

# Satisfying Real-Time Requirements of Multicore Software on ARINC 653: The Issue of Undocumented Hardware

Bjorn Andersson

Dionisio de Niz

Mark Klein

Software Engineering Institute  
Carnegie Mellon University  
Pittsburgh, PA 15213

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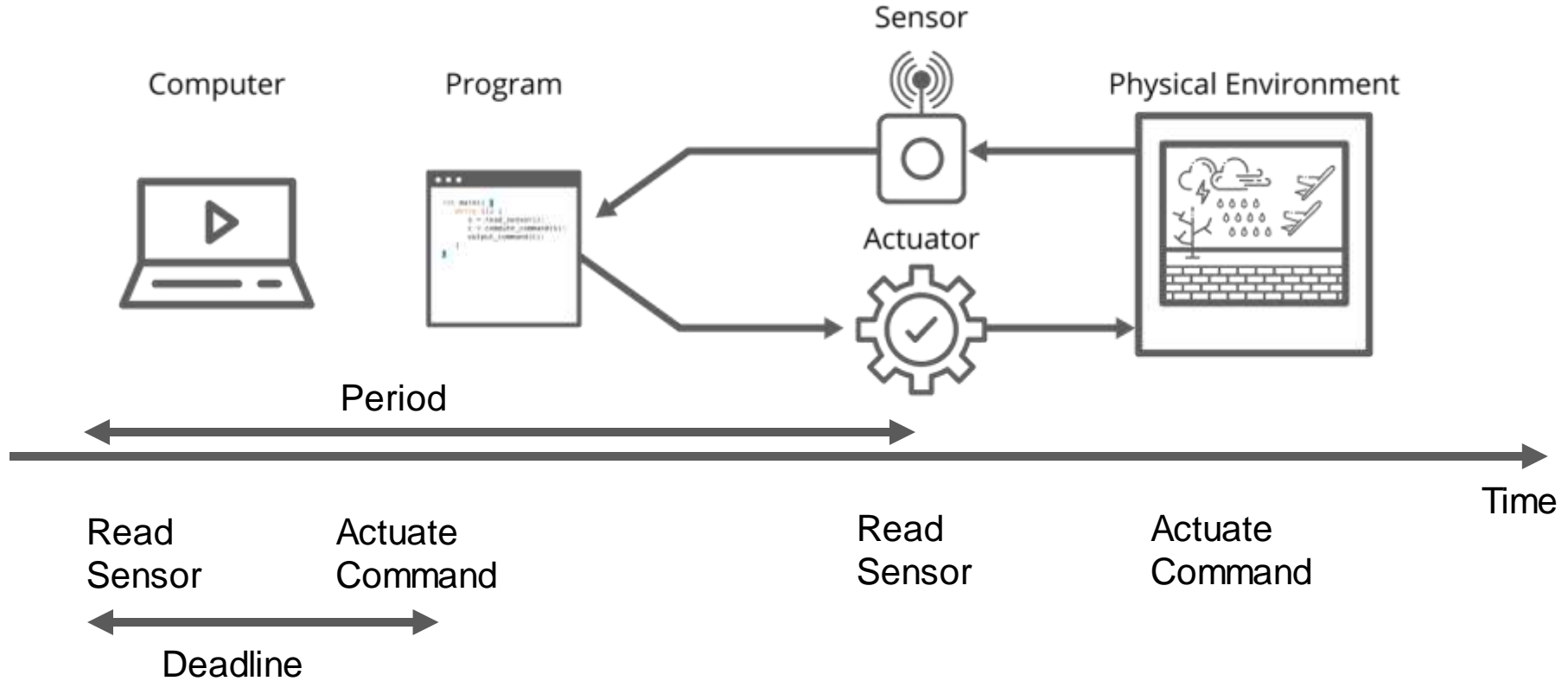
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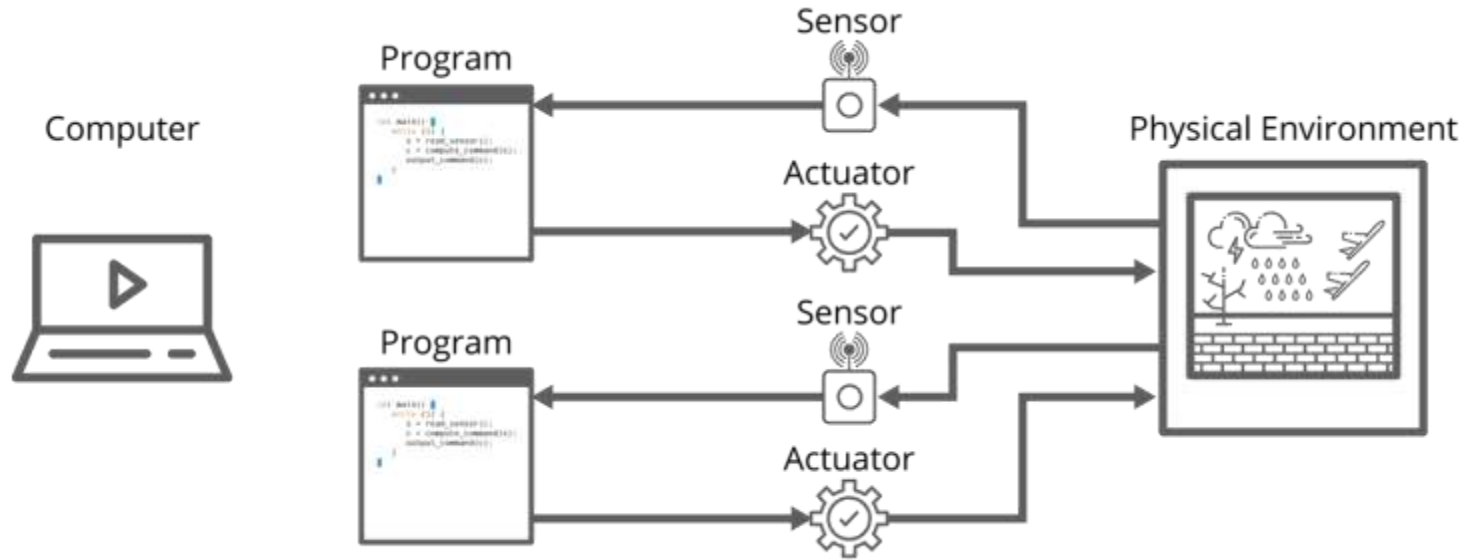
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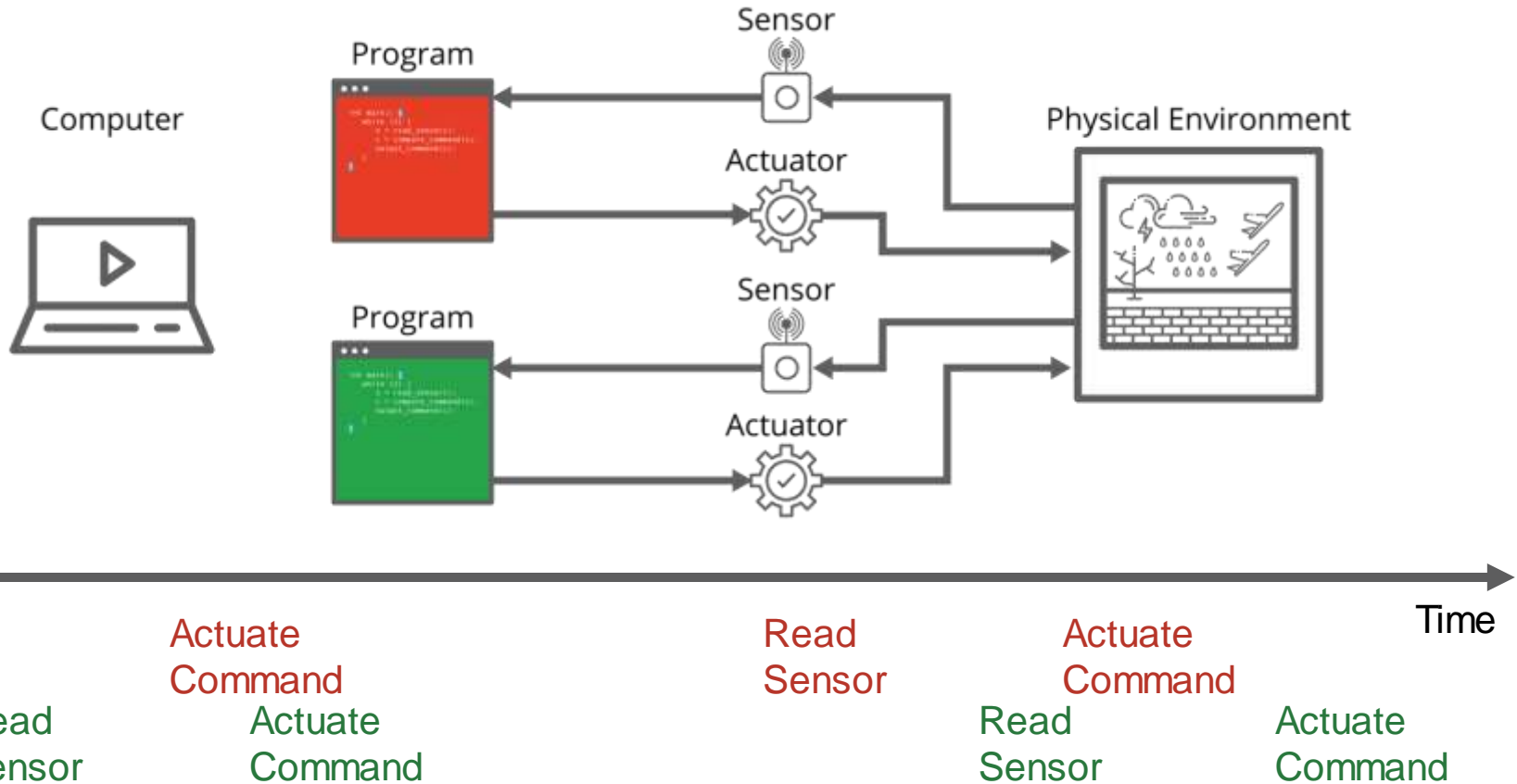
# Single-core real-time systems



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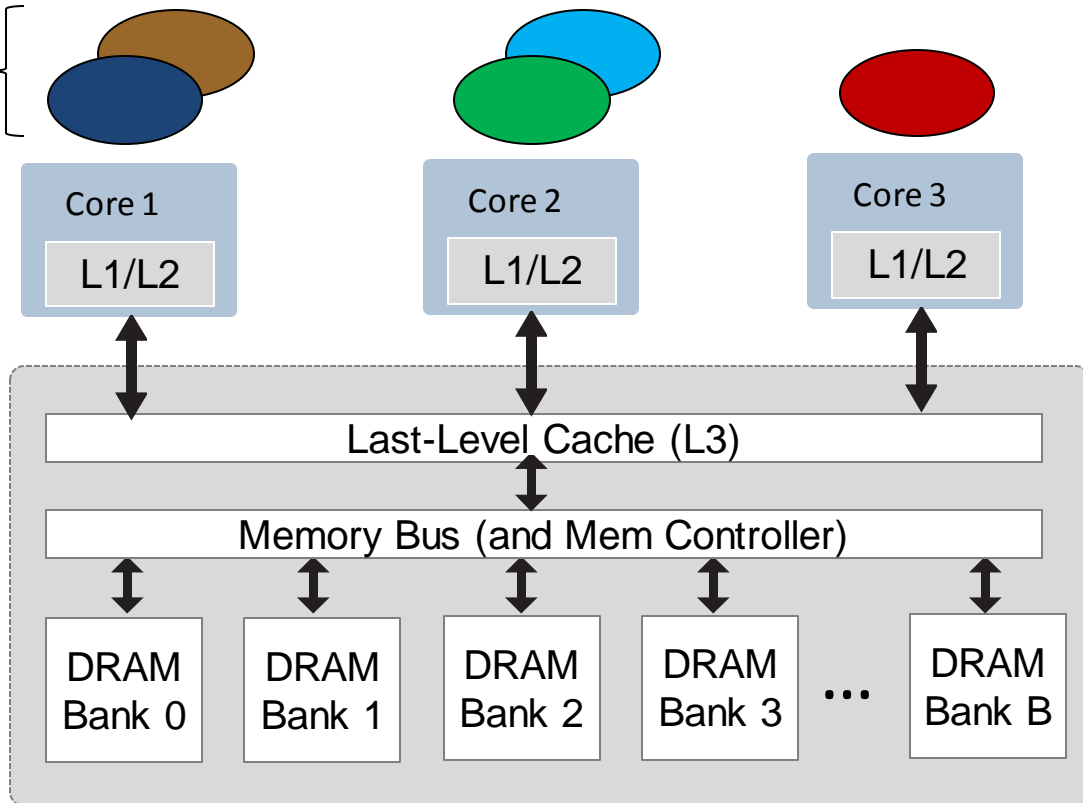


# Multicore real-time systems

## Issues

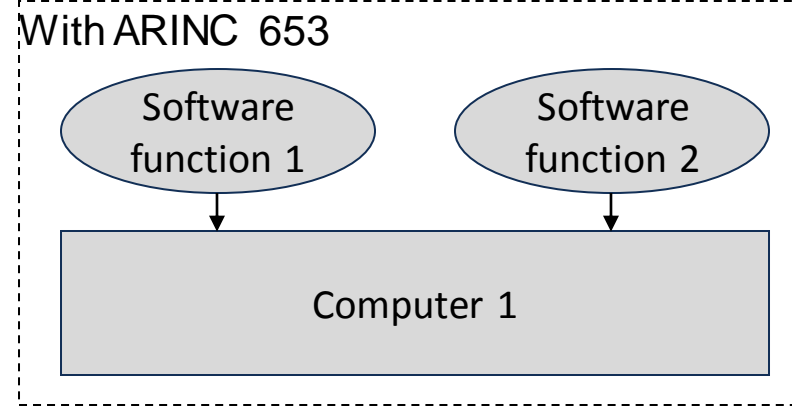
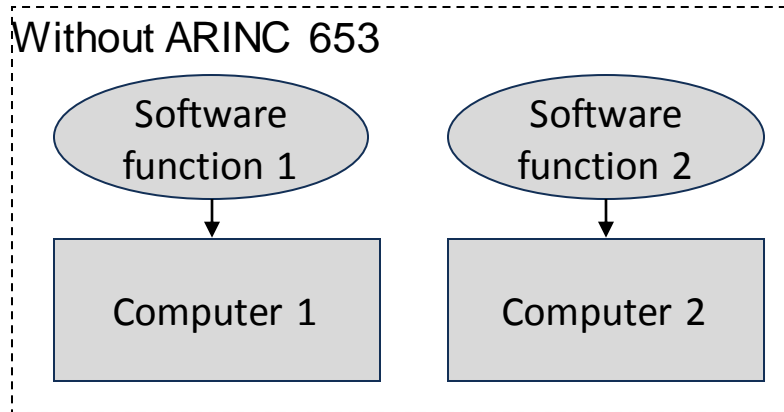
- Shared hardware resources impact timing.
- 103 times slowdown has been observed [Yun15].
- Most current methods cannot deal with undocumented resources.
- Even when resources are documented, current methods can only analyze/manage a small set of them.
- The problem is getting worse:
  - \* Slowdown increasing
  - \* More undocumented h/w

## Processes



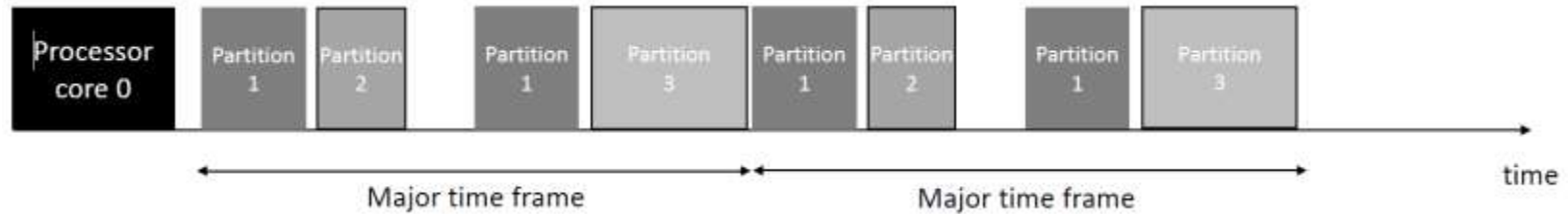
# ARINC 653

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- ARINC 653 uses a time-triggered scheduler to supply processing time to partitions.
- ARINC 653 initially only supported single-core systems





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## 2.2.1 Core Modules with Multiple Processor Cores

This standard includes support for the ARINC 653 services to be utilized with a core module that contains a single or multiple processor cores. With multiple processor cores, additional scheduling paradigms are feasible on a core module:

- Multiple processes within a partition scheduled to execute concurrently on different processor cores.
- Multiple partitions scheduled to execute concurrently on different processor cores.

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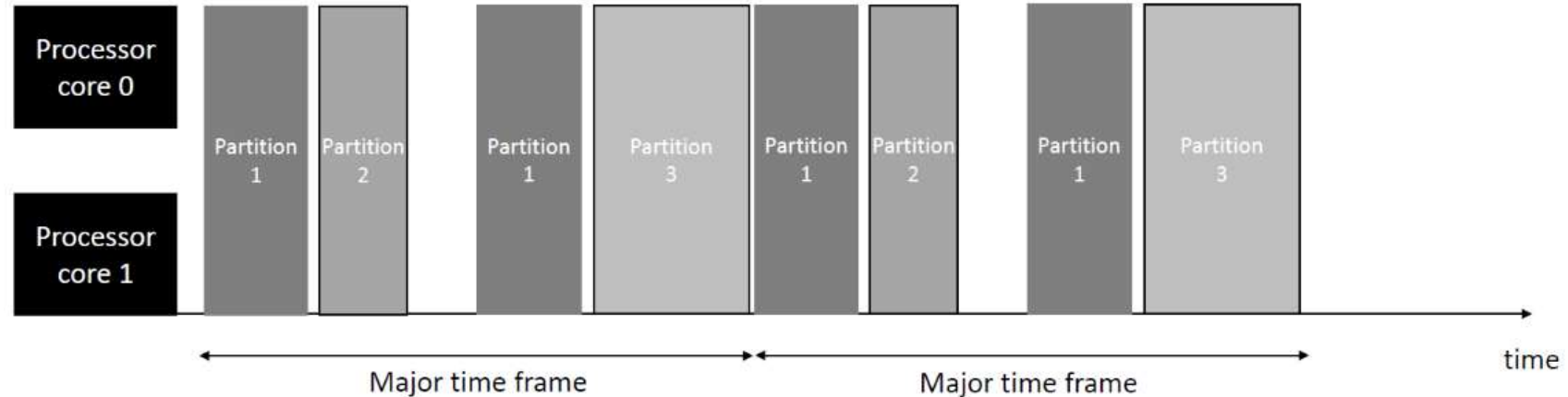
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- Multiple processes within a partition scheduled to execute concurrently on different processor cores.
- Multiple partitions scheduled to execute concurrently on different processor cores.

In the rest of this talk, we will assume this paradigm.

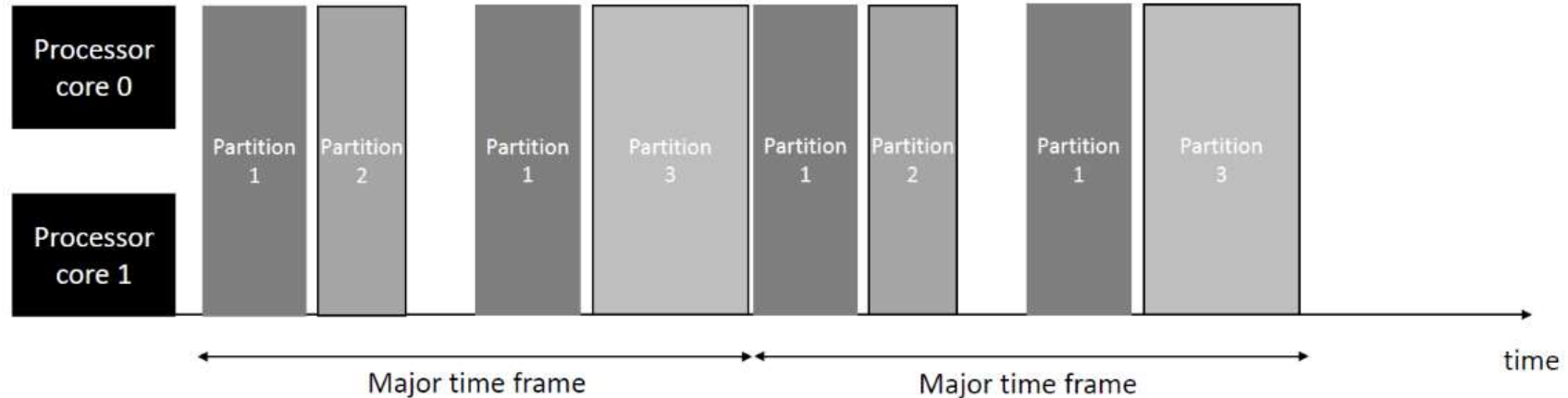
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- How do we analyze real-time software executing over ARINC 653 on multicore processor with undocumented hardware?

# Previous work

## This Paper Compared to State-Of-The-Art

Can analyze ARINC 653	Yes	[5,6,7]	This paper
	No		[8]
		No	Yes
Can analyze undocumented hardware			

## References

- [5] Y.-H. Lee, D. Kim, M. Younis, and J. Zhou, “Scheduling tool and algorithm for integrated modular avionics systems,” DASC, 2000.
- [6] A. Mok, D.-C. Tsou, and R. de Rooij, “The MSP.RTL real-time scheduler synthesis tool,” RTSS, 1996.
- [7] N. C. Audsley and A. J. Wellings, “Analysing APEX applications,” RTSS, 1996.
- [8] B. Andersson, H. Kim, D. de Niz, M. Klein, R. Rajkumar, and J. Lehoczky, “Schedulability Analysis of Tasks with Co-Runner-Dependent Execution Times,” TECS, 2018.

# Previous work

In this paper, we adapt [8] for ARINC 653.

This Paper Compared to State-Of-The-Art

Can analyze ARINC 653	Yes	[5,6,7]	This paper
	No		[8]
		No	Yes
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## References

- [5] Y.-H. Lee, D. Kim, M. Younis, and J. Zhou, "Scheduling tool and algorithm for integrated modular avionics systems," DASC, 2000.
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Can analyze ARINC 653	Yes	[5,6,7]	This paper
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Can analyze undocumented hardware			

[8] uses a model that describes the effect of sharing of hardware resources in the memory system without actually modelling the resources in the memory system.



allows analysis of software executing on undocumented hardware.



# Main result in this paper

**Theorem 1:** If  $\forall \tau_i \in \tau \quad \exists t \in [0, D_i]$   
 $reqlpARINC653(\tau, \Pi, PART, i, t) \leq sbf_I(\tau, \Pi, PART, i, t)$ , then the system is schedulable.

This is a minor adaptation from previous work [8].

This is new in this paper.

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**Theorem 1:** If  $\forall \tau_i \in \tau \quad \exists t \in [0, D_i]$   
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How much processing time is requested

How much processing time is supplied

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system is schedulable.

The ARINC 653 standard  
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 $req_{lpARINC653}(\tau, \Pi, PART, i, t) \leq sbf_I(\tau, \Pi, PART, i, t)$ , then the  
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The ARINC 653 standard can be interpreted in different ways. This yields different bounds on supply of processing time.

I allows you to specify which interpretation you want to use.

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 $req_{lpARINC653}(\tau, \Pi, PART, i, t) \leq sbf_I(\tau, \Pi, PART, i, t)$ , then the  
system is schedulable.

For details: see paper.

## Conclusion

It is possible to satisfy real-time requirements of multicore software on ARINC 653 and deal with the issue of undocumented multicore.