Cryptoleq: A Heterogeneous Abstract Machine for Encrypted and Unencrypted Computation

MONDAY November 7, 2016
2:00 PM – HEC 450

The rapid expansion and increased popularity of cloud computing comes with no shortage of privacy concerns about outsourcing computation to semi-trusted parties. Leveraging the power of encryption, this presentation introduces Cryptoleq: an abstract machine based on the concept of One Instruction Set Computer, capable of performing general-purpose computation on encrypted programs. The program operands are protected using the Paillier partially homomorphic cryptosystem, which supports addition on the encrypted domain. Full homomorphism over addition and multiplication, which is necessary for enabling general-purpose computation, is achieved by inventing a software re-encryption module written using Cryptoleq instructions and blended into the executing program. Cryptoleq is heterogeneous, allowing mixing encrypted and unencrypted instruction operands in the same program memory space. Programming with Cryptoleq is facilitated using an enhanced assembly language that allows development of any advanced algorithm on encrypted datasets. As a case study, the performance of a typical Private Information Retrieval problem

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