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FLEXRAY SCHEDULE OPTIMIZATION OF THE STATIC SEGMENT

Presented By
Najeeb
2013 – 5 – 16

OUTLINE

Problem Definition

Schedule Optimization

Results

Conclusions

PROBLEM DEFINITION

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- ✓ The cycle repetition denotes the frequency of a PDU in the multiplexing and is always a power of two 2^n

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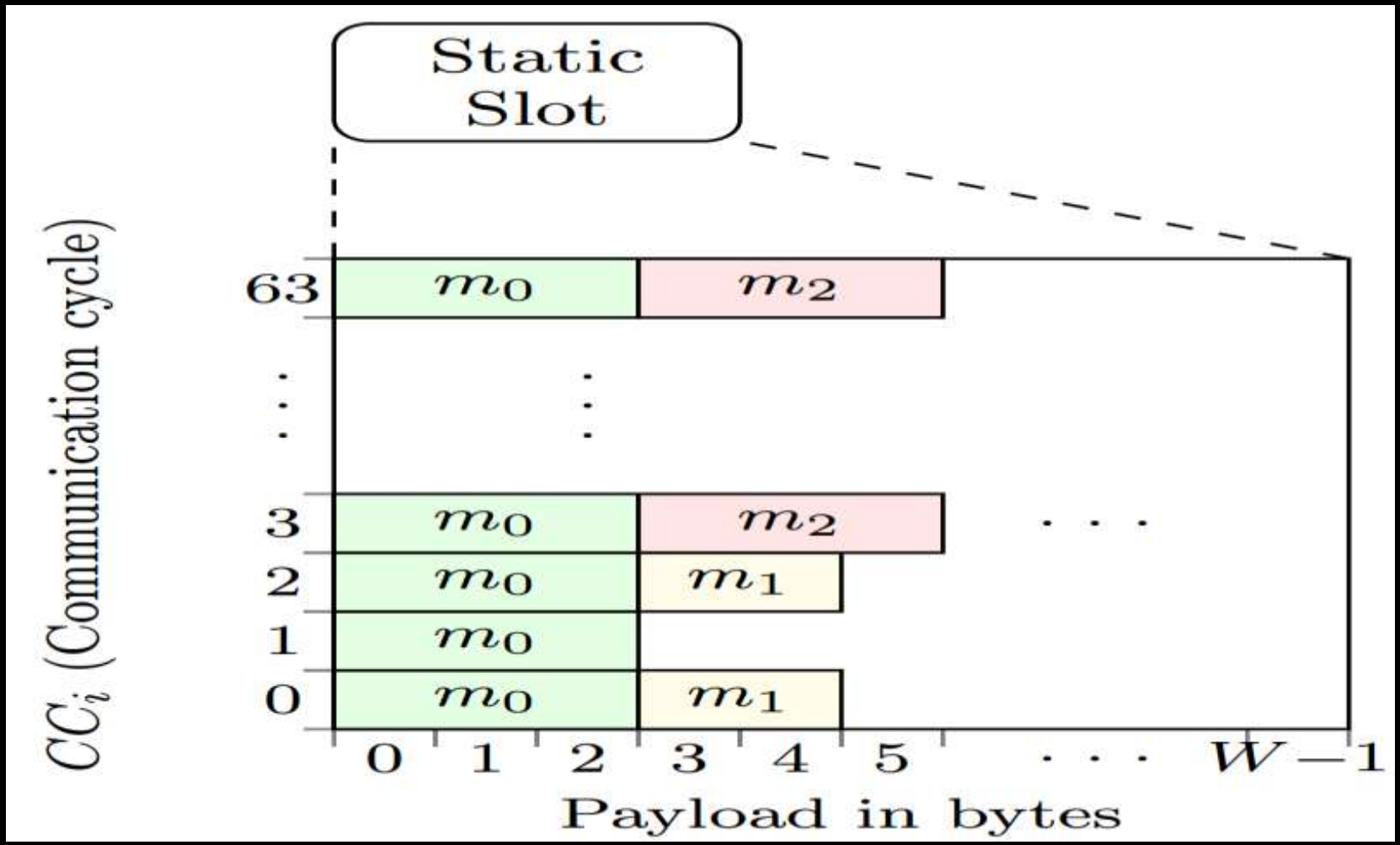

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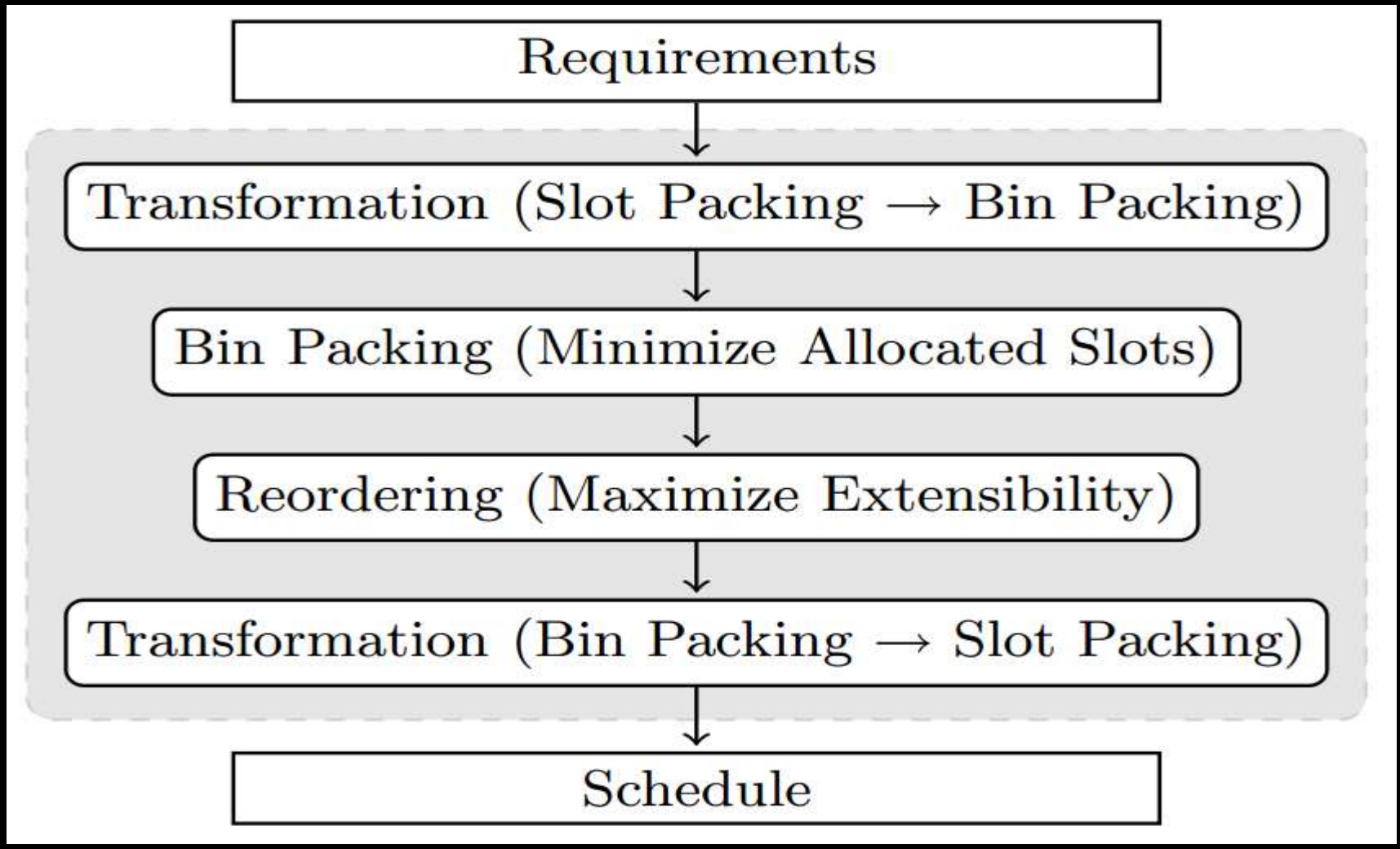
- The goal is to minimize the number of slots to maximize the utilization.

SCHEDULE OPTIMIZATION



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- ✓ w_m : length in bytes
- ✓ r_m : repetitions in the powers of two

PROBLEM TRANSFORMATION

- ✓ For a feasible slot packing, two values for each PDU have to be determined
- ✓ x_m : Offset in bytes on the x-axis
- ✓ b_m : The base cycle that defines the offset on the y-axis. It holds that $b_m < r_m$
- ✓ The task of the transformation of the slot packing into a bin packing is to convert each PDU into a rectangle element and determine its position such that each feasible slot packing results in a feasible bin packing and vice versa
- ✓ The bin size is the same as the slot size with width W and height H

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$$l_m = t(b_m, r_m) \text{ and } b_m = t(l_m, r_m)$$

$$y_m = l_m \cdot h_m = t(b_m, r_m) \cdot \frac{H}{r_m}$$

$$b_m = t(\frac{y_m}{h_m}, r_m) = t(\frac{y_m}{h_m}, \frac{H}{h_m}).$$

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Transformation to Bin Problem:

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Transformation to Slot Problem:

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$$h_m = \frac{H}{r_m}$$

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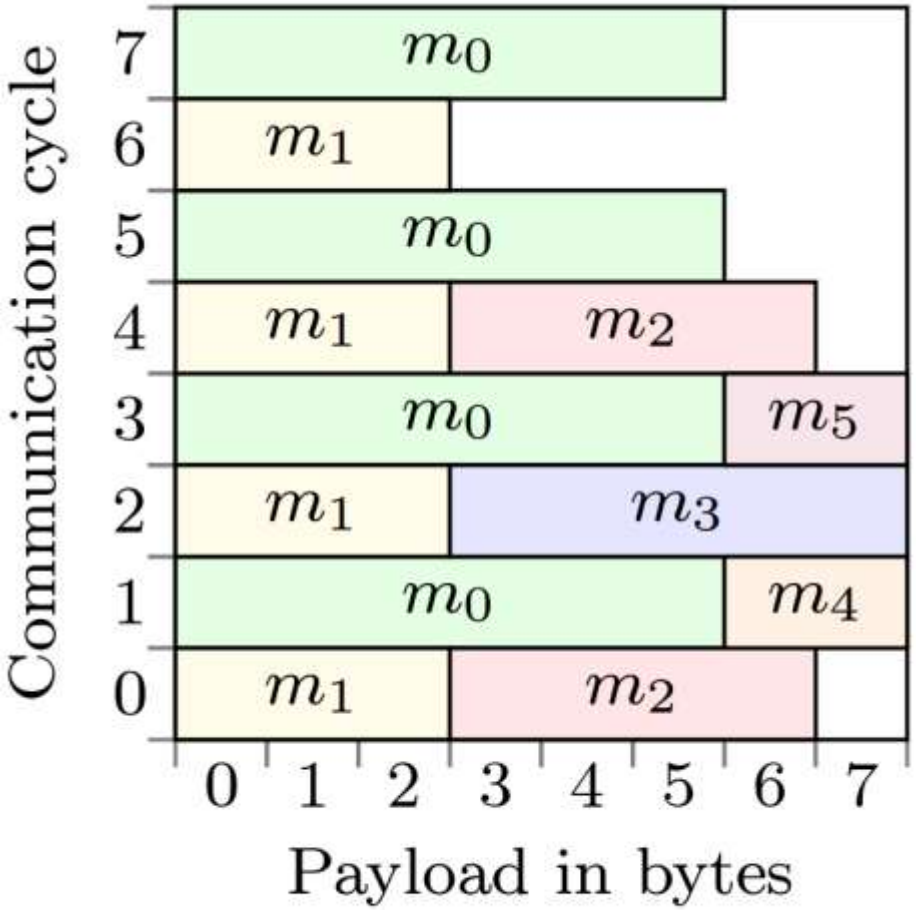
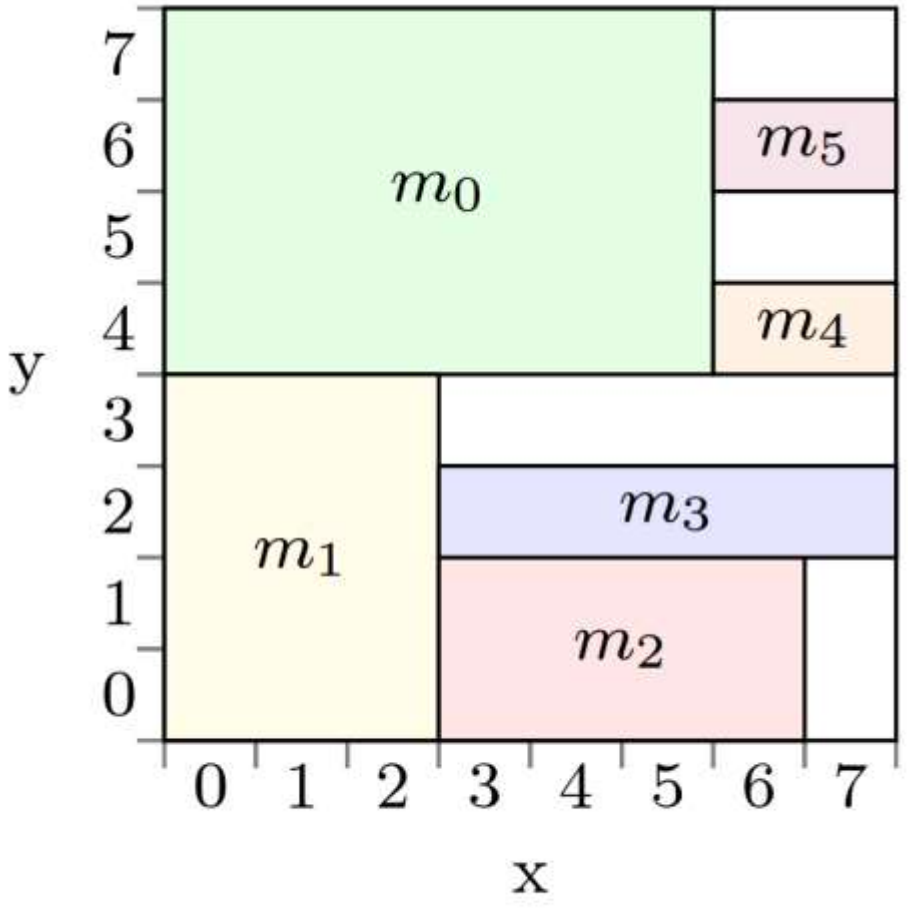


(a) Slot



(b) Bin

BIN PACKING

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- ✓ Each element m can be placed everywhere on the x-axis but only on a multiple of its height on the y-axis, i.e., $y_m = l \cdot h_m$

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Algorithm 1 Fast greedy heuristic for bin packing.

```
1: S = {} //set of bins
2: for m ∈ M do
3:     for s ∈ S do
4:         if place(m, s) then
5:             continue with next m
6:         end if
7:     end for
8:     create new s and add it to S
9:     place(m, s)
10: end for
```

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- ✓ The ILP is formulated as follows

INTEGER LINEAR PROGRAMMING

$$min \sum_{s \in S} \mathbf{s}$$

$$\forall\ m \in M : \sum_{s \in S} \sum_{l=0}^{\frac{H}{h_m}-1} \mathbf{m_{s,l}} = 1$$

$$\forall\ s \in S, \{y = 0, ..., H-1\} : \sum_{m \in M} w_m \cdot \mathbf{m}_{\mathbf{s},\left\lfloor \frac{\mathbf{y}}{\mathbf{h_m}} \right\rfloor} \leq W$$

$$\forall\ m \in M, s \in S, \{l = 0, ..., \frac{H}{h_m} - 1\} : \mathbf{s} - \mathbf{m_{s,l}} \geq 0$$

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- ✓ The complexity of an ILP is exponential in general
- ✓ In contrast to the heuristic approach, the presented ILP cannot be used incrementally, i.e., an already allocated bin cannot be filled with additional elements without moving the old elements

ENHANCED ILP

$$lb(M) = \frac{\sum_{m \in M} w_m \cdot h_m}{W \cdot H}$$

$$\sum_{s \in S} \mathbf{s} \geq \lceil lb(M) \rceil$$

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- ✓ This requirement arises if the scheduling problem uses the in-cycle repetition of PDUs

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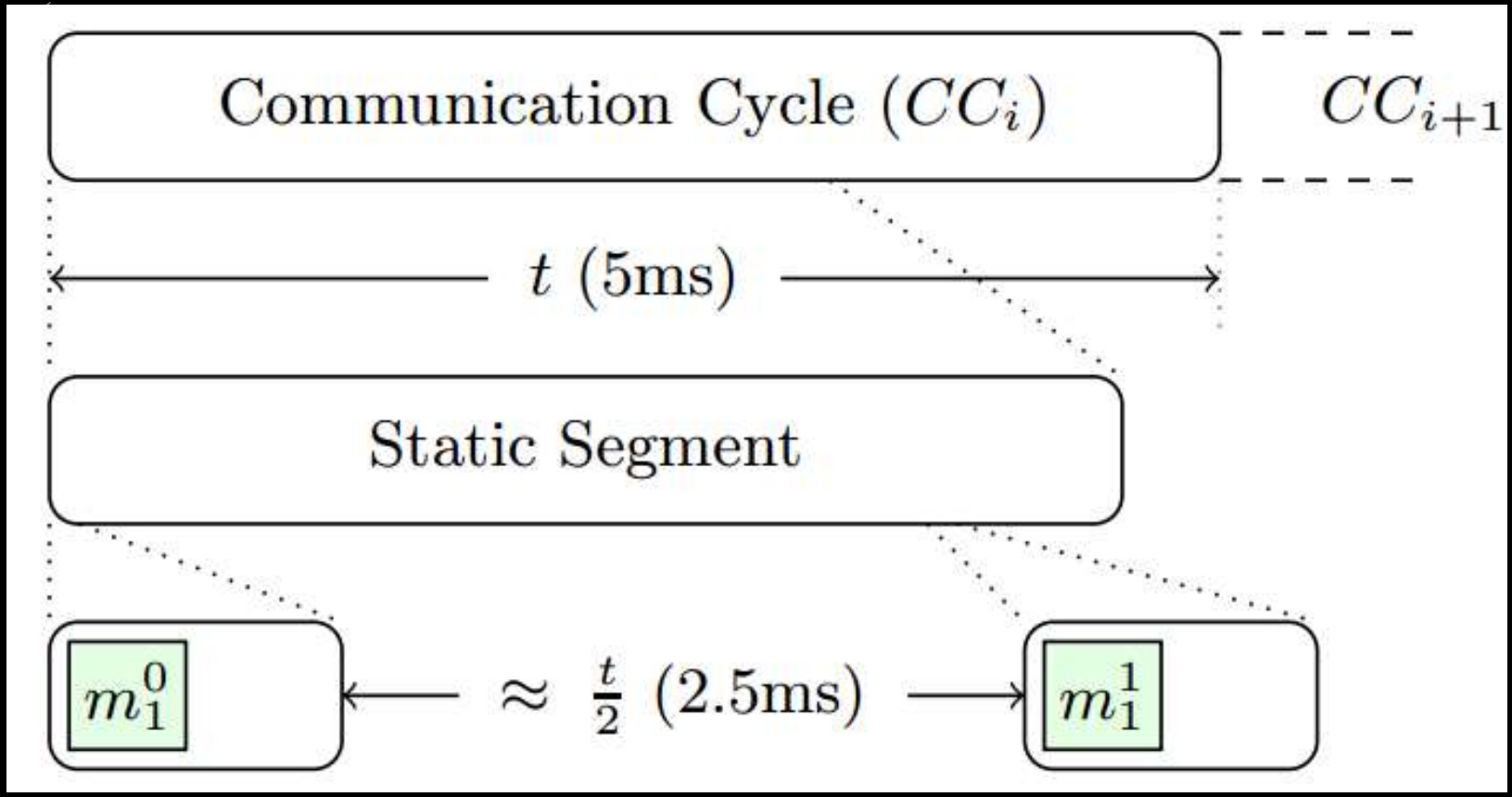

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- ✓ The void space of a bin should be connected to enable the placement of large elements as well as several small elements

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$$E(s) = 1 - U(s) - \frac{w_{max}}{W} \cdot \frac{h_{max}}{H}$$

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- ✓ Reordering the elements in a bin with the proposed metric is not possible with a complete method like an ILP since the objective function is not linear
- ✓ An approach based on Simulated Annealing is used

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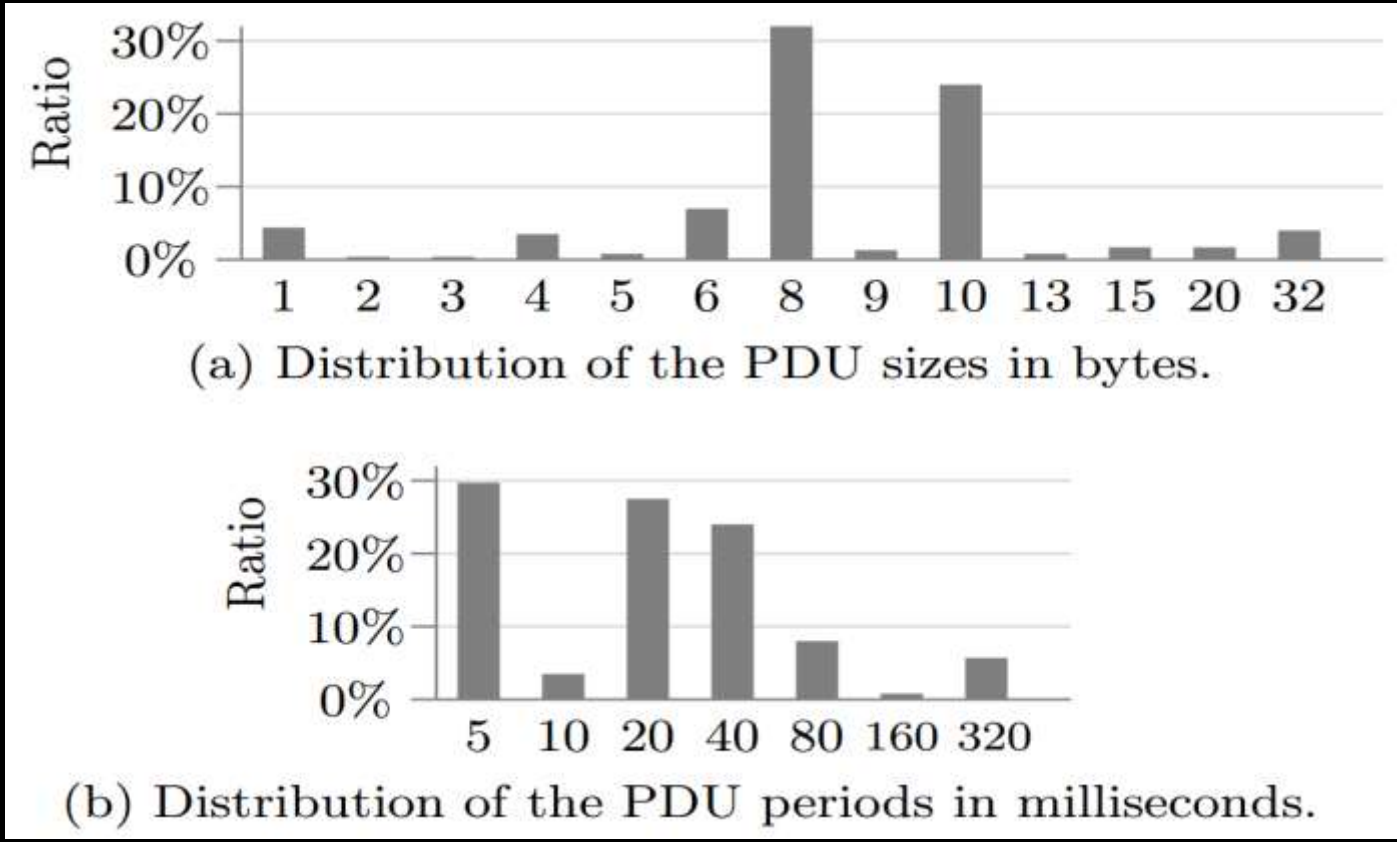

SCHEDULE OPTIMIZATION

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Method	runtime	slots	avg. $E(s)$
Heuristic	**0.065s**	**27**	0.029
+ Reordering	+42.5s	**27**	0.016
ILP* (CPLEX)	25.7s	**27**	0.028
ILP (CPLEX)	0.080s	**27**	0.028
+ Reordering	+48.0s	**27**	**0.019**
TTX Plan	360s	29	0.043

INCREMENTAL SCHEDULING

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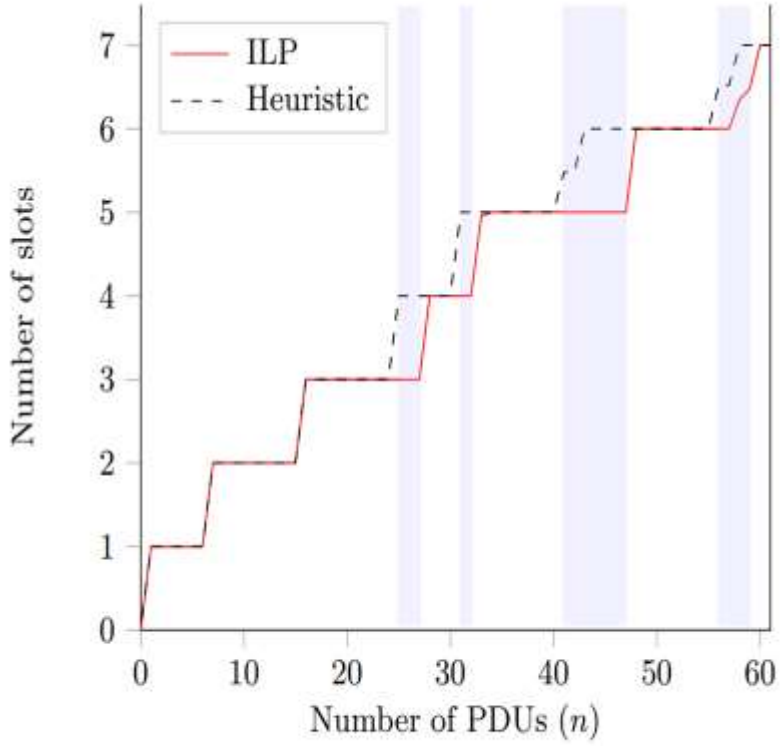
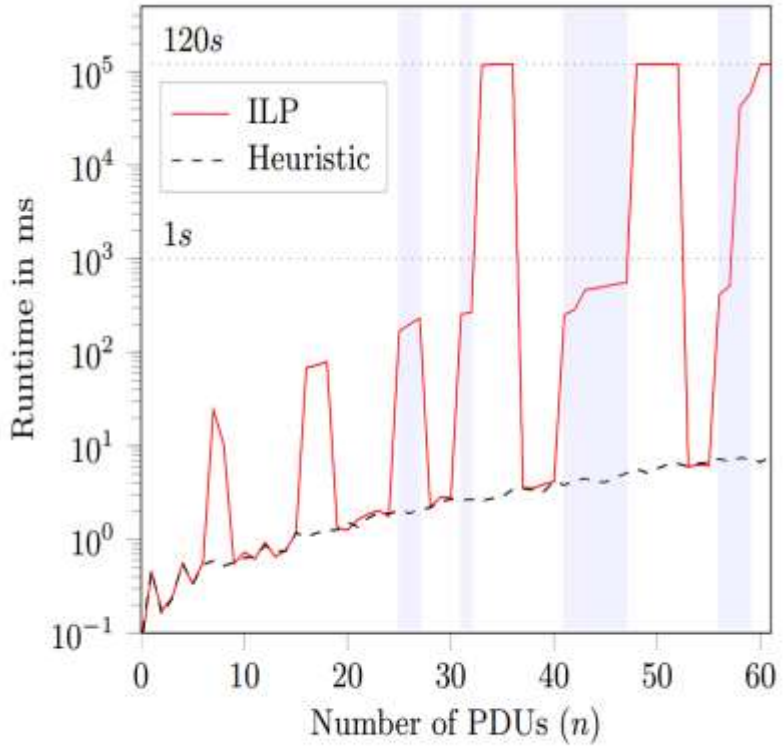
Method	runtime	slots	avg. $E(s)$
ILP (0.028) $\rightarrow$ Heuristic	0.022s	38	0.036
ILP (0.019) $\rightarrow$ Heuristic	0.020s	**37**	0.035
ILP (CPLEX)	12.2s	35	0.033

SCALABILITY



(a) Number of allocated slots depending on the number of scheduled PDUs.



(b) Runtime of the scheduling approaches depending on the number of scheduled PDUs.

THE END

THANK YOU