# Multiprocessor Real-Time Computing: Formal Foundations

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## The Challenge

As real-time embedded systems become ever more prevalent, important, and complex, it is becoming imperative that the formal foundations upon which the design and analysis of such systems are based keep pace with technological innovations. In this research project, we focus on two of the more fundamental advances that have occurred in the real-time and embedded systems domain: first, the **software** that comprises such systems is becoming increasingly more complex; and second, such systems are increasingly coming to be implemented on execution **platforms** comprised of multiple processing units. We propose to enhance our understanding of the behavior of complex, multiprocessor, real-time systems by providing a *firm theoretical foundation for the analysis of timing constraints* in such systems, and to obtain new tools, techniques, and methodologies for the analysis of such systems.

## The Approach

We plan to achieve these objectives by pursuing the following specific goals.

- Deriving new **abstract models** of real-time tasks that accurately capture salient features of real-life application systems that are to be implemented on multiprocessor platforms, and identifying rules for mapping application systems onto the most appropriate models.

- Designing new **run-time multiprocessor scheduling algorithms** that are provably better than ones currently used, both in terms of run-time efficiency and in terms of tractability of off-line analysis.

- Analyzing various (current and new) task models in order to enhance our understanding of what intrinsic properties render a model intractable from a timing analysis point of view, and to identify **very general classes of tractable models**.

- Constructing **"proof-of-concept" software** that validates the usefulness of the theoretical results obtained during the course of this research.

By achieving these goals, we would have significantly enhanced our capabilities to design, reason about, and implement real-time systems on multiprocessor platforms.

## Significance

Almost all prior results from multiprocessor real-time scheduling theory consider extremely simple ("pure" periodic or rate-based) task models; the importance of the proposed research is underscored by the observation that in the case of uniprocessor real-time scheduling, moving from these simple task models to more general ones changed what was then current industry practice in a dramatic manner. We are hopeful that corresponding advances in multiprocessor scheduling theory will bring about similar changes in current industry practice in the real-time and embedded applications domains today. That is, it is our expectation that success in this project, by creating a new design and analysis framework for multiprocessor real-time systems, will translate into a significantly enhanced ability for embedded and safety-critical real-time systems designers to provide formally verified systems at a significantly lower cost.

## Project Members

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