Embedded computer systems are now everywhere: from alarm clocks to PDAs, from mobile phones to cars, almost all the devices we use are controlled by embedded computer systems. An important class of embedded computer systems is that of real-time systems, which have to fulfill strict timing requirements. As realtime systems become more complex, they are often implemented using distributed heterogeneous architectures. The main objective of this thesis is to develop analysis and synthesis methods for communication-intensive heterogeneous hard real-time systems. The systems are heterogeneous not only in terms of platforms and communication protocols, but also in terms of scheduling policies. Regarding this last aspect, in this thesis we consider time-driven systems, event-driven systems, and a combination of both, called multi-cluster systems. The analysis takes into account the heterogeneous interconnected nature of the architecture, and is based on an application model that captures both the dataflow and the flow of control. The proposed synthesis techniques derive optimized implementations of the system that fulfill the design constraints. An important part of the system implementation is the synthesis of the communication infrastructure, which has a significant impact on the overall system performance and cost. To reduce the time-to-market of products, the design of real-time systems seldom starts from scratch. Typically, designers start from an already existing system, running certain applications, and the design problem is to implement new functionality on top of this system. Hence, in addition to the analysis and synthesis methods proposed, we have also considered mapping and scheduling within such an incremental design process. The analysis and synthesis techniques proposed have been thoroughly evaluated using a solid experimental platform. Besides the evaluations, performed using a large number of generated example applications, we have also validated our approaches using a realistic case study consisting of a vehicle cruise controller.

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