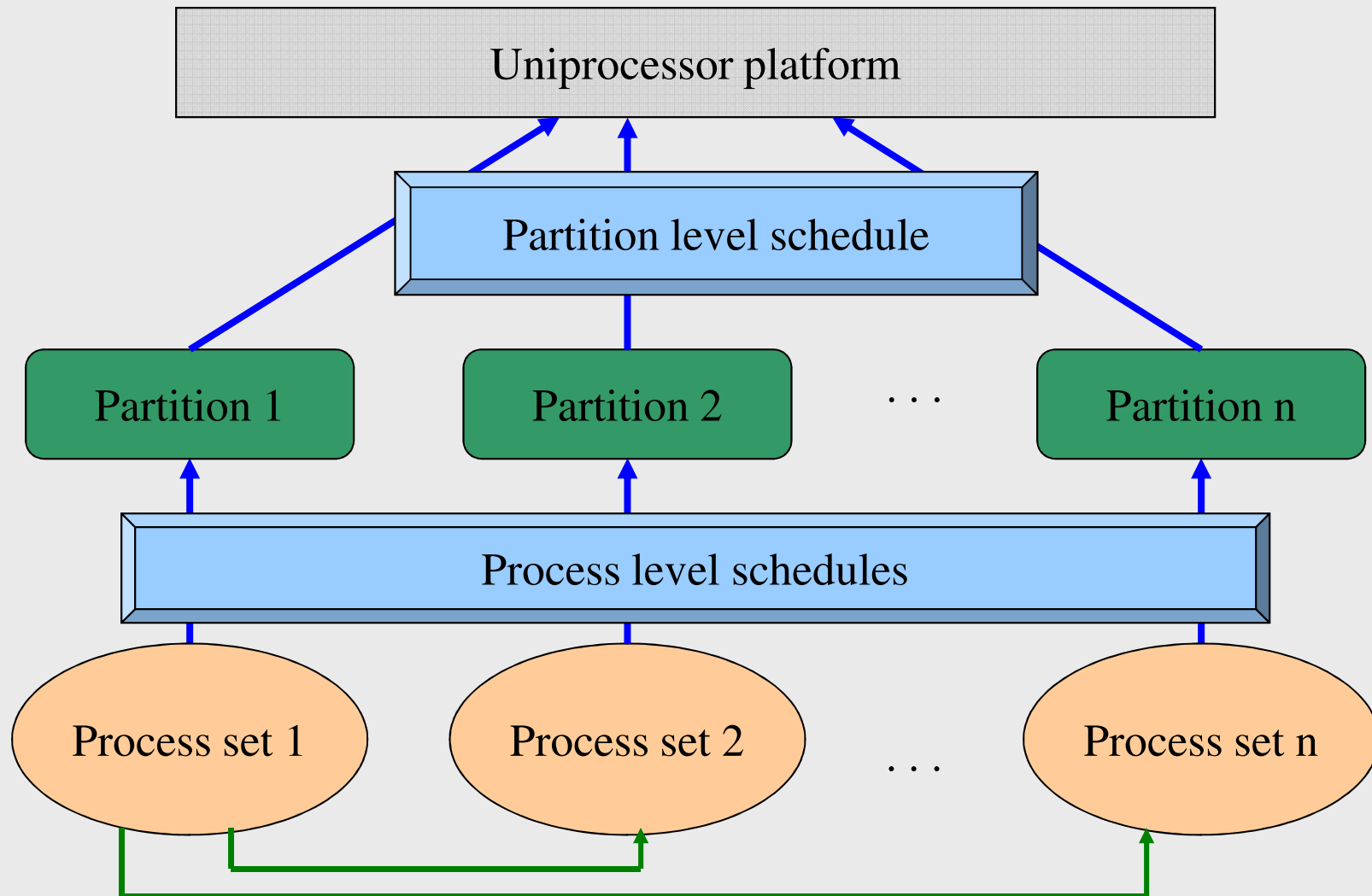


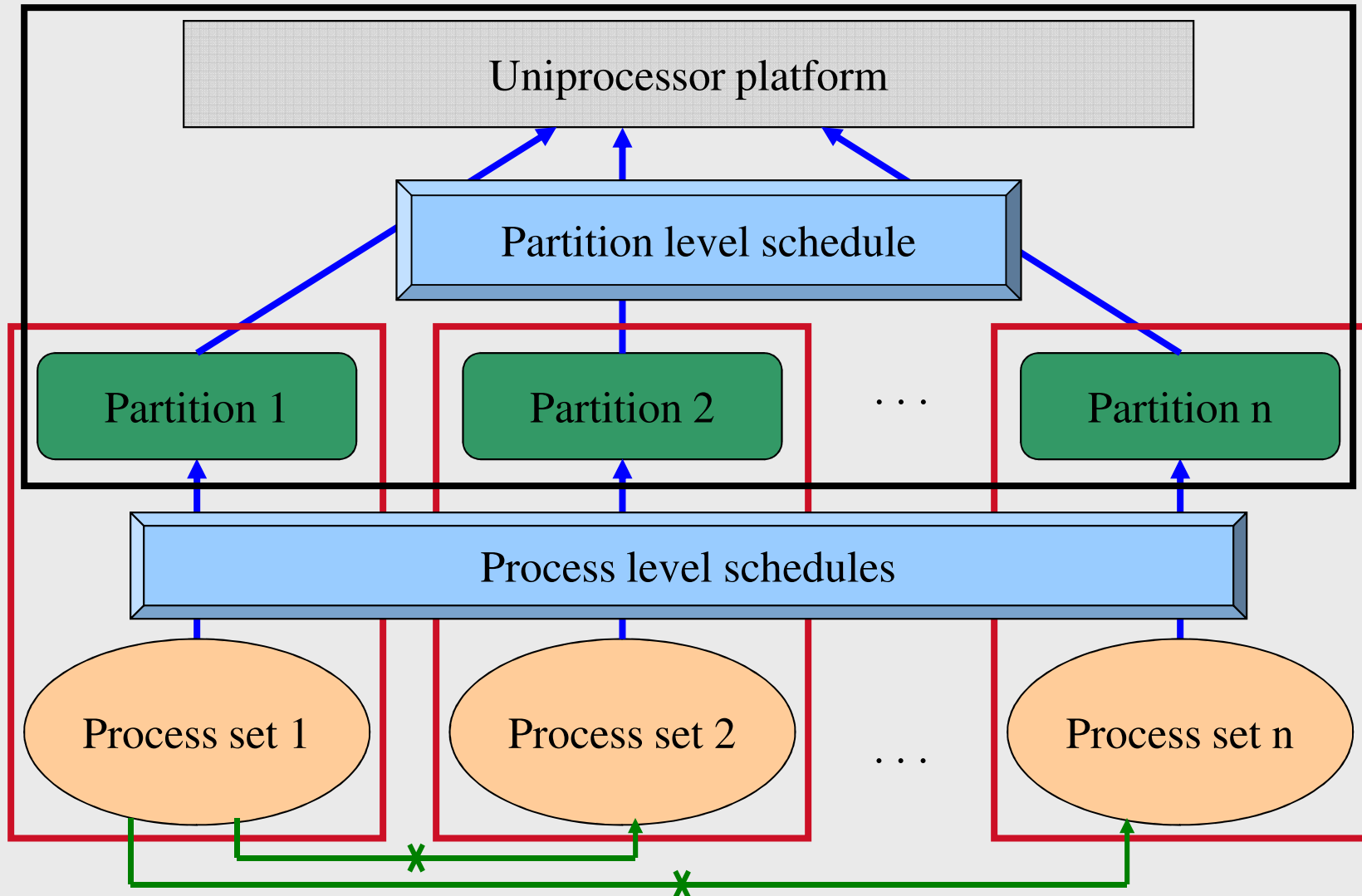
# Compositional analysis of ARINC 653 systems

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# ARINC-653 Avionics OS



# ARINC-653: Schedulability



# Main steps

- Extract partition workloads from AADL
- Abstract away inter-partition communication
  - Well-known methods based on offsets, jitter, and constrained deadlines
- Compute partition interfaces
  - Use periodic or EDP resource models
  - Assume DM scheduler (can be adjusted to other schedulers)
  - Each partition appears to the top-level as a single task
- Generate DM partition schedule

# Resource Satisfiability Analysis

- Given a component and a resource model, **resource satisfiability analysis** is to determine if, for every time interval,

(maximum possible)  
**resource demand**

that the component's task set needs  
under its scheduling algorithm



(minimum possible)  
**resource supply**

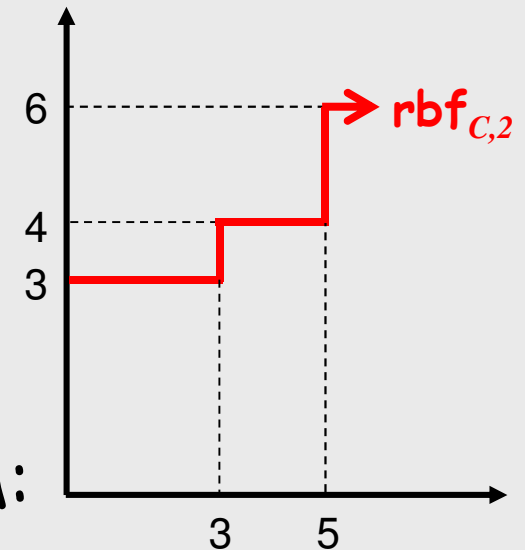
that resource model  
provides

# Component Resource Demand (DM)

- $rbf_{C,i}(t)$  : The maximum resource request with priority at least  $i$  of component  $C$  over all intervals of length  $t$
- $C$  has workload  $\tau_i = (T_i, C_i, D_i)$ ,  $i = 1, \dots, n$ , with  $D_1 \leq D_2 \dots \leq D_n$  and uses DM scheduler
- No offset/jitter:

$$rbf_{C,i}(t) = \sum_{j=1}^i \left\lceil \frac{t}{T_j} \right\rceil C_j$$

- Extensions to offsets/jitter exist
- E.g.,  $C = \{(3,1,3), (5,2,5)\}$  under DM:



# Resource supply

- Periodic resource model:  $\Phi=(\Pi,\Theta)$
- Supply Bound Function:

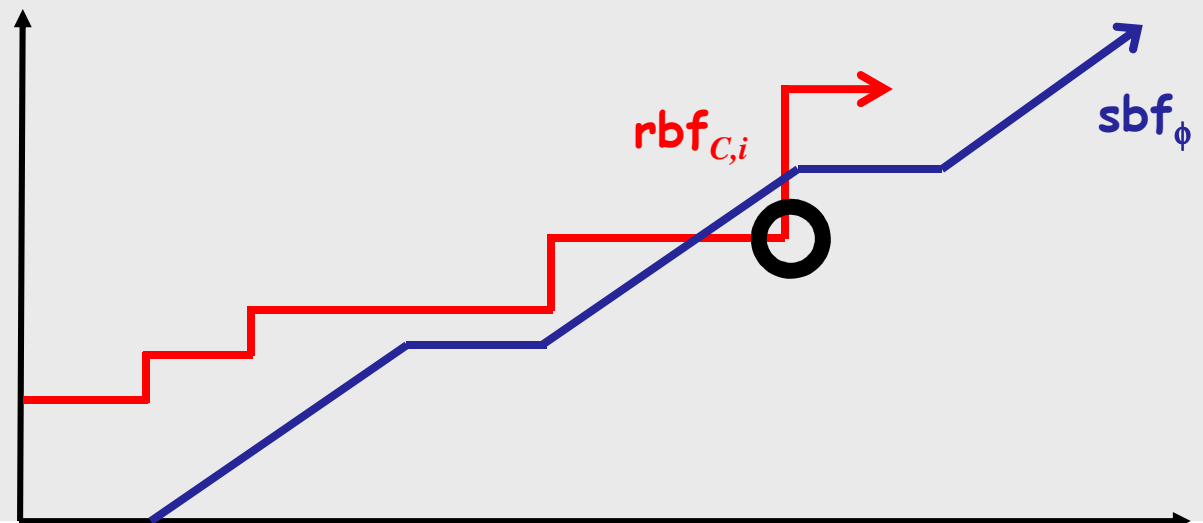
$$sbf_{\Phi}(t) = \left\lfloor \frac{t}{\Pi} \right\rfloor \Theta + \max \{ 0, t - (\Pi - \Theta) - \left\lfloor \frac{t}{\Pi} \right\rfloor \Pi \}$$

- Improved for harmonic periods

# Resource Satisfiability Analysis

- Component  $\mathcal{C}$  is schedulable under DM using periodic resource model  $\Phi=(\Pi,\Theta)$  iff, for all  $i: 1 \leq i \leq n$ , there exists  $t_i$  s.t.,  $\text{rbf}_{\mathcal{C},i}(t_i) \leq \text{sbf}_{\Phi}(t_i)$
- Set  $\Pi$  to be the partition period
- Find smallest  $\Theta_i$  that satisfies the condition, for each  $i$
- Take  $\Theta$  to be the largest  $\Theta_i$

$(\Pi,\Theta)$  is the  
partition interface



# Partition schedule generation

- Each partition is now represented as a single periodic task
- Determine schedulability of this task set under DM
  - Using the same resource satisfiability analysis
- Simulate execution of the task set under DM to the hyperperiod
  - Yields a static partition schedule

# CARTS tool

- Performs middle steps:
  - Interface generation and sched. analysis
- Does not abstract out connections or generate partition schedule

The screenshot displays the 'Compositional Analysis of Real-Time Systems' application window. The main area is split into two panes. The left pane shows a tree view of the XML output for 'OUTPUT\_71.xml', with a checked 'OS Scheduler' and a sub-tree for 'PART45 ID=45' containing four tasks: 'PART45\_IN ID=1', 'PART45\_OUT ID=2', 'PART45\_OUT\_5HZ ID=3', and 'PART45\_20HZ ID=4'. The right pane shows the corresponding XML code, including a system declaration for 'DM' and a component declaration for 'PART45 ID=45' with its four tasks and their parameters. Below the XML panes, a table titled 'Analysis Result with ARINC Algorithm' shows resource and process parameters. The status bar at the bottom indicates 'Line: 1 of 8 | Col: 0 | Char: 0'.

Analysis Result with ARINC Algorithm	
Resourc...	Period: 1.0, Bandwidth: 0.00325, Deadline: 1.0
Process...	Period: 1.0, Execution Time: 0.00325, Deadline: 1.0