DELEGATEE: Brokered Delegation Using Trusted Execution Environments

Sinisa Matetic and Moritz Schneider, *ETH Zurich*; Andrew Miller, *UIUC*;
Ari Juels, *Cornell Tech*; Srdjan Capkun, *ETH Zurich*

CSC 6991
Presented by: Shikha Sikligar

Overview

- Background
- Introduction
- Problem Statement
- DELEGATEE
  - Security Analysis
  - Implementation
  - Performance Analysis
  - Limitations
- Conclusion

Background

- **Brokered Delegation** – allows user's to flexibly share and delegate access, without requiring explicit support from service providers
  - New type of delegation restricted under policy enforcements by a TEE enclave
- **Trusted Execution Environments (TEEs)** - a secure area inside a main processor
  - Emergence of TEEs, such as Intel SGX, enables an alternative way to achieve delegation without trust between the Owner and Delegatee

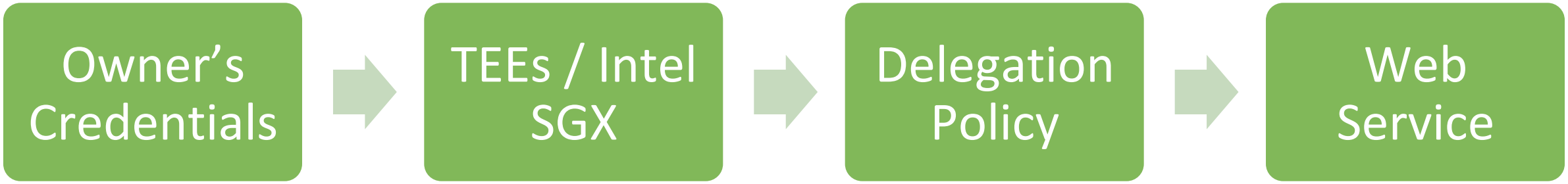
Introduction

- Many online services either have limited support or no support for delegation
  - Delegation – the ability to share a portion of one's authority with another
- Delegation allows user's to safely and selectively secure online accounts and services
- Researcher's created DELEGATEE
  - Provides brokered delegation for many existing web services

Problem Statement

- Two major motivations:
  - To demonstrate the many settings in which brokered delegation gives rise to new functionality
  - To demonstrate how trusted hardware TEEs can transform any mandatory access control policy within online services into a discretionary one
- DELEGATEE allows users to delegate authority
- Challenge: Without backend support two possible strategies
  - Owner remains online and mediate requests
  - Owner provides Delegatee with a resource for unmediated access

DELEGATEE


Owner's Credentials
TEEs / Intel SGX
Delegation Policy
Web Service

DELEGATEE

- Decentralized Peer-to-Peer System
  - A system in which a Delegatee uses brokered credentials to execute secure enclaves

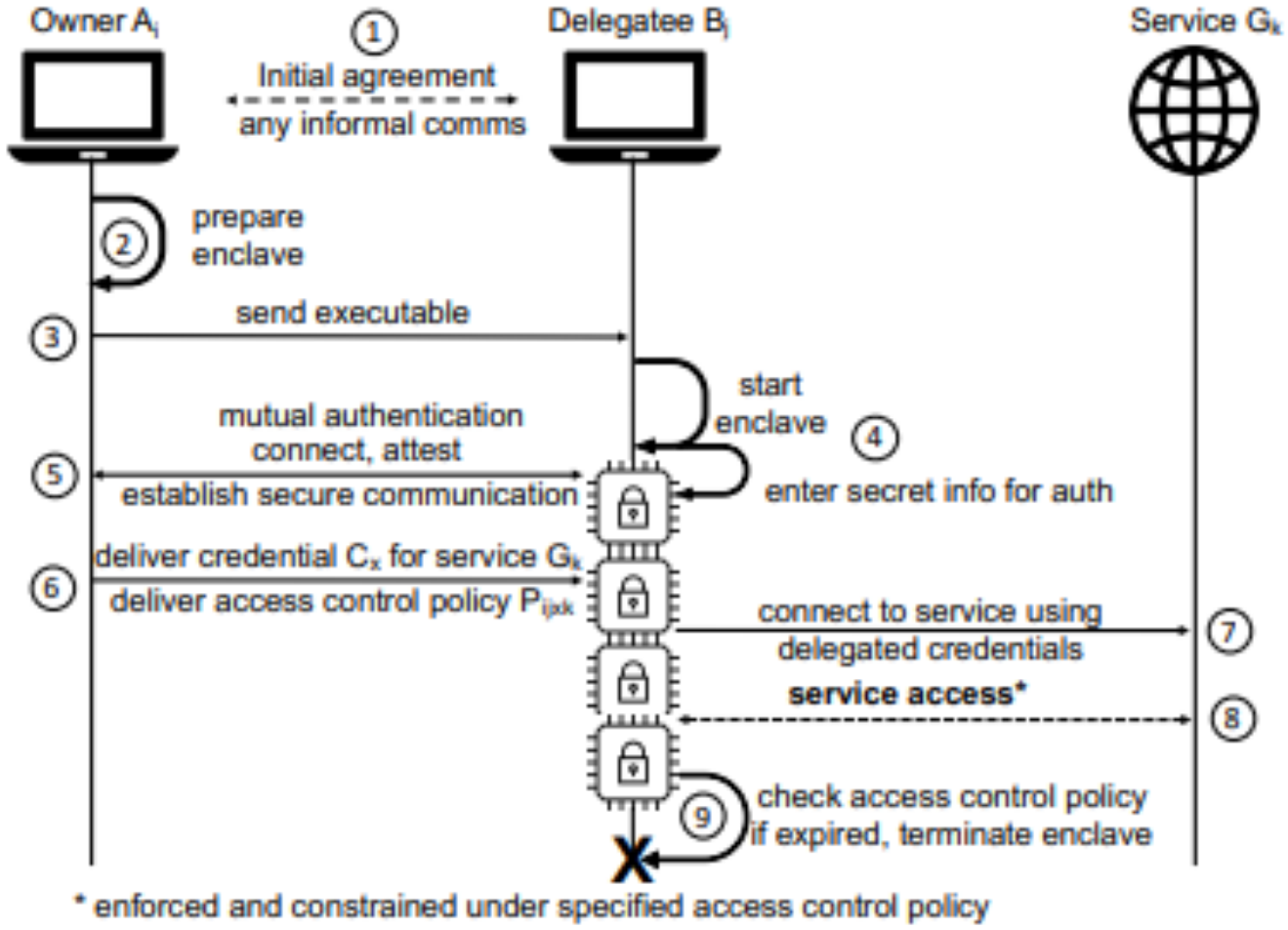


Figure 1: DELEGATEE's P2P system architecture

DELEGATEE

- Centralized Broker System
  - A system which operates through a third party

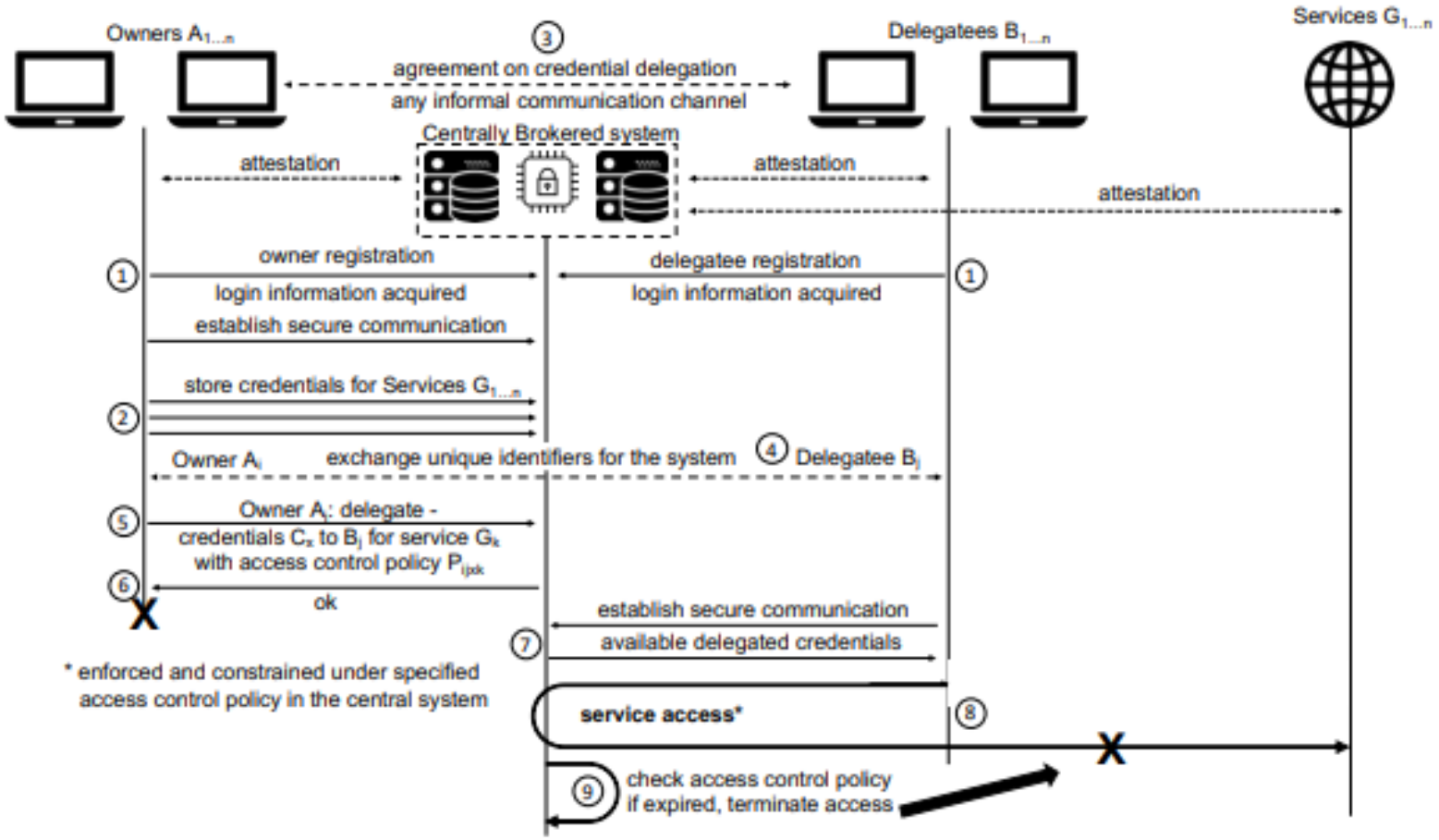


Figure 2: Centrally Brokered system architecture for credential delegation with DELEGATEE

DELEGATEE System Design Details

- DELEGATEE supports both identity-based (non-anonymous) and anonymous use models
  - Identity-based model
  - Anonymous model
- Policy Creations and Enforcement
  - Aim to prevent attackers from modifying the policies or changing the enforcement
  - Burden remains on the Owner to choose an appropriate access control policy

Security Analysis

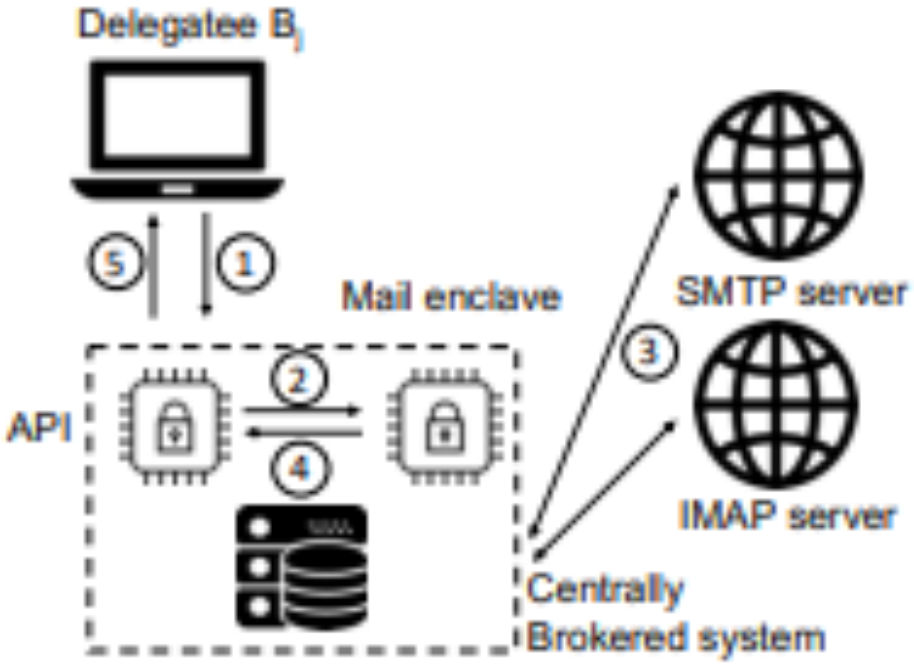
- Main security proprieties that DELEGATEE will ensure
  - Owner's access credentials remain confidential
  - The use of the delegated credentials is defined by the access control policy which will not be violated.
  - Use of the credentials should only be granted to the intended Delegatee, as authorized by the Owner
- DELEGATEE system is designed in a way that breaking the SGX protection mechanism on an arbitrary enclave will not weaken the system
- Attacker will need to break the exact enclave running DELEGATEE

Implementation

- DELEGATEE was implemented on four service specific enclaves
  - Mail
  - PayPal
  - Credit card/e-banking
  - Full website access
- An additional enclave was implemented to authenticate users and store credentials
- A browser extension was implemented to communicate with the Centrally Brokered system and Delegatee

Implementation - Mail

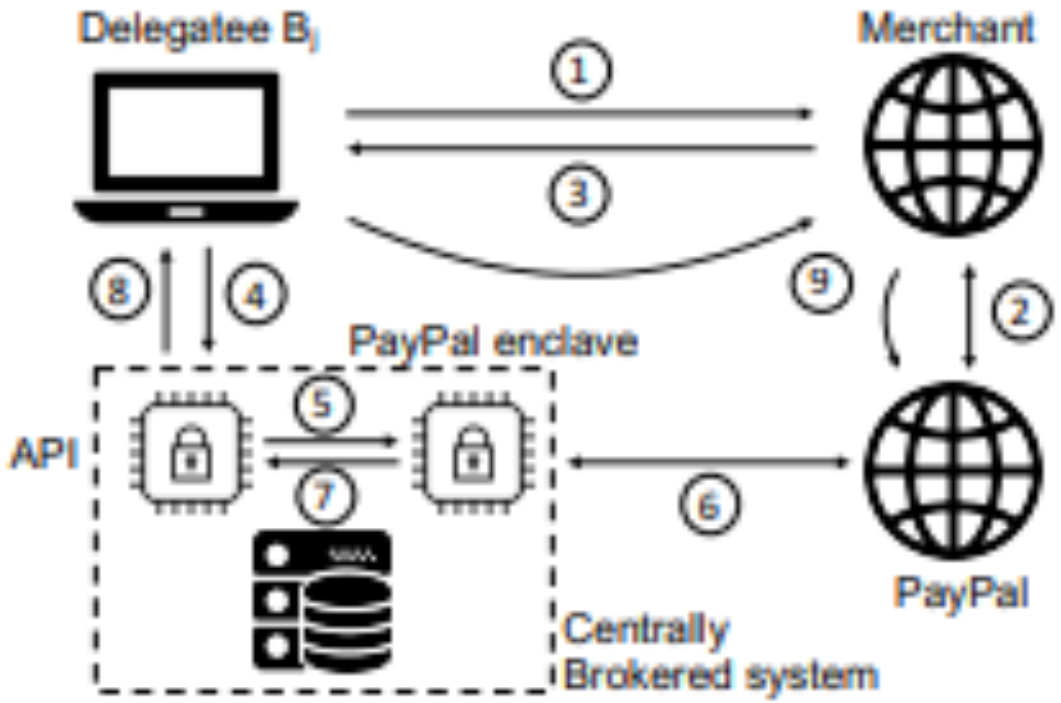
- DELEGATEE implemented in the mail enclave



(a) Mail model

Implementation - PayPal

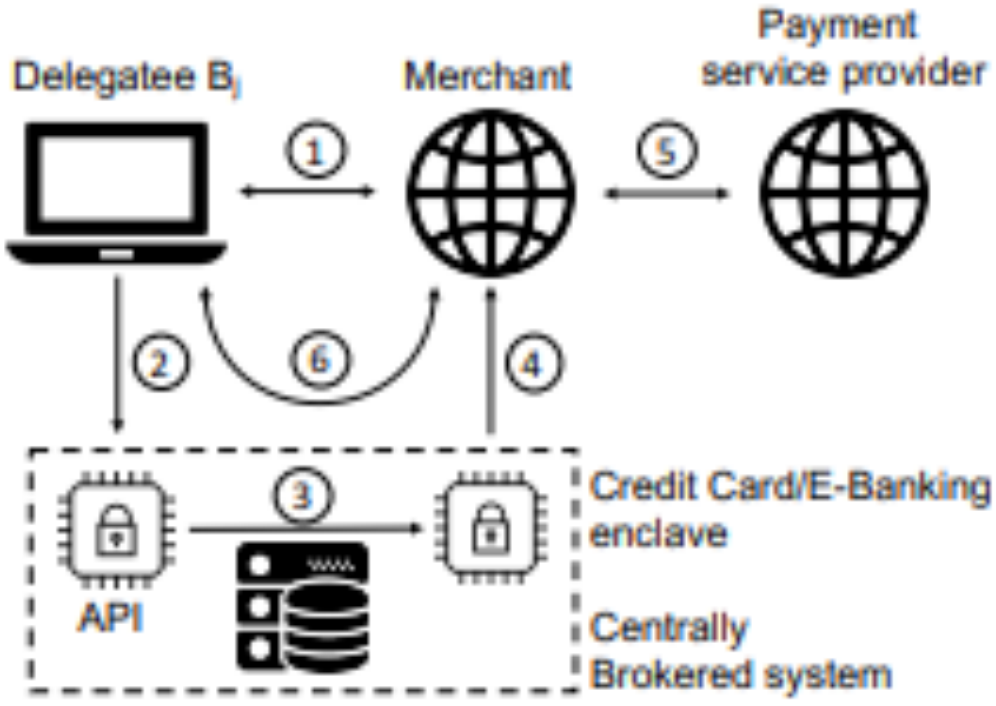
- DELEGATEE was implemented using the no javascript fallback mechanism from PayPal
- Tested using PayPal's sandbox and real-world environment
- Browser extension allows the user to choose DELEGATEE at checkout



(b) PayPal transaction model

Implementation – Credit Card/E-Banking

- Similar to the implementation of the PayPal enclave
- Upon checkout the browser extension is triggered if a payment form is avaiable



(c) Credit card / e-banking model

Implementation – Full Website Access

- Implemented a HTTPS proxy enclave using cookies to set the correct host name and parse through requests

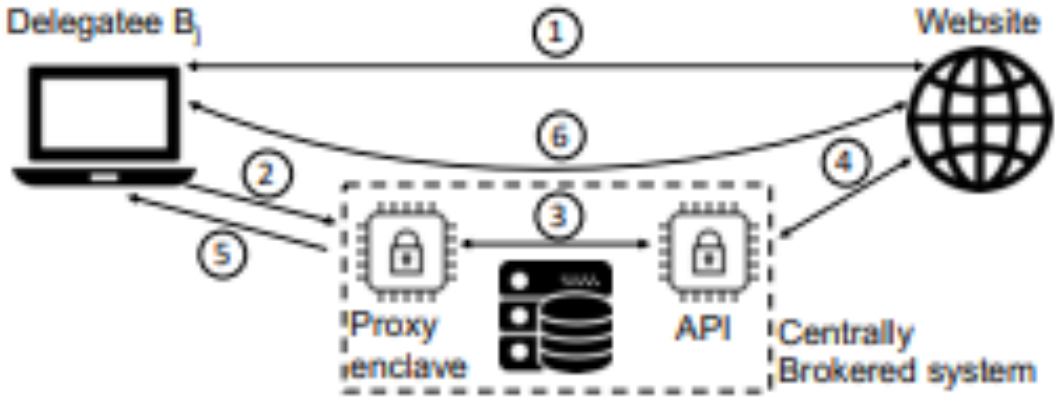


Figure 4: Login model

Performance Analysis

- Conducted on two i7-7700 machines with 16 GB RAM, connected via the internet and local network
- Can serve up to 100 users
- Mail, PayPal, Credit Card, and Full Website Access performed well
- Testing conducted on streaming websites, such as Netflix, was the same to normal streaming

Limitations

- Development of a generic module to support a variety of services
- Authentication challenges
  - Two-Step Authentication
  - IP Address changes
  - Simultaneous login attempts
- Bandwidth to support video streaming
- Secondary markets

Conclusion

- Proposed a new concept called Broker Delegation, which uses TEEs to enable flexible delegation
- Implementation and experiments show that DELEGATEE can be applied to real-world applications
- DELEGATEE runs with minimal overhead and preserves security against a strong attacker