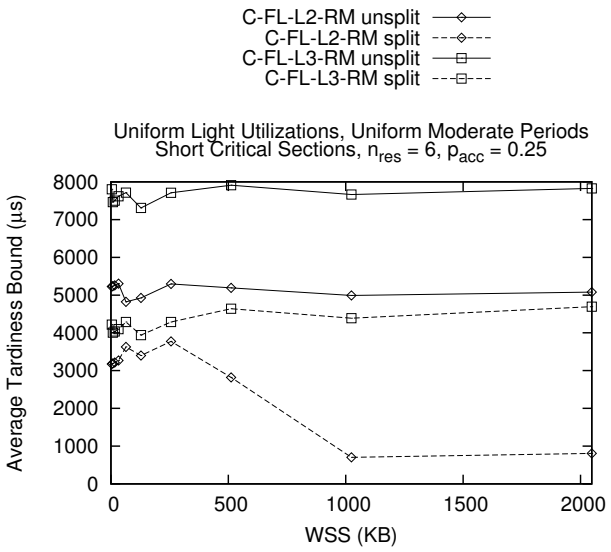

Figure B.113: By WSS: Uniform Light Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

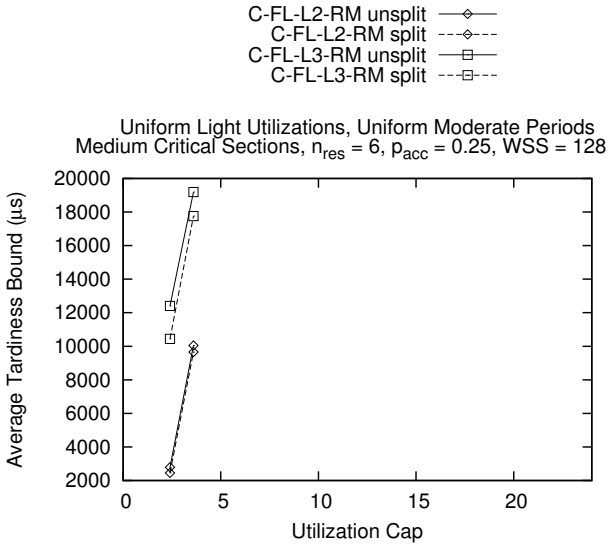

Figure B.112: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

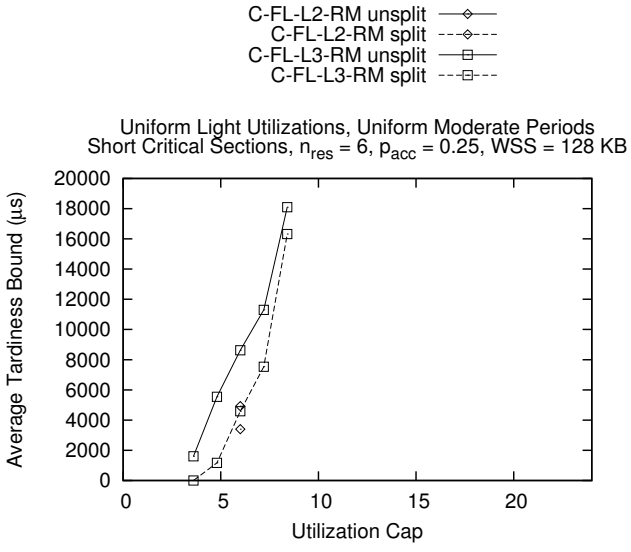

Figure B.114: By Utilization Cap: Uniform Light Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

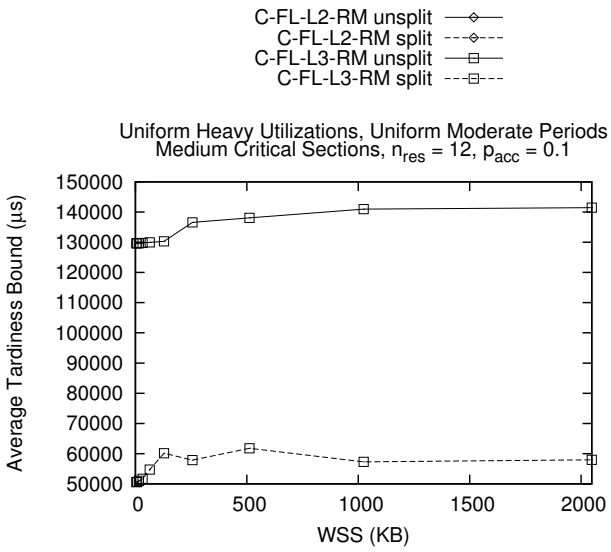

Figure B.115: By WSS: Uniform Heavy Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

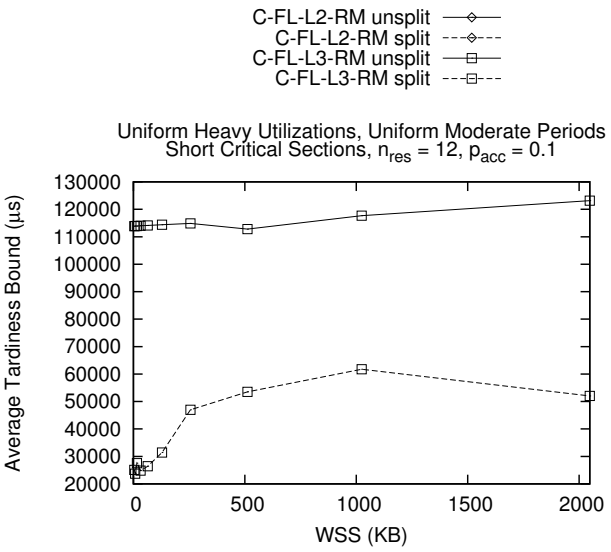

Figure B.117: By WSS: Uniform Heavy Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

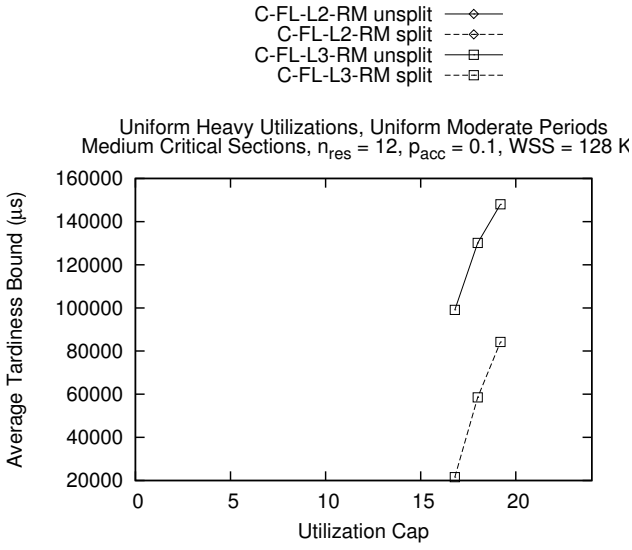

Figure B.116: By Utilization Cap: Uniform Heavy Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

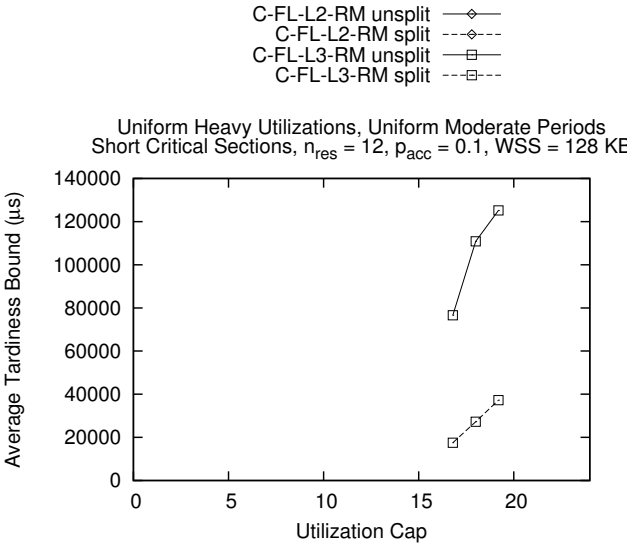

Figure B.118: By Utilization Cap: Uniform Heavy Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

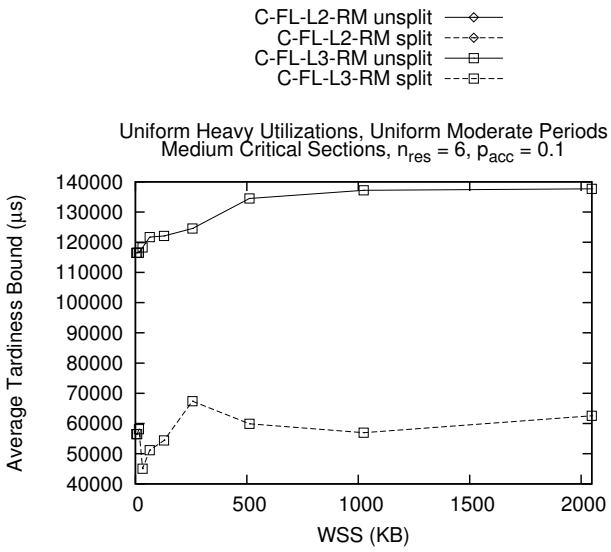

Figure B.119: By WSS: Uniform Heavy Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

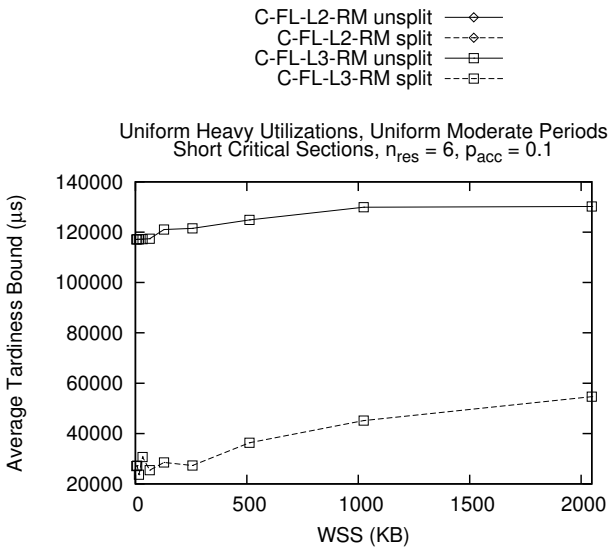

Figure B.121: By WSS: Uniform Heavy Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

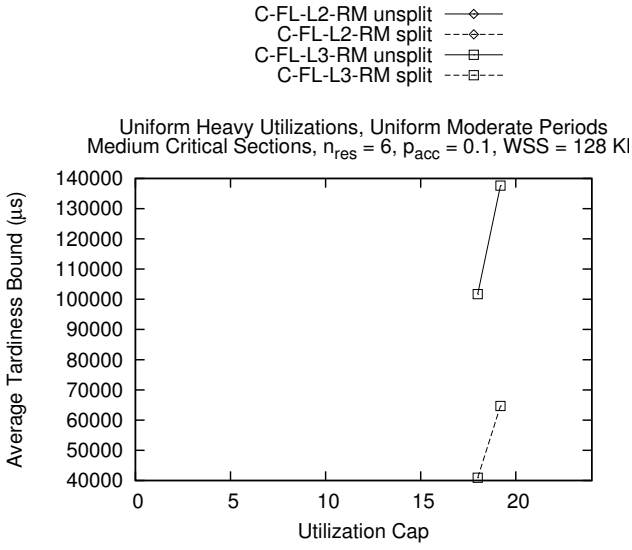

Figure B.120: By Utilization Cap: Uniform Heavy Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

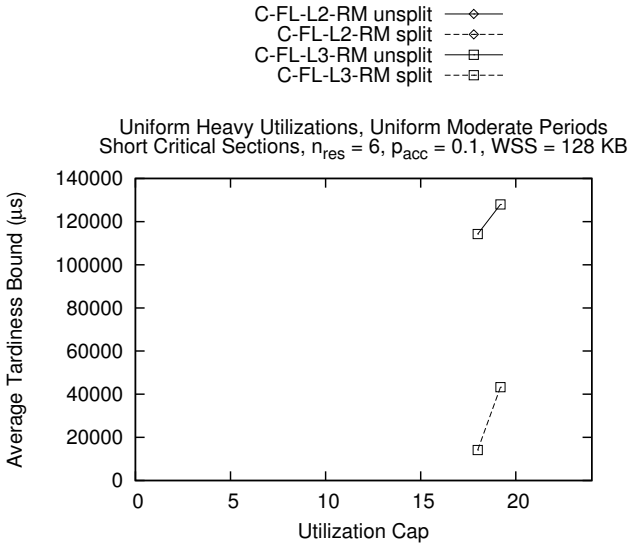

Figure B.122: By Utilization Cap: Uniform Heavy Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

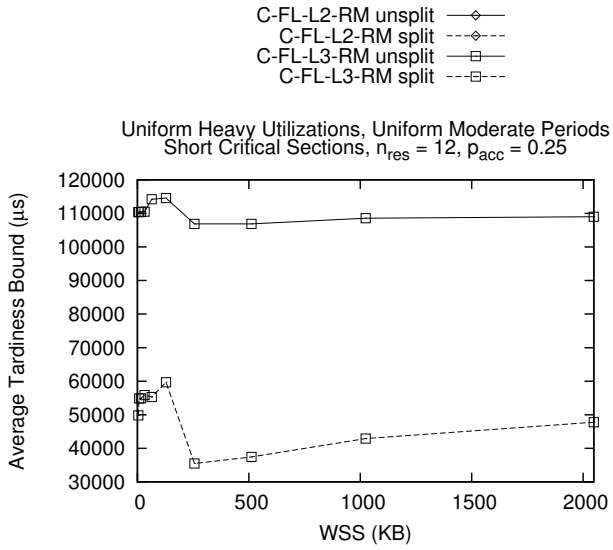

Figure B.123: By WSS: Uniform Heavy Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

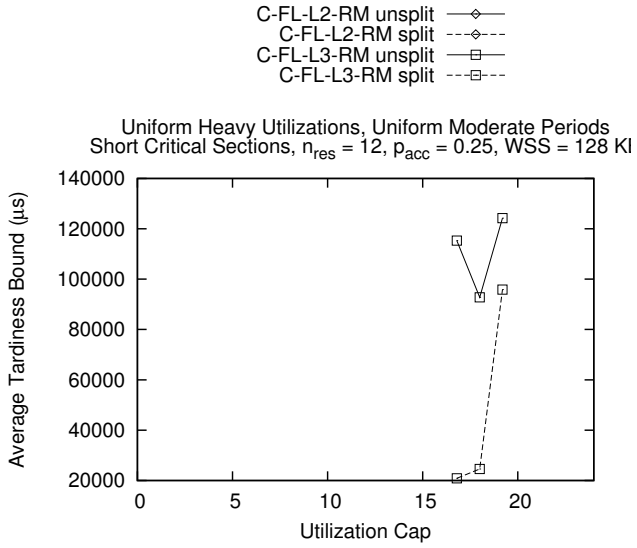

Figure B.124: By Utilization Cap: Uniform Heavy Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

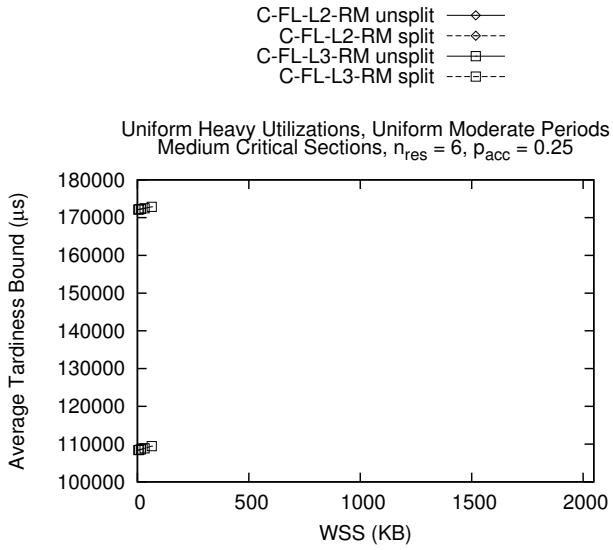

Figure B.125: By WSS: Uniform Heavy Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

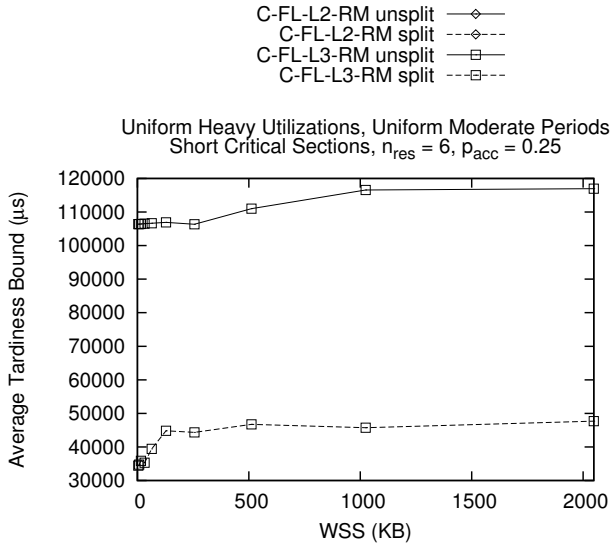

Figure B.126: By WSS: Uniform Heavy Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

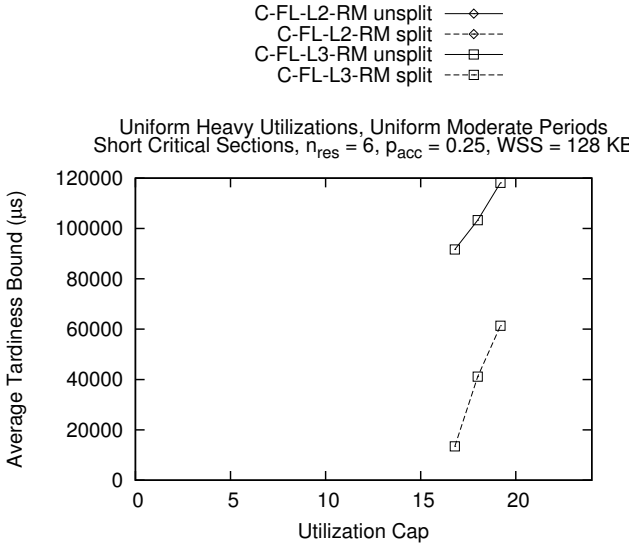

Figure B.127: By Utilization Cap: Uniform Heavy Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

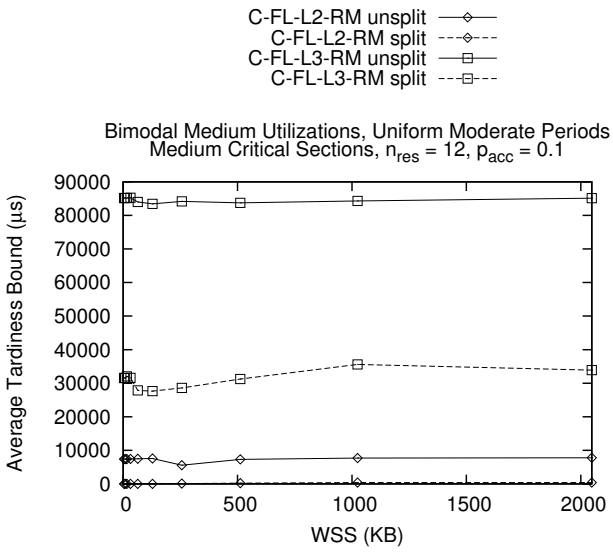

Figure B.128: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

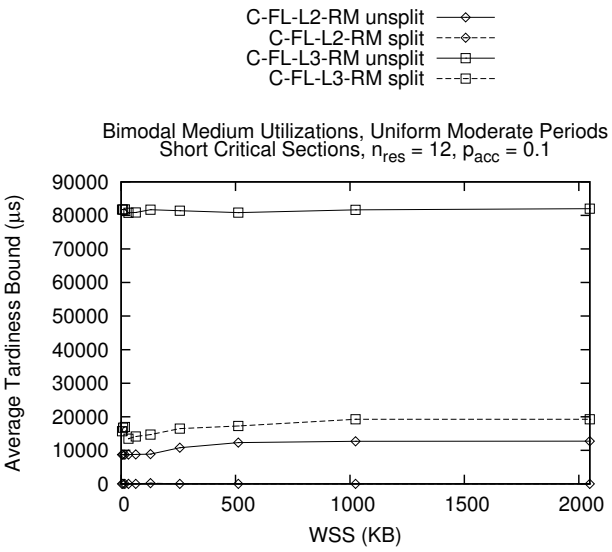

Figure B.130: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

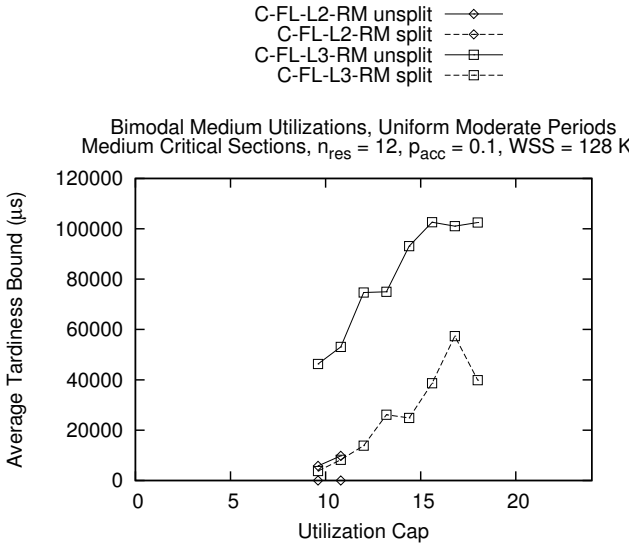

Figure B.129: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

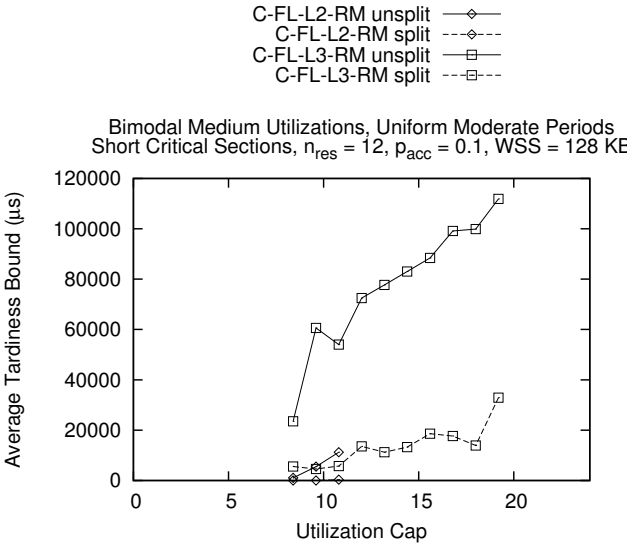

Figure B.131: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

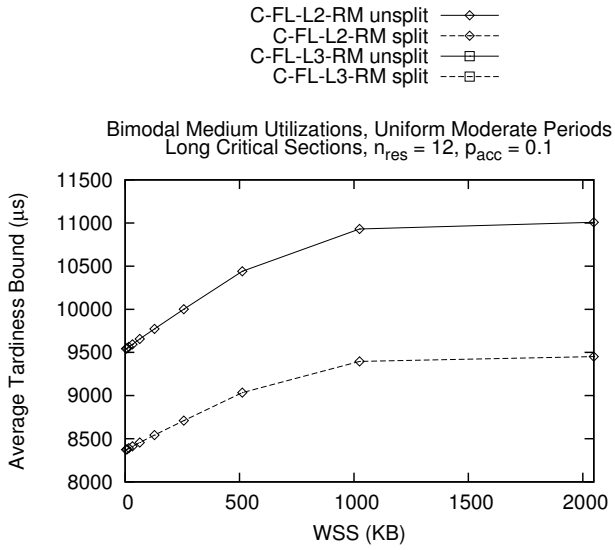

Figure B.132: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Long Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

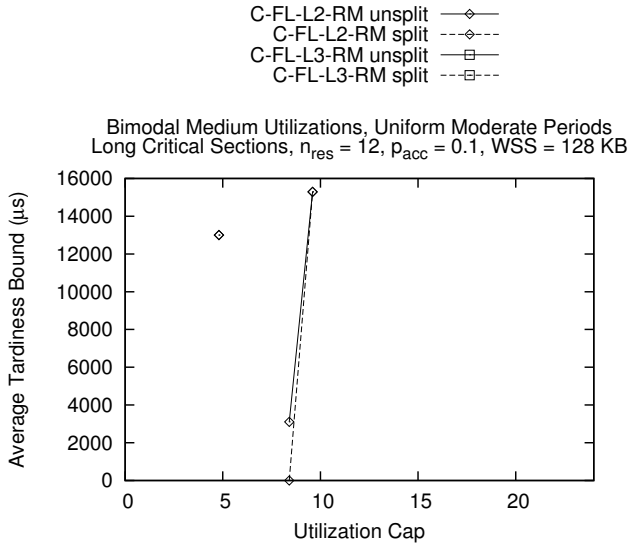

Figure B.133: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods, Long Critical Sections, $n_{res} = 12$, $p_{acc} = 0.1$

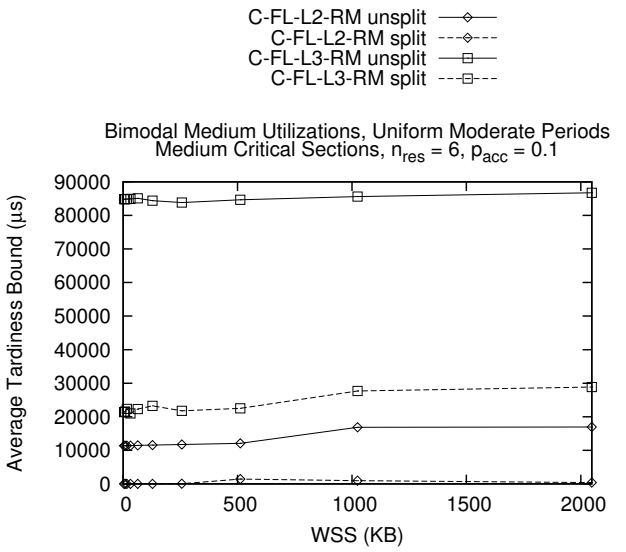

Figure B.134: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

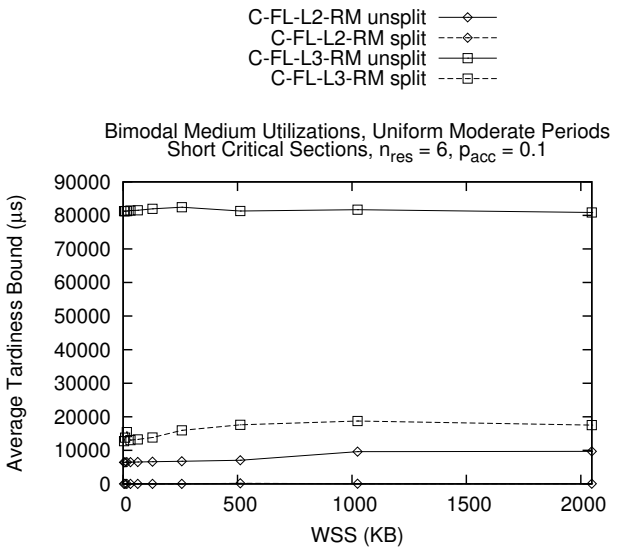

Figure B.136: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

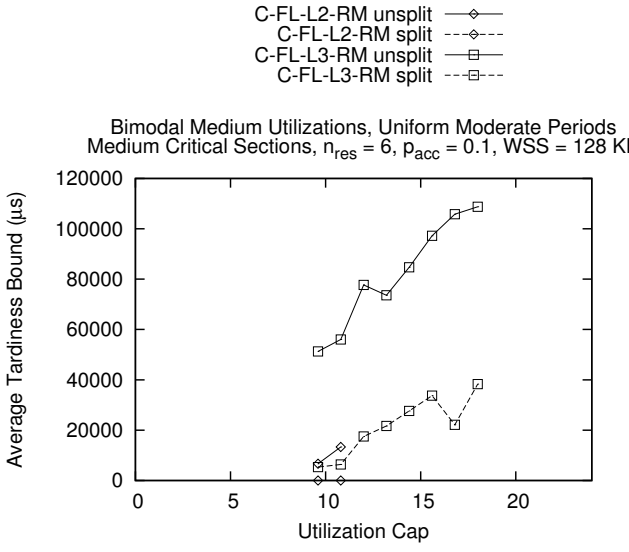

Figure B.135: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

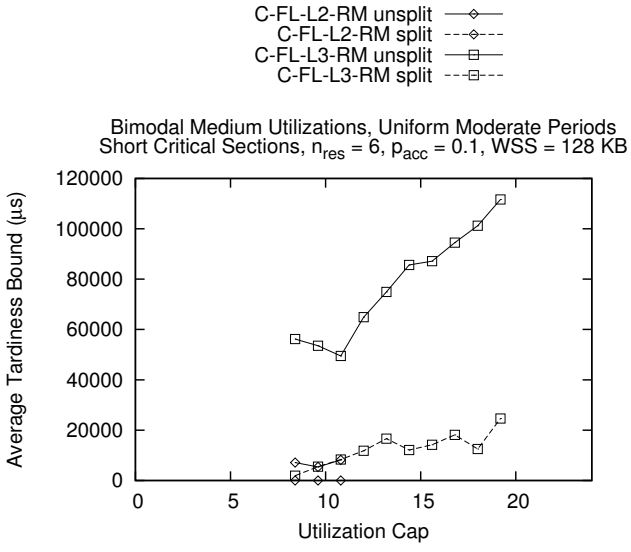

Figure B.137: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

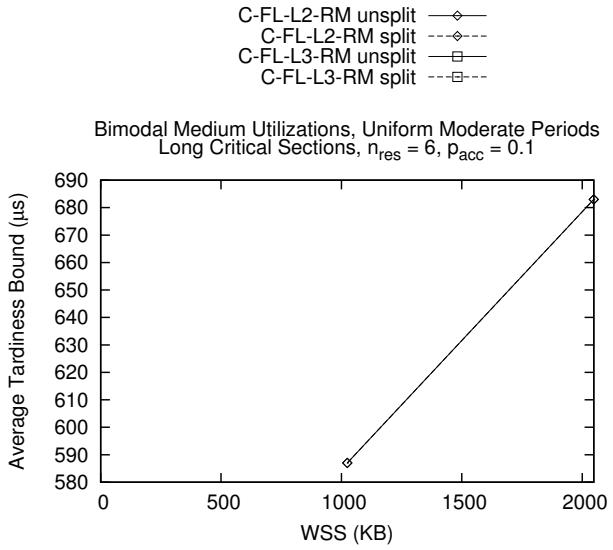

Figure B.138: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Long Critical Sections, $n_{res} = 6$, $p_{acc} = 0.1$

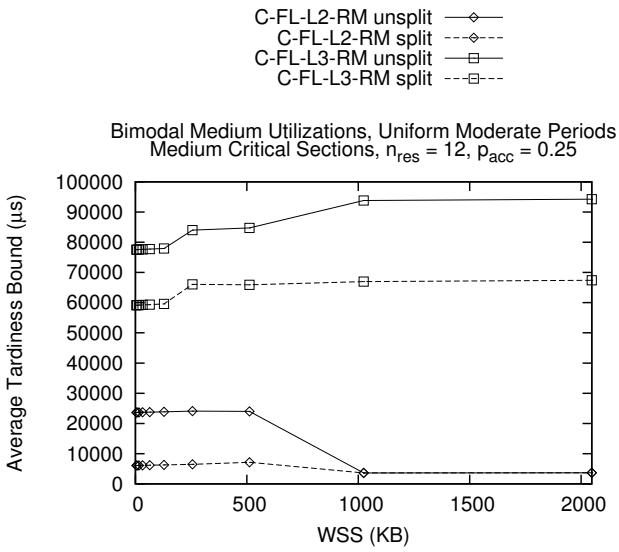

Figure B.139: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

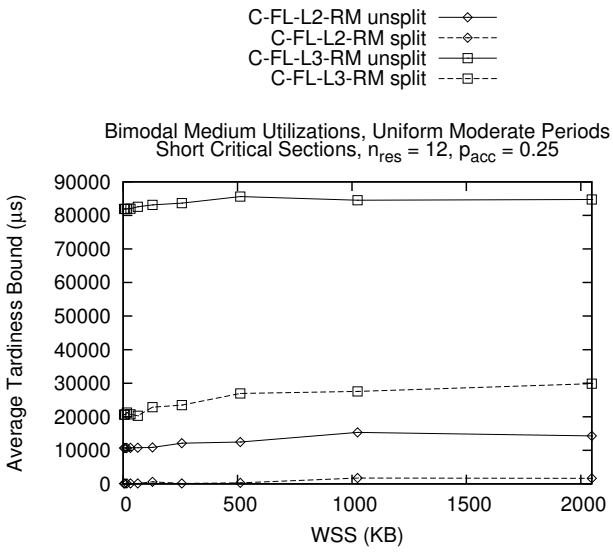

Figure B.141: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

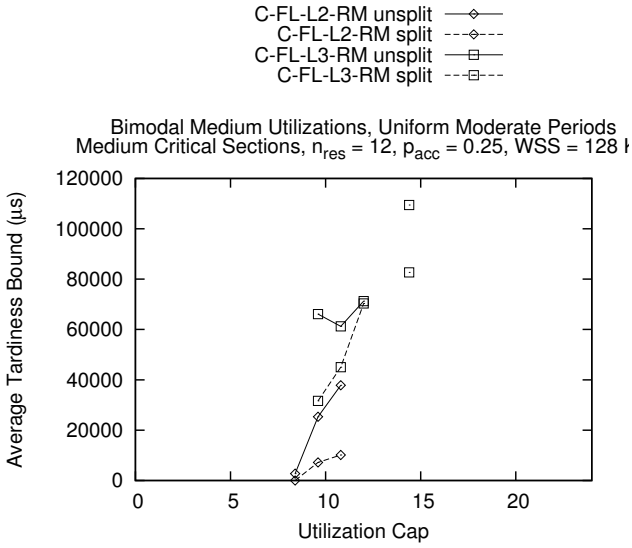

Figure B.140: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

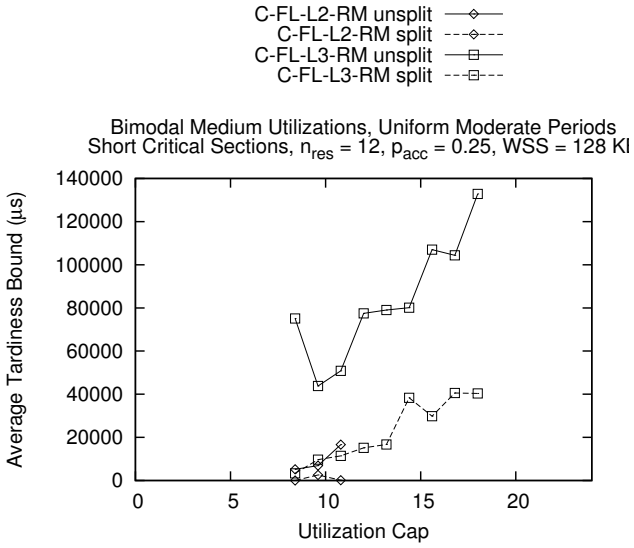

Figure B.142: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 12$, $p_{acc} = 0.25$

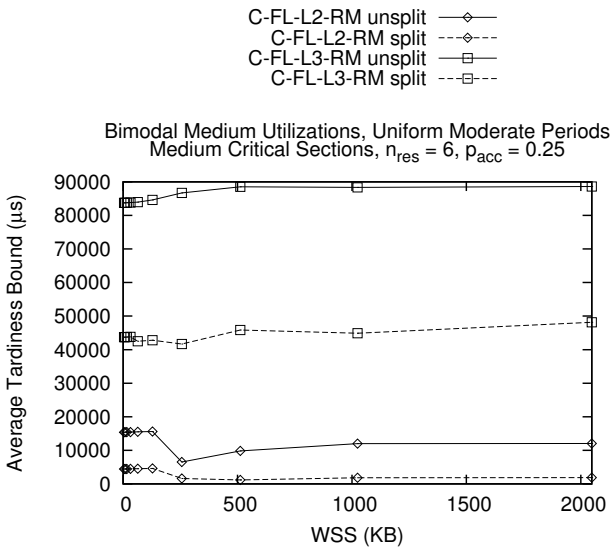

Figure B.143: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

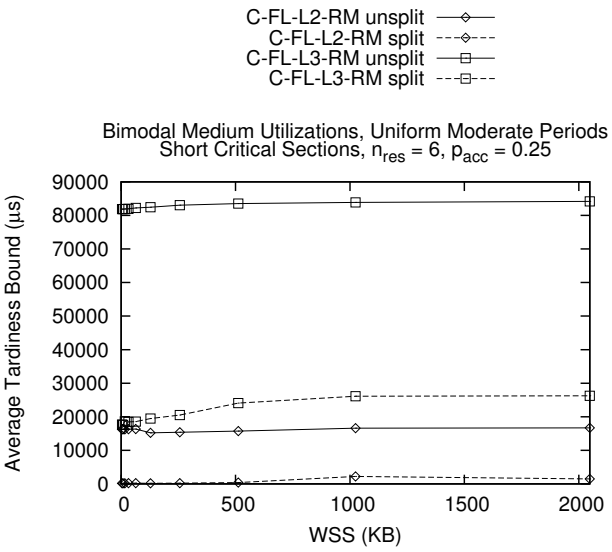

Figure B.145: By WSS: Bimodal Medium Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

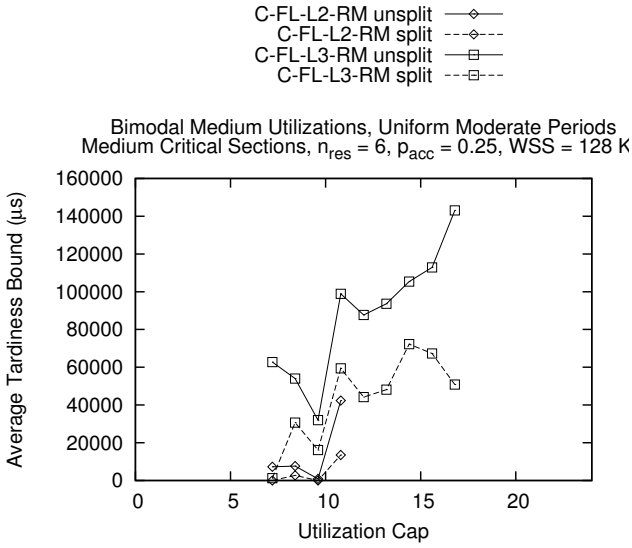

Figure B.144: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods, Medium Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$

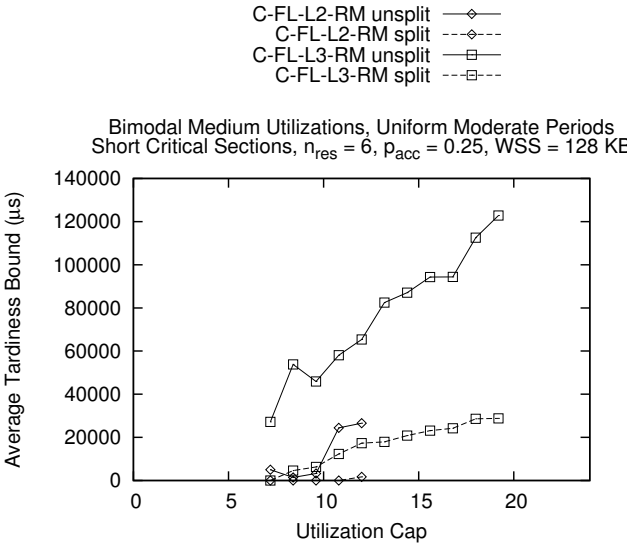

Figure B.146: By Utilization Cap: Bimodal Medium Utilizations, Uniform Moderate Periods, Short Critical Sections, $n_{res} = 6$, $p_{acc} = 0.25$