Static Cache Analysis for Deriving Timing Properties of Safety-Critical CPS Software

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Abstract

Tasks in safety-critical cyber-physical systems (CPS), such as aerial and ground vehicles, have stringent timing requirements whose violation may cause disastrous consequences. To verify whether a given task set satisfies its timing constraints, knowledge of certain timing properties, such as the worst-case execution time (WCET) for each task, is required. However, due to the use of modern hardware platforms, soundly and precisely deriving such knowledge becomes very challenging. In this talk, I will discuss (1) how to tighten the WCET estimation when there are many loops by cache persistence analysis, (2) how to significantly improve the precision of the WCET estimation in the presence of inclusive cache hierarchies, and (3) how to bound a task's multi-level cache-related preemption delay under preemptive scheduling strategies. Additionally, tasks in safety-critical CPS have high security requirements. Following my discussion on memory hierarchies, I will present my recent work on hardware security related to the DRAM attacks, which put the security of not only CPS but also more general computing devices at risk.

Bio

Zhenkai Zhang is a research scientist at Vanderbilt University's Institute for Software Integrated Systems. He also holds an adjunct assistant professor position in the Department of Electrical Engineering and Computer Science at Vanderbilt University. He received his Ph.D. degree in Computer Science from Vanderbilt University, M.S. degree from University of Chinese Academy of Sciences, and B.S. degree from Beijing Institute of Technology. His research work is in the areas of cyber-physical systems (including real-time and embedded systems), cybersecurity, and the intersection of these two. Many of his research results have appeared at top venues such as ICCPS, RTSS, RTAS, EMSOFT, and LCTES.