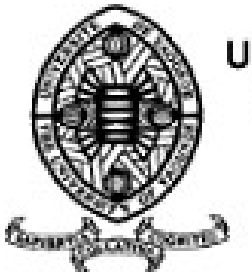

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Detection of scheduling anomalies in real-time system

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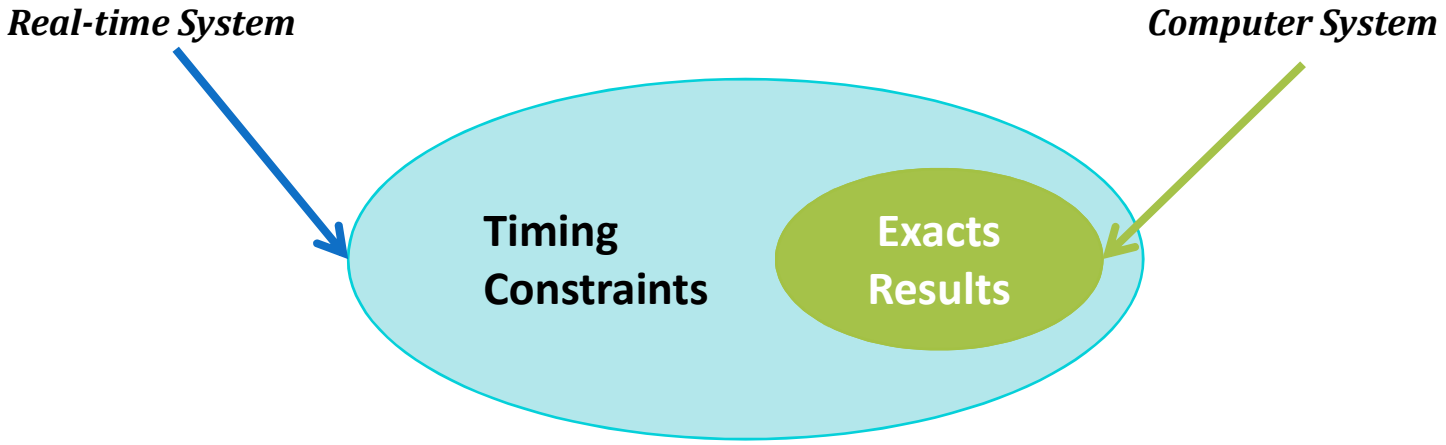
Outline

1. Context
2. Problem statement and contributions
3. Scheduling anomalies models
4. Monitoring of scheduling anomalies
5. Conclusion

Context

Real-time system ?

System made of a set of task that have timing constraints to meet.

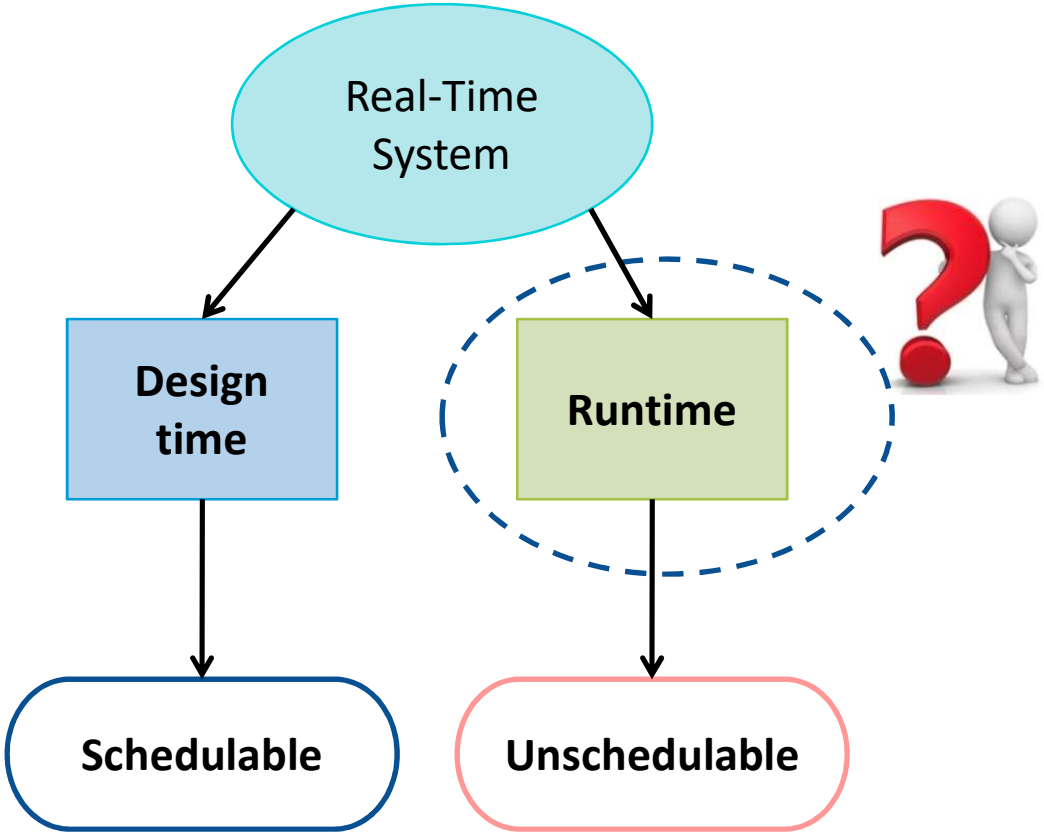


Aircraft, Satellites

Electronic device

Industrials

Problem statement (1/2)



What events ?

- Increasing resources
- Execution time reduced
- Etc.…

A scheduling anomaly refers to a counter-intuitive phenomenon in which increasing the system resources or relaxing the application constraints can lead to missed deadline. (Almeida06)

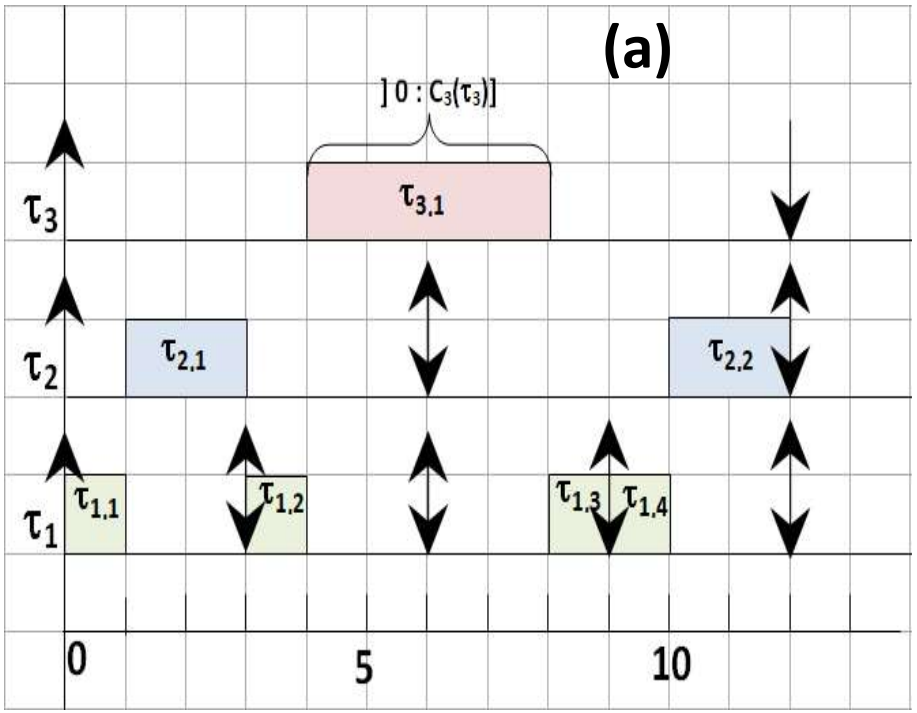
- ❑ When do scheduling anomalies occur?
- ❑ How to detect these anomalies in real-time systems?

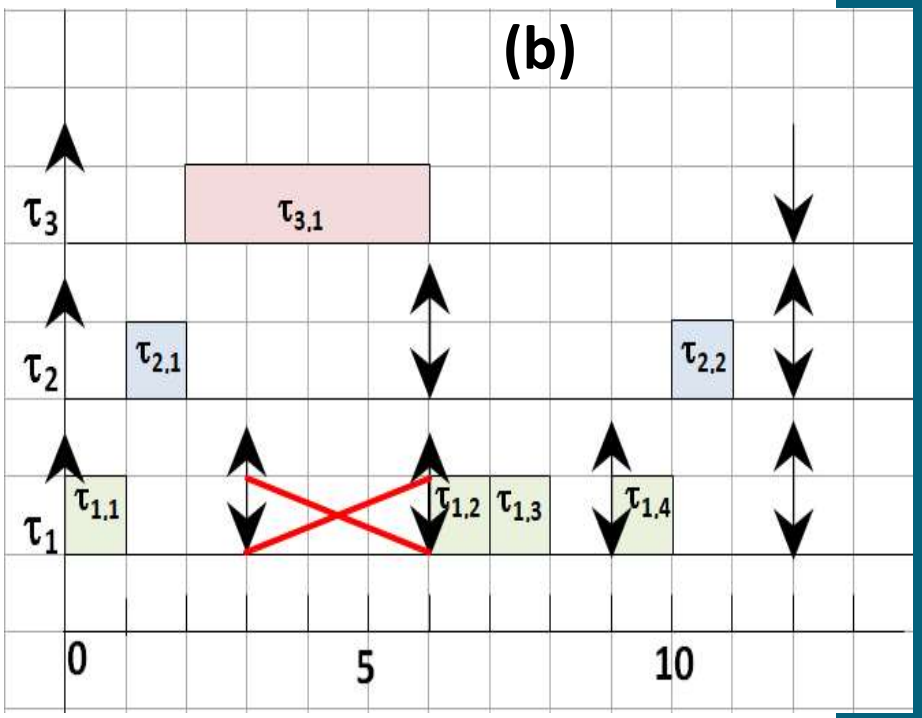
Problem Statement (2/2)

3 periodics tasks scheduled with a non-preemptive fixed-priority scheduler in an uniprocessor system.

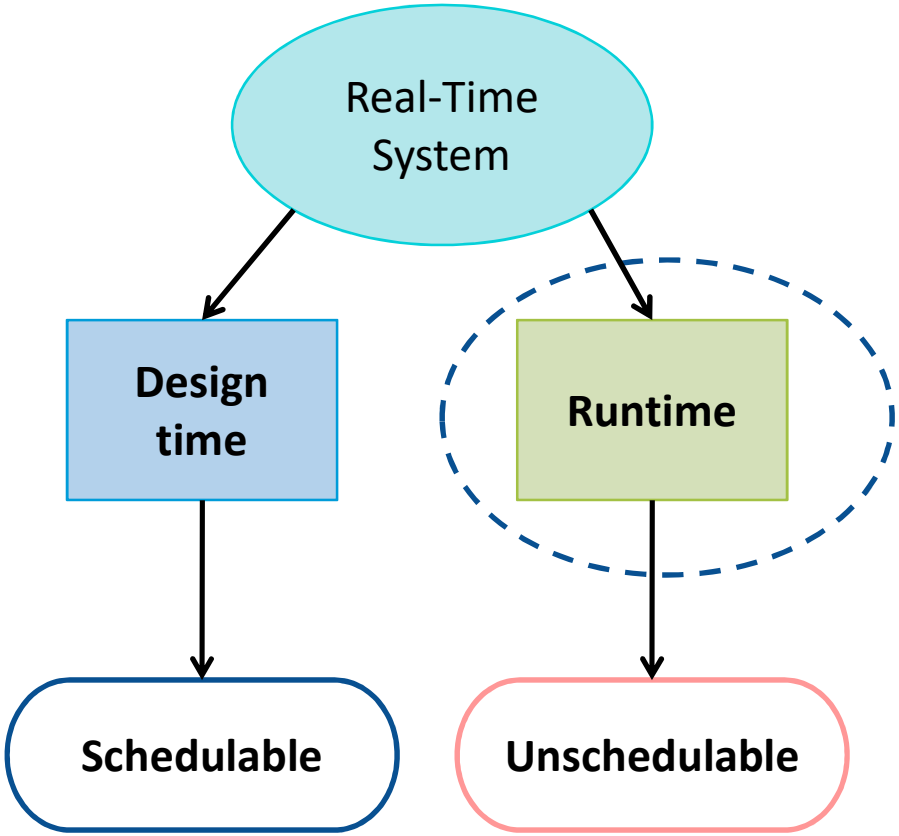
Each task $\tau_i = (R_i(\tau_i), C_i(\tau_i), D_i(\tau_i), T_i(\tau_i), \mu_i(\tau_i))$

$\tau_1 = (0, 1, 3, 3, 99)$; $\tau_2 = (0, 2, 6, 6, 98)$; $\tau_3 = (0, 4, 12, 12, 97)$;





Contributions



1. **Model analysis to specify scheduling anomalies**
   - ✓ **Static constraints**
   - ✓ **Dynamic constraints**

2. **MONANO: Monitoring library on POSIX/RTEMS**

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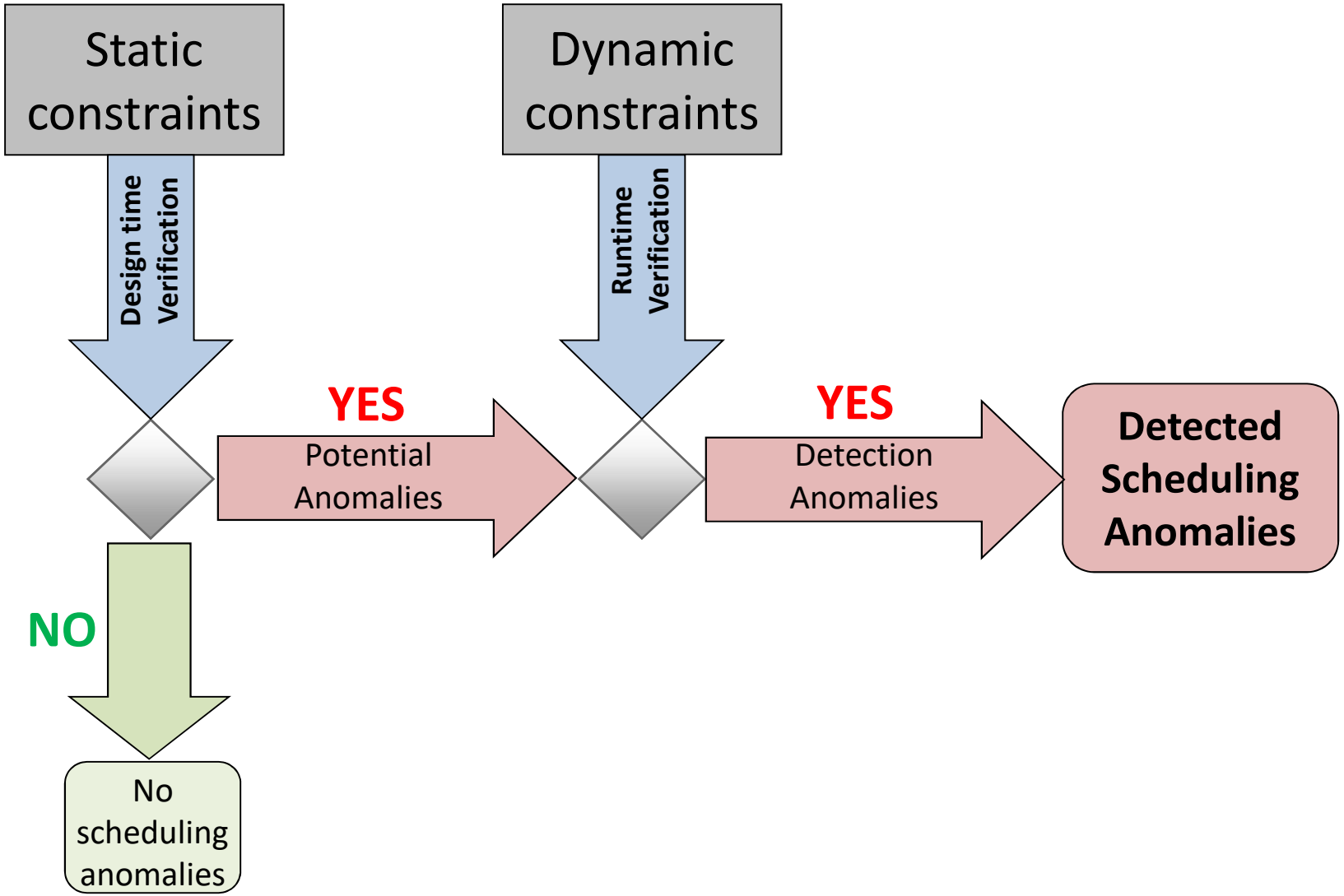
Scheduling anomalies model (1/2)



Scheduling anomalies model (2/2)

- **7 types of scheduling anomalies identified from the literature**

- **17 Static constraints**
  - 8 related to tasks
  - 9 related to the execution platform
  - ⇨ **19 scenarios combining static constraints**
- **7 Dynamic constraints**

- **Ex. :** Reducing task execution time, increasing processor speed, increasing task period, ….
  - ⇨ Reducing task execution time: 7 scenarios combining static constraints

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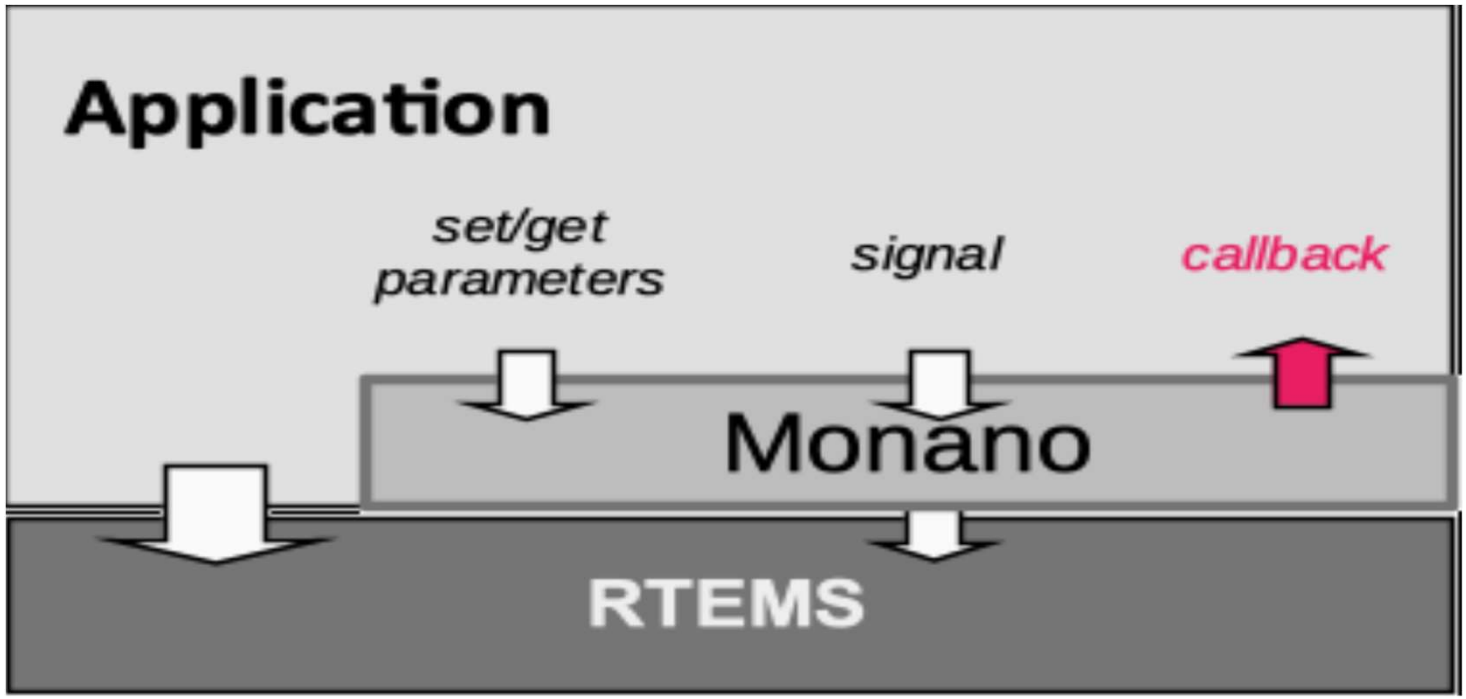
Monitoring of scheduling anomalies (1/3)



- MONANO, a user-level library to validate our approach
- Services:
  - Store architecture model of monitored applications
  - Creation of monitored threads
  - **Measure and compute metrics to verify dynamic and static constraints**
  - Anomaly detection and application callback

Monitoring of scheduling anomalies (2/3)

Function pthread_monano_verify_reduce_execution_time
begin
….
if (execution_time(τ_i) < C_i (τ_i) ***then***
Callback()
end

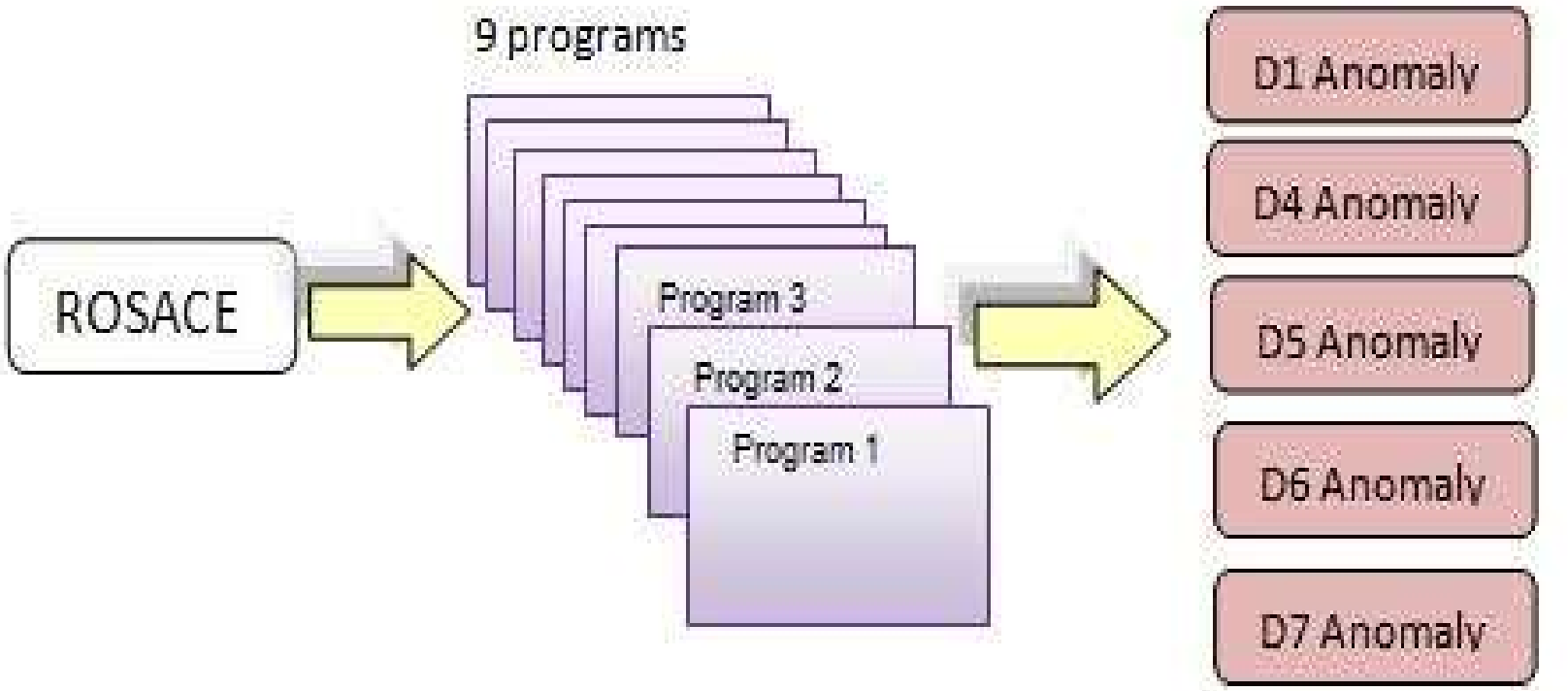
Function pthread_monano_signal_departure_time
begin
start_execution(τ_i) = clock_gettime()
…
end

Function pthread_monano_signal_end_time
begin
end_execution(τ_i) = clock_gettime()
execution_time(τ_i)=end_execution(τ_i) - start_execution(τ_i) - blocking_time(τ_i) - preemption_time(τ_i)
…..
if (blocking_time(τ_j) ==0) ***then***
preemption_time(τ_j) = (end_execution(τ_i) - start_execution(τ_i)) + preemption_time(τ_j)
else
preemption_time(τ_j) = (end_execution(τ_i) - end_blocking(τ_i)) + preemption_time(τ_j)
end if
…..
end

- **6 Algorithms to check** for dynamic constraints
- **5 Algorithms to compute** task execution time during its runtime.
- **1 Algorithm to verify** the schedulability of the system
- Etc….

Monitoring of scheduling anomalies (3/3)

- **MONANO Validation**
  - Static and dynamic constraints leading to scheduling anomalies
  - ROSACE : Aircraft flight controller application of 15 tasks developed on RTEMS (Pagetti14)
  - Anomaly detection and application callback



Conclusion

- **Problem statement**
  - Detection of scheduling anomalies in real-time systems
- **Contributions**
  - Model made of constraints to specify scheduling anomalies. Checked both on design and runtime
  - A POSIX/RTEMS Monitoring library called MONANO to detect scheduling anomalies in uniprocessor system
- **Results**
  - Verify that MONANO can be implemented on POSIX/RTEMS
  - Detection of 5 scheduling anomalies for uniprocessor system from the 7 identified from the literature
- **Future work**
  - Complete MONANO evaluation (overhead, scalability)
  - Extend MONANO to multiprocessor system