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## Real-Time Systems

Anno accademico 2012/13 Laurea magistrale in informatica Dipartimento di Matematica Università di Padova Tullio Vardanega

## Outline Introduction **Distributed systems** 1. 6. Dependability issues Analysis issues 2. 7. WCET analysis Scheduling issues a. 3. Schedulability analysis b. Fixed-priority scheduling 4. 8. Multicore systems Task interactions and a. blocking Bibliography Exercises and extensions b. J. Liu, "Real-Time Systems", Prentice Hall, 2000 System issues 5. A. Burns and A. Wellings, " Programming real-time a. "Concurrent and Real-Time systems Programming in Ada", Cambridge University Press 2012/13 UniPD / T. Vardanega 2 of 390 Real-Time Systems

## 1. Introduction

## Initial intuition /1 ■ Real-time system – I □ An aggregate of computers, I/O devices and applicationspecific software, all characterized by Intensive interaction with external environment Time-dependent variations in the state of the external environment Need to keep control over all individual parts of the external environment and to react to changes • System activities subject to timing constraints Reactivity, accuracy, duration, completion, responsiveness: all dimensions of *timeliness* System activities are inherently concurrent □ The satisfaction of such constraints must be proved 2012/13 UniPD / T. Vardanega Real-Time Systems 4 of 390















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![](_page_4_Figure_3.jpeg)

![](_page_4_Figure_4.jpeg)

![](_page_5_Figure_2.jpeg)

![](_page_5_Figure_3.jpeg)

![](_page_5_Figure_4.jpeg)

![](_page_5_Figure_5.jpeg)

![](_page_6_Figure_2.jpeg)

![](_page_6_Figure_3.jpeg)

![](_page_6_Figure_4.jpeg)

![](_page_6_Figure_5.jpeg)

![](_page_7_Figure_2.jpeg)

![](_page_7_Figure_3.jpeg)

![](_page_7_Figure_4.jpeg)

![](_page_7_Figure_5.jpeg)

![](_page_8_Figure_2.jpeg)

![](_page_8_Figure_3.jpeg)

![](_page_8_Figure_4.jpeg)

Relative deadline Period = 2

(0,7]

 $\bigcirc$ 

(2,5]

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(2,9]

 $\bigcirc$ 

(5,8]

(4,11]

Phase \

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![](_page_9_Figure_2.jpeg)

Extended precedence graphs (task graphs)

(6,13]

0

(8,11] (11,14] (14,17]

(8,15]

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Independent jobs

Dependent jobs

Job of type AND (join)

Job of type OR (branch)

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typically followed by

a join job

![](_page_9_Figure_3.jpeg)

![](_page_10_Figure_2.jpeg)

![](_page_10_Picture_3.jpeg)

![](_page_10_Picture_4.jpeg)

![](_page_11_Figure_2.jpeg)

![](_page_11_Figure_3.jpeg)

![](_page_11_Figure_4.jpeg)

![](_page_11_Figure_5.jpeg)