



# TWC: Medium: Language-Hardware Co-Design for Practical and Verifiable Information Flow Control

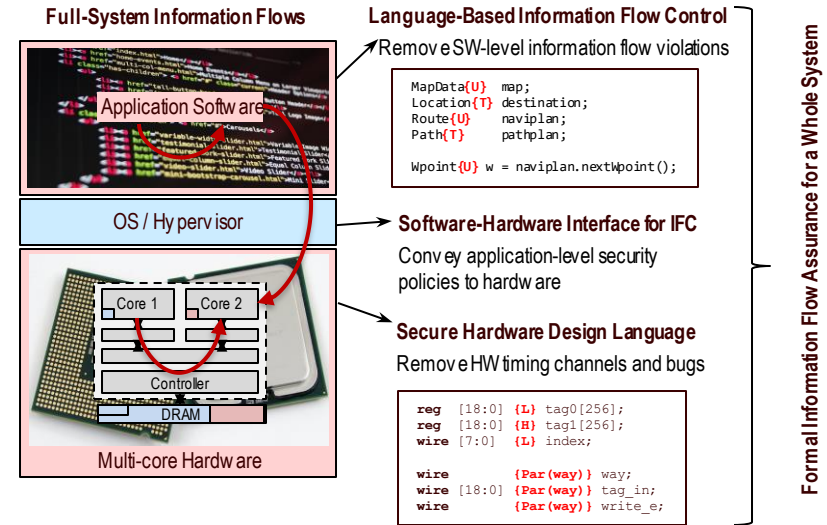
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## Challenge

- **Problem:** Emerging applications and platforms require strong security assurance that is not possible today
  - No information leak among VMs in cloud computing
  - Integrity guarantee for safety-critical autonomous systems
- **Objective:** Co-design software and hardware with strong, comprehensive, verifiable information flow assurance
  - All software-visible information flows **including timing channels**

## Solution and Technical Highlights

- Integrated approach to offer **whole-system security** where all software-visible information flows are **verified statically**.
  - **Software:** Use language-level information flow control (IFC) to verify explicit and implicit flows, mitigate software timing channels, and identify needs for hardware-level control.
  - **Hardware:** Design a multi-core processor with strong information flow assurance, including timing channels
  - **Interface:** Develop a SW-HW interface with label virtualization to convey rich software-level security policies to hardware
- **Formal security assurance** with static information flow analysis
- Major technical developments in HW design and verification
  - **Efficient HW timing channel protection:** uni-directional protection for caches (DAC'16) and memory (HPCA'16), quantifiable information flow control for memory (HPCA'17)
  - **Security verification:** safe exceptions and scheduling (PLDI'16, CCS'16), security level changes (DAC'17), processor prototype (CCS'18), ISA with information flow security (CSF'19)
  - **Application:** hardware isolation such as ARM TrustZone (ASPLOS'17), secure CPS (CPS-SPC'18)



## Scientific Impact

- Create a **new capability** to design computing systems with end-to-end security assurance across a whole system, including timing channels in microarchitecture.
- **New directions** in interdisciplinary research to co-design software, hardware, and formal verification methods for holistic system security

## Broader Impact

- **Impact on society:** Significantly improve security and assurance of critical computing platforms
- **Education and outreach:** new course modules for programming languages and architecture, student training, high-school and K-12 outreach, and industry collaboration.