F3ildCrypt: End-to-End Protection of Sensitive Information in Web Services

Matthew Burnside and Angelos D. Keromytis

Department of Computer Science
Columbia University
{mb, angelos}@cs.columbia.edu

ISC 2009

Motivation

- Identity-related information is valuable
- You must provide such information when using an online merchant
- This information is vulnerable to disclosure at the endpoints and in transit
- Can we protect this information end-to-end without revealing details of the logical corporate architecture?

Outline

Introduction

Merchant trust

Users have to trust online merchants:

- Merchant is not malicious
- Merchant will always protect sensitive information
- Merchant site is maintained by diligent sysadmins

SOA trust

In Service Oriented Architectures, users have to trust:

- Merchant *and peer SOAs* are not malicious
- Merchant *and peer SOAs* will always protect sensitive information
- Merchant *and peer SOAs* are maintained by diligent sysadmins

Data in transit

In this work, we focus on data in transit

- Approach does not protect against nodes with legitimate access to the data
- We protect the data from the web browser to the back-end database

Design alternative

Pair-wise key distribution

- Generate a certificate for each potential target host in the SOA pipeline
- Deliver certificate set to each web browser
- Browser encrypts each field direct to its destination host

Design alternative (cont.)

Issues with pair-wise key distribution

- Certificates for all hosts in any partner SOAs must also be delivered
- Certificate set must be updated each time the architecture of the SOA or SOA partners varies
- Reveals the logical architecture of the SOA and its SOA partners

Related work

Proxy re-encryption

- Given: plaintext P, Alice $\langle pk_A, sk_A \rangle$, and Bob $\langle pk_B, sk_B \rangle$
- There exists some $rk_{A \to B} = F(sk_A, pk_B)$ such that:

$$pk_B(p) = rk_{A \to B}(pk_A(P))$$

- [Blaze et al., 1998]

W3bCrypt

Introduced end-to-end encryption in web pipelines

- Firefox plugin for application-level crypto
- *"Encryption as a stylesheet"*
- Requires disclosure of corporate network details
- [Stavrou et al., 2006]

Architecture

Architecture

- Network model
- Design goals
- F3ieldCrypt architecture

Network model

- SOA-style network
- Each SOA may have multiple partner SOAs
- SOAs wish to prevent disclosure of logical architecture and peering

Design goals

- End-to-end protection of XML fields – even across SOA boundaries
- Confidentiality of logical architecture of each SOA must be respected

This work does not focus on providing protection against compromise or failure of entities with legitimate access to sensitive information.

F3ieldCrypt architecture

- Each SOA s publishes a public key pk_{E_s}
- Browser b generates plaintext P
- b sends $C = pk_{E_s}(P)$ to s
- s proxy re-encrypts C to internal hosts and partner SOAs $0 \ldots n$

Key generation

- Key pair $\langle pk_{E_s}, sk_{E_s} \rangle$ generated at the external-key holder
- SOA collects the public keys of its applications $pk_{I_0} ... pk_{I_n}$
- Use in conjunction with sk_{E_s} to generate $rk_{E \rightarrow I_0} ... rk_{E \rightarrow I_n}$

F3ieldCrypt architecture (cont.)

- By proxy re-encryption:

$$pk_{I_j}(P) = rk_{E \rightarrow I_j}(pk_E(P))$$

- Keys $rk_{E \rightarrow I_0} \ldots rk_{E \rightarrow I_n}$ stored at proxy re-encryption engine

Proxy re-encryption engine

- Fields arrive at PRE encrypted under pk_{E_s}
- Each field f is re-encrypted under $pk_{E \rightarrow I_j}$
- The mapping $f \rightarrow j$ is determined from a XACML policy

Client policy and crypto engines

Web clients receive a re-cryptography engine and a policy engine.

- Policy engine uses a XACML policy to determine which fields to encrypt
- Re-crypto engine encrypts XML fields as directed by the policy engine.

Evaluation

Implementation

- Java-based Re-crypto engine based on JHU-MIT Proxy Re-cryptography Library for each web client
- Python-based XML proxy for each internal application to store keys and unwrap XML
- XML gateway at the SOA stores the re-encryption engine

Testbed servers

Dell PowerEdge 2650 Servers

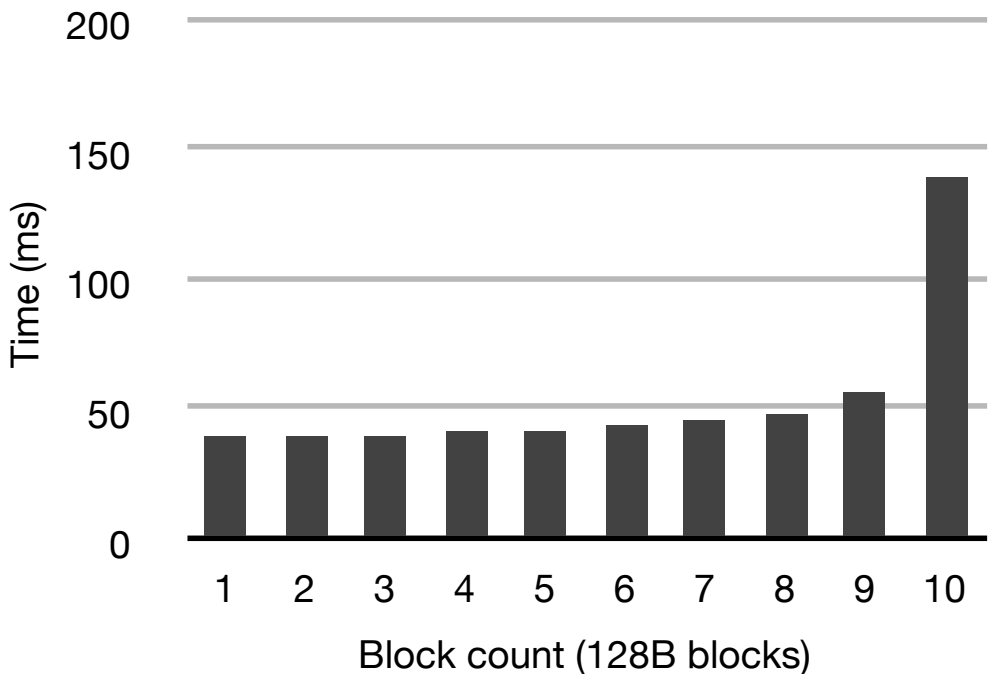
- 2.0GHz Intel Zeon processor, 1GB RAM, Gigabit Ethernet
- OpenBSD 4.2
- OpenBSD PF firewall, Apache 1.3.29, PHP 4.4.1, MySQL 5.0.45

Testbed client

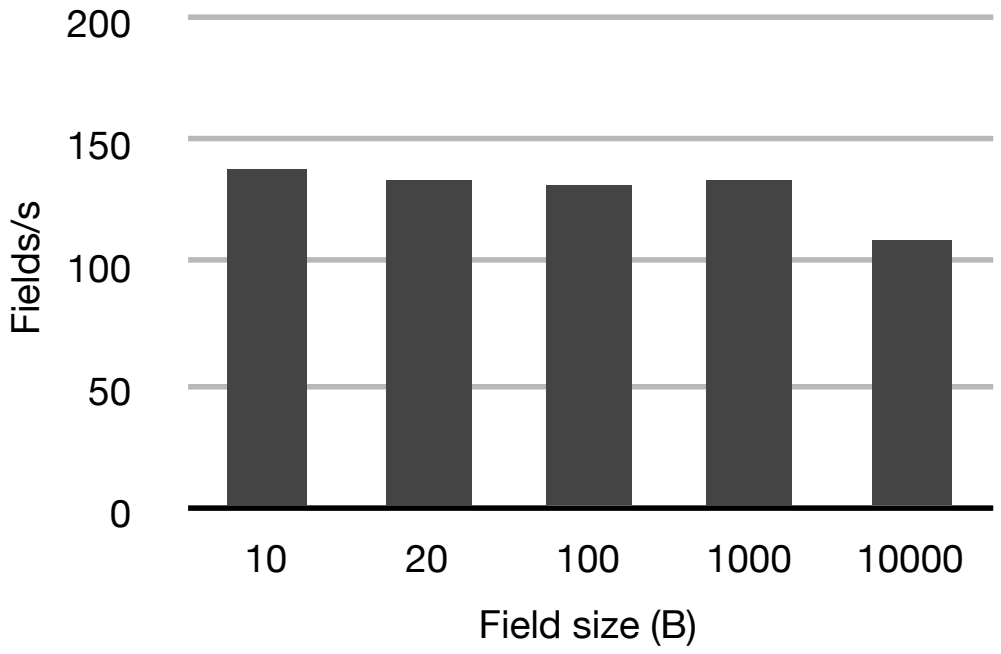
Macbook Pro

- 2.4 GHz Intel Core 2 Duo, 2GB RAM, Gigabit Ethernet
- OS X 10.5.2, Darwin kernel 9.2.2, Mozilla Firefox 2.0.0.13

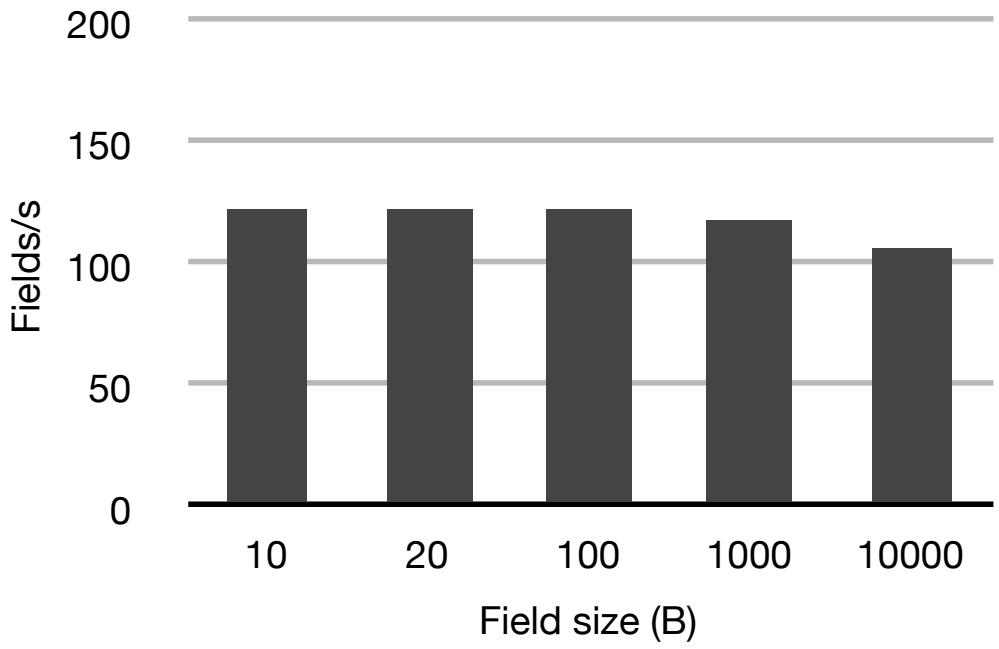
Block encryption on the client



Re-encryption rate at an XML gateway



Decryption rate at an XML proxy



Conclusion

- End-to-end protection to users
- Protection of logical architecture and partnering for SOAs


G. Ateniese, K. Fu, M. Green, and S. Hohenberger.
Improved proxy re-encryption schemes with applications to secure distributed storage.
In *Proceedings of the 12th Annual Network and Distributed Systems Security Symposium (NDSS 2005)*, 2005.


Matt Blaze, G. Bleumer, and M. Strauss.
Divertible protocols and atomic proxy cryptography.
In *Proceedings of Eurocrypt '98*, pages 127–144, 1998.


Angelos Stavrou, Michael Locasto, and Angelos Keromytis.
W3bcrypt: Encryption as a stylesheet.
In *Proceedings of the 4th Applied Cryptography and Network Security Conference (ACNS 2006)*, pages 349–364, 2006.