Zeus: Stream Group Soft Real-time Parallel Scheduler

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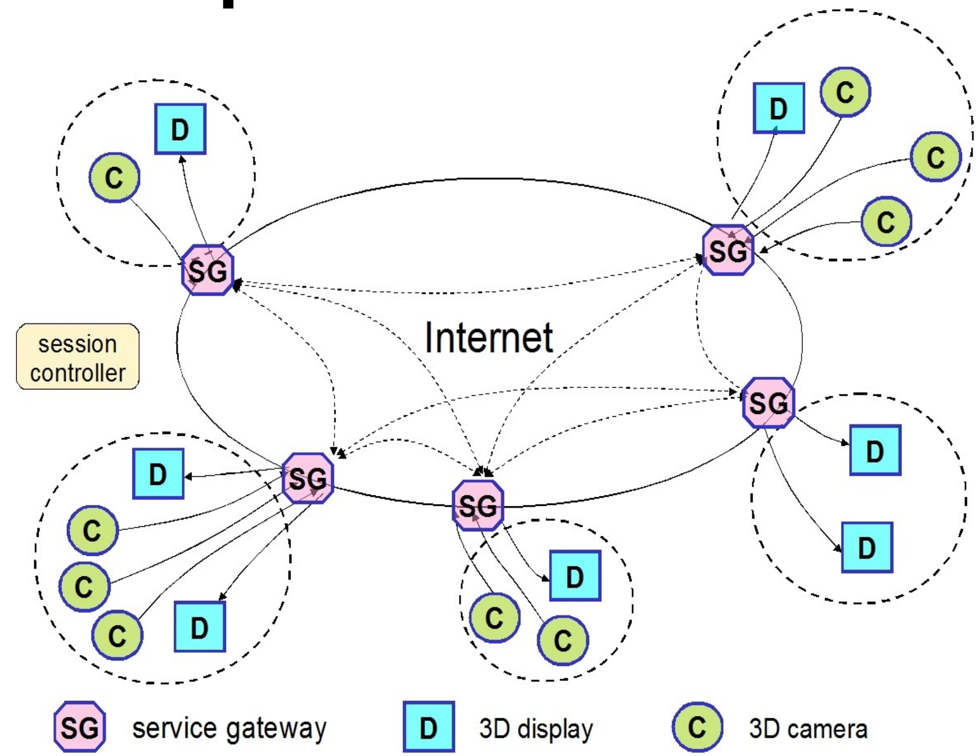
Problem Description

- Distributed Interactive Multimedia Environments (DIME) are becoming ubiquitous (e.g. Online Gaming, 3D Teleimmersion, Interactive TV)
- DIME are systems with correlated multistreams that use Content Delivery Networks to process and disseminate the content among its user
- CPU QoS in terms of jitter, delay and bandwidth are critical in such systems
- Current architectures (VMM and OS) do not provide adequate abstractions and mechanisms to efficiently guarantee QoS to groups of correlated and dependent streams in multicore systems



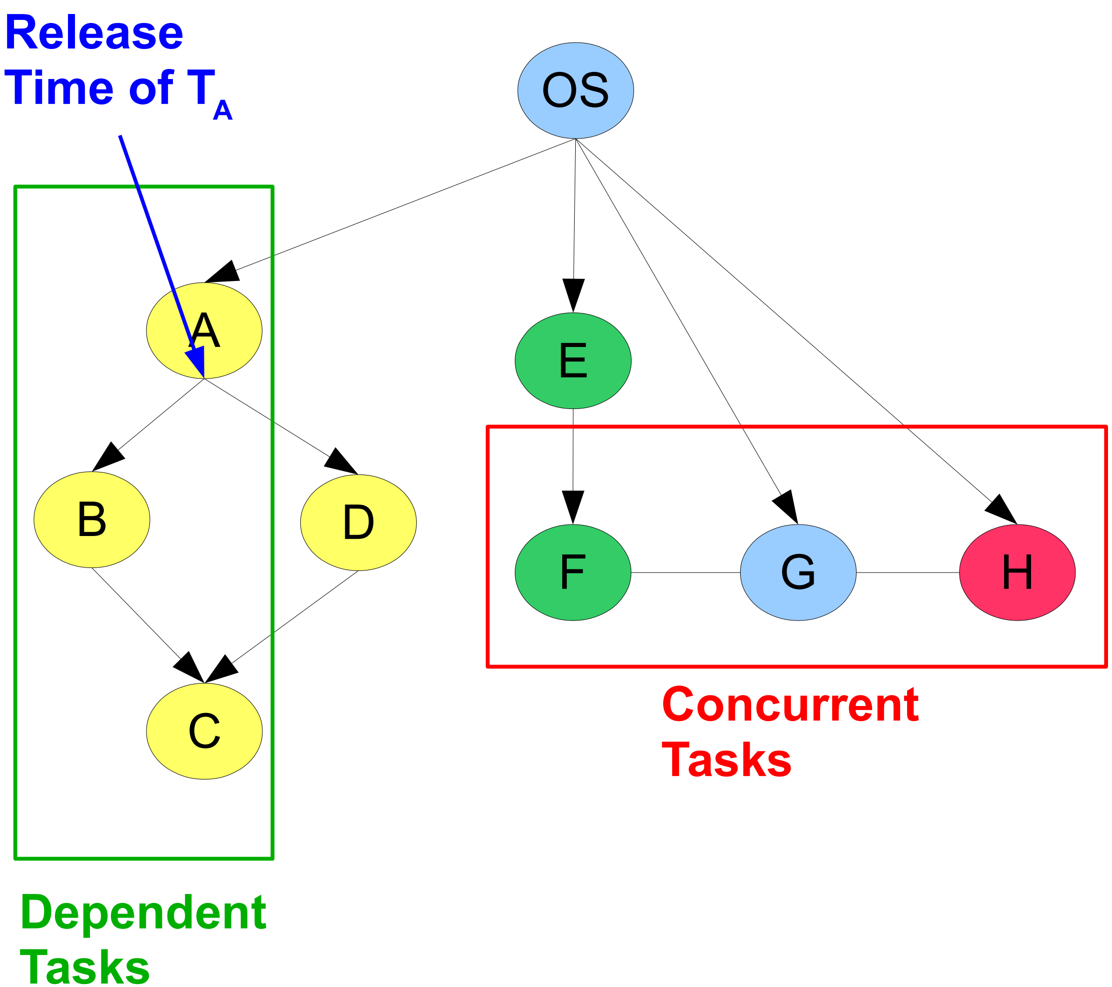
Challenges

- More streams than cores
- Two type of Dependencies
  - Dependent: Consumer-Producer Relationship (A → B)
    - If A does not happen then B should not either
  - Concurrent: Temporal Correlation (A0, A1, A2, .. An)
    - A0 to An have the same period and should be scheduled concurrently
- Tasks have Period and Bandwidth variation
  - Cameras have variable frame rate and variable frame size
- Some tasks in the chain may be optional

Solution Overview

- Restrict process admission to Posets
  - Hasse diagram
- Use process algebra type notation to allow user to describe the dependencies
- Use Liu-Layland model (Period=Deadline)
- Shadow Tasks to allow Temporal Correlated tasks to be scheduled at the same time
- Best Effort is scheduled in place of Shadow Tasks
- Goal is to obtain a Flat EDF schedule

Modified Hasse Diagram



- Each nodes represent a process
- Add a directed edge if there is dependence
- Add a non directed edge between two concurrent nodes

Deadline Constraint: $D(T_A) < D(T_B)$

Processor Demand Constraint: $S(T_A) + C(T_A) + C(T_B) + C(T_C) < D(T_C)$

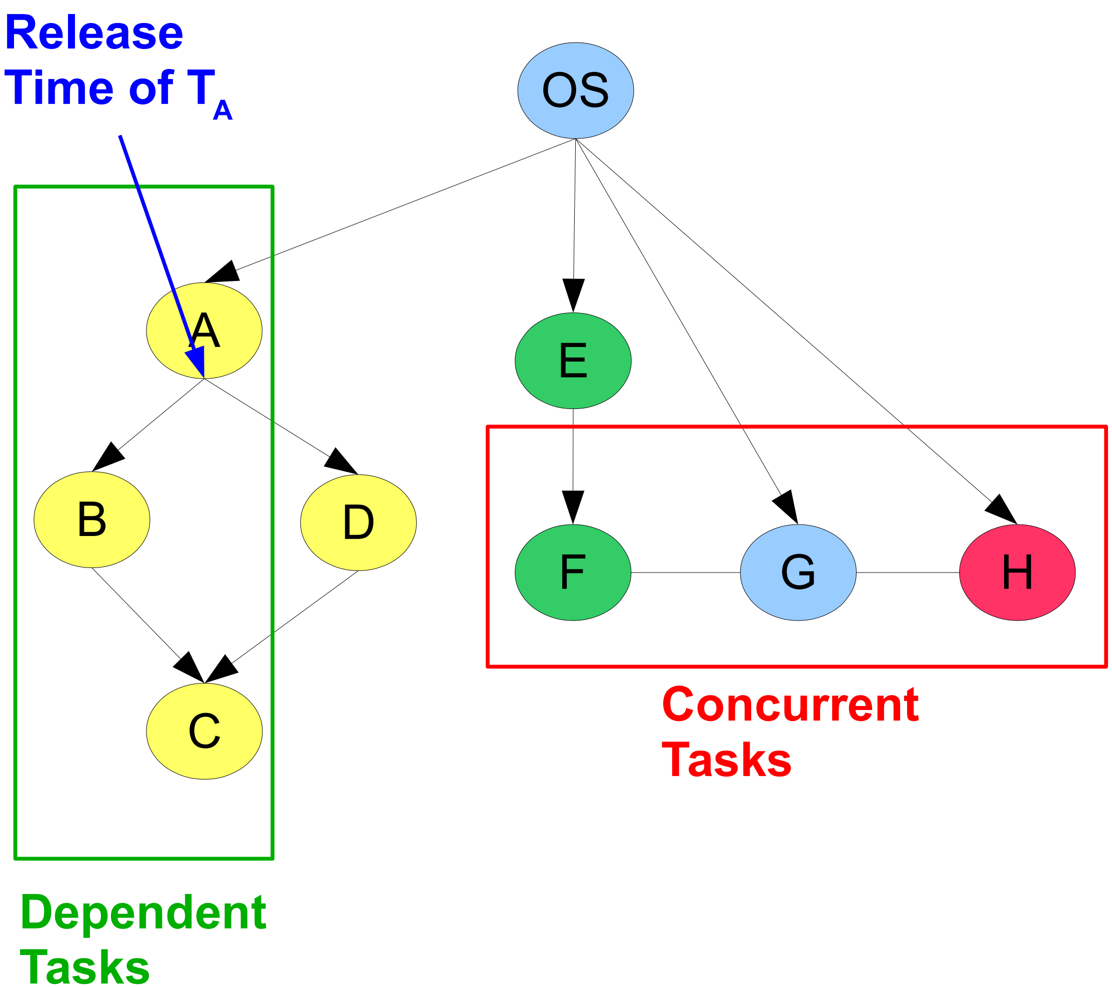
Release Time Constraint:

$S(T_F) + \max[(C(T_F), C(T_G), C(T_H)] < \min[D(T_F), D(T_G), D(T_H)]$

Dependence Specification

- Let the user specify the dependencies using a simple process algebra
  - Allows to model the system
  - Unambiguous
- Simplify the notation
  - P | Q : Process P and Q execute concurrently
  - P[c,d]: Process P executes for c clock units and has a deadline d
  - P>Q: Q waits for P to terminate

Hasse Diagram Construction



Specification

$T_A[C(T_A),\ D(T_A)]$

$T_B[C(T_B),\ D(T_B)]$

$T_A > T_B$

$T_A > T_D$

$T_D > T_C$

$T_E > T_F$

$T_F \mid T_G \mid T_H$

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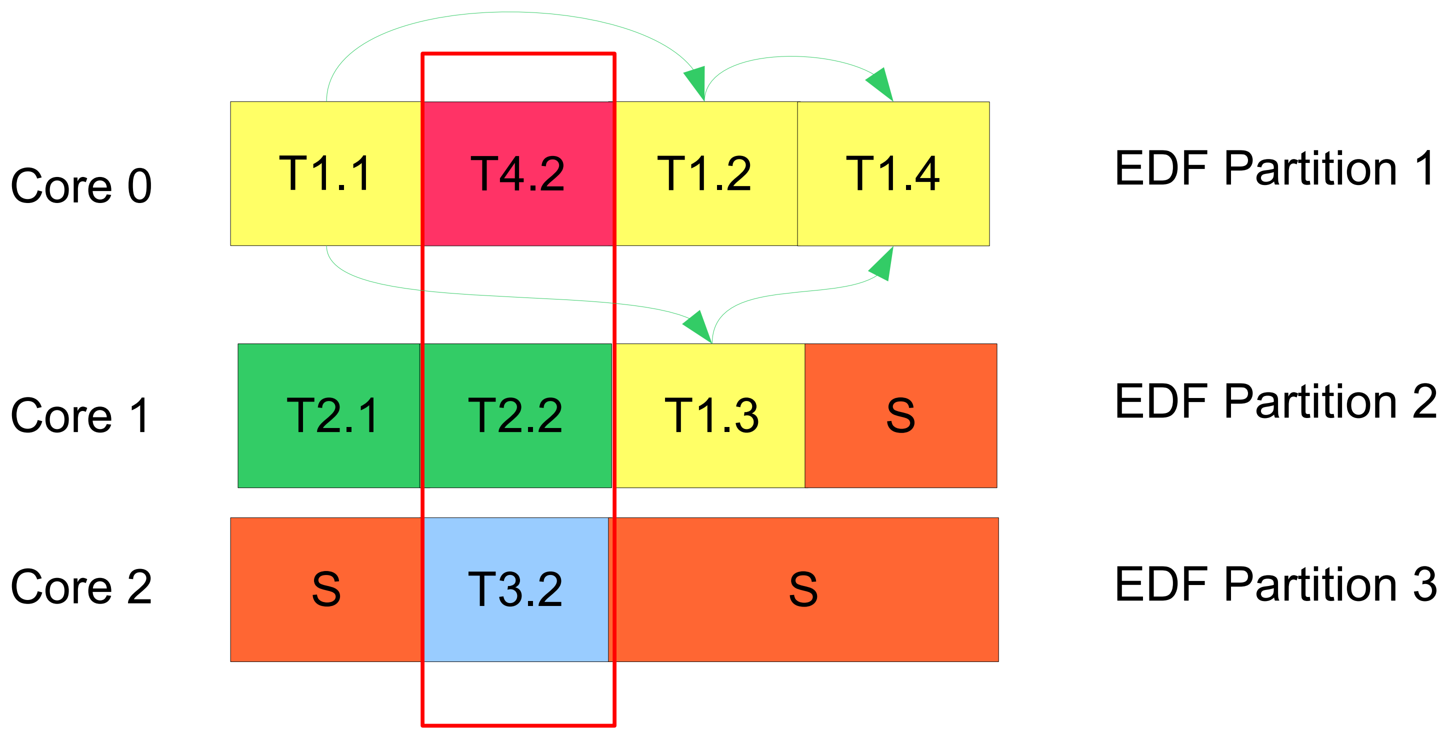
Partitioned EDF Schedule



- One partition per core. The use EDF on each partition independently
- Partitioning is an NP complete problem: Need a heuristic!
- Shadow tasks are used for Best Effort Scheduling (promotes work conservation) and suspending the processor (save energy)

Partitioning Heuristic

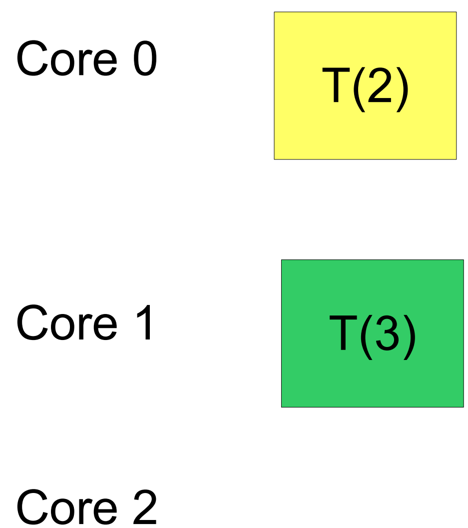
Let T be the set of tasks ordered by deadline in the system, and let T_i the task with the smallest deadline that has a concurrent dependence with task $T_{i+1} \ldots T_j$

1. Use Worst Fit heuristic to assign tasks T_1 to T_{i-1}.

2. Insert a shadow task S_k in each partition k with deadline $d(T_{i+k})$ and allocation C_k such that the starting time of task $T_i = T_{i+1} = \ldots = T_j$ if each task is placed in different partitions and scheduled under EDF.

3. Insert tasks T_i to T_j each one in a different partition

4. Continue inserting tasks in set T



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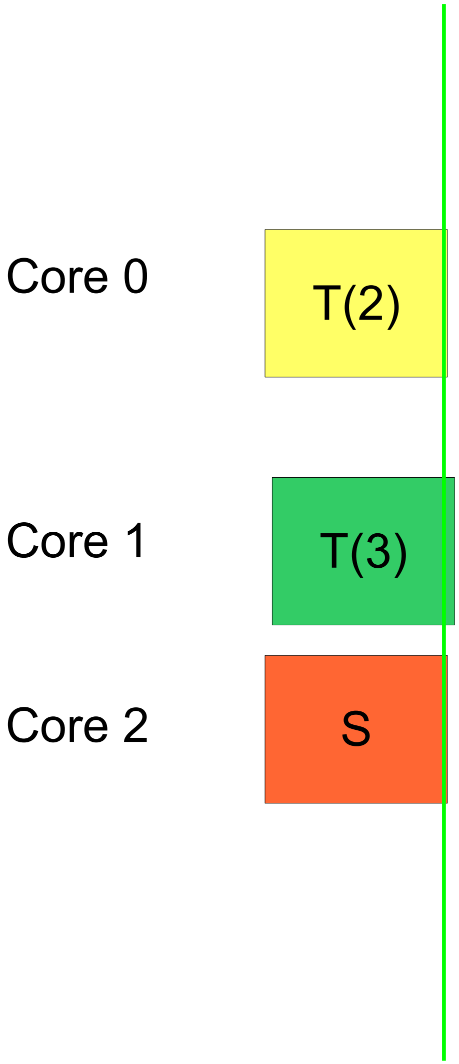

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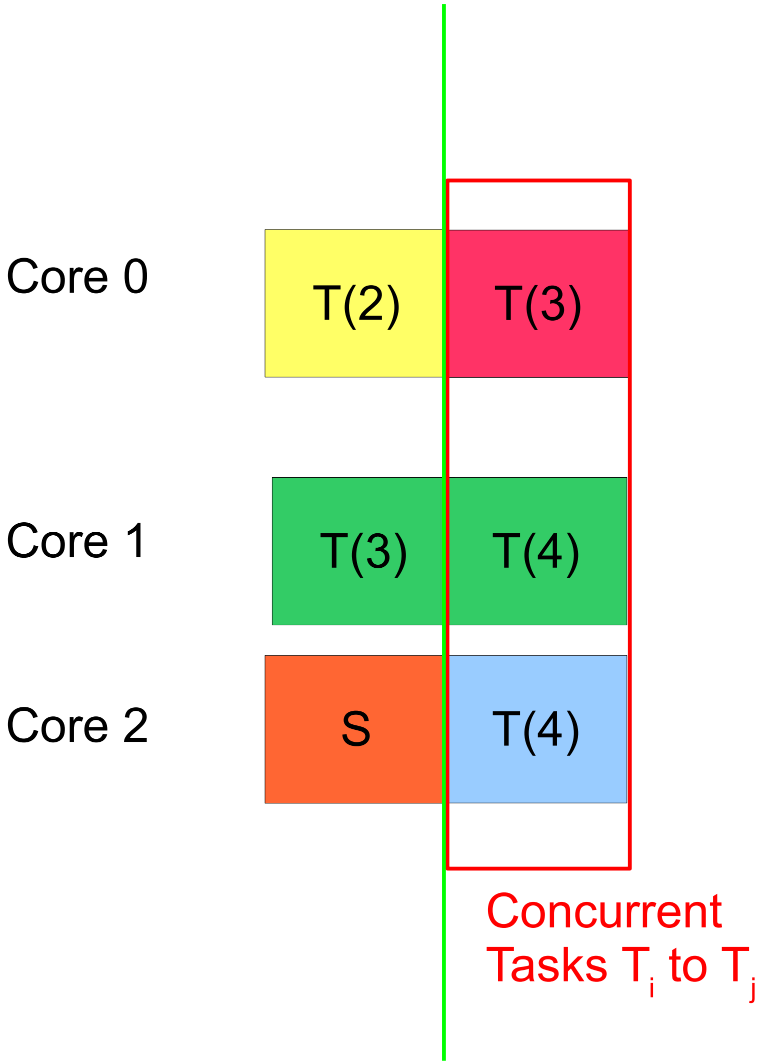

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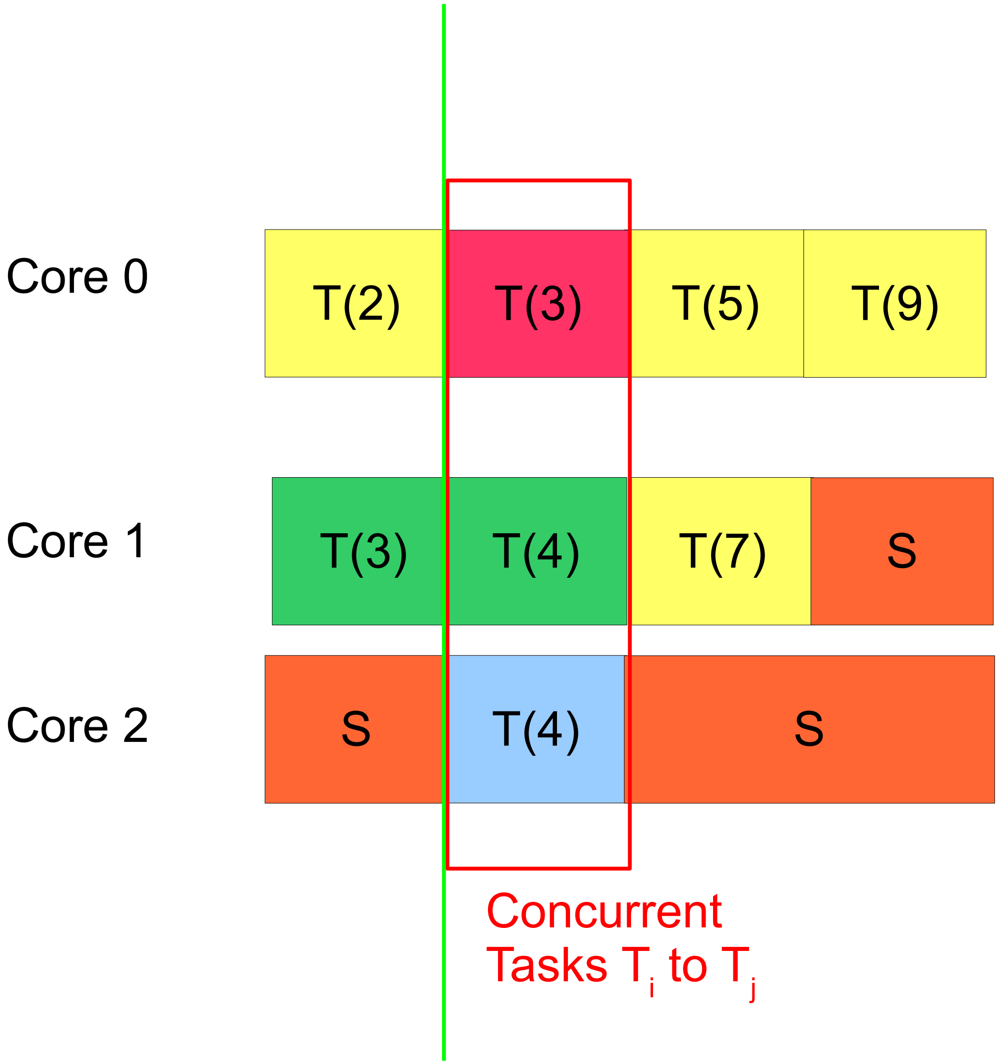
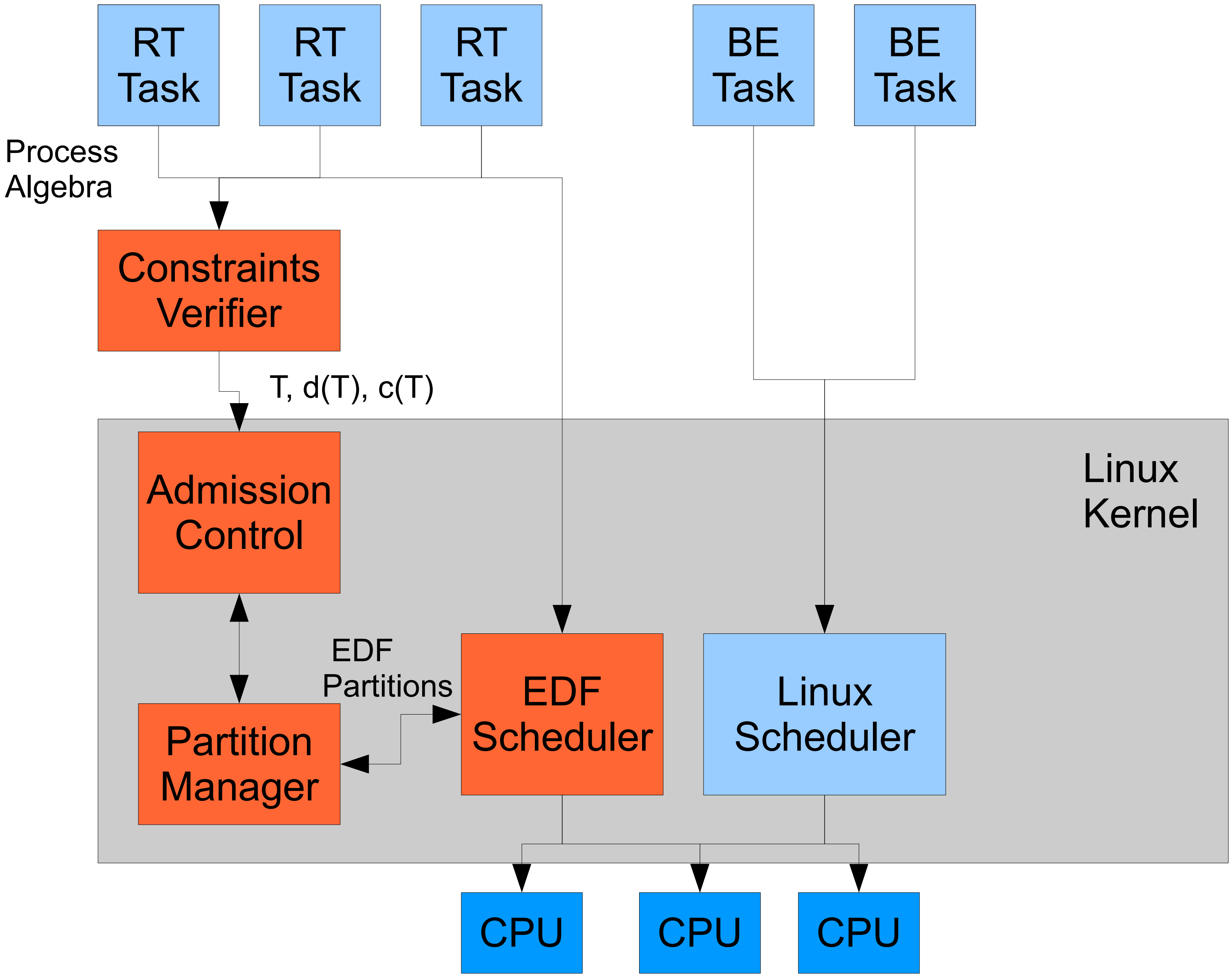


The admission control needs to consider the maximum C_k for all jobs of S_k in the hyperperiod

Zeus Implementation Overview



Future Work

- Modified Admission control equations
- Compare our heuristic with the optimal schedule (Simulation of random task sets)
- Initial implementation of the Constraint Verifier
  - Modify iDSRT CPU scheduler