# Practical implications of Intel SGX with Graphene

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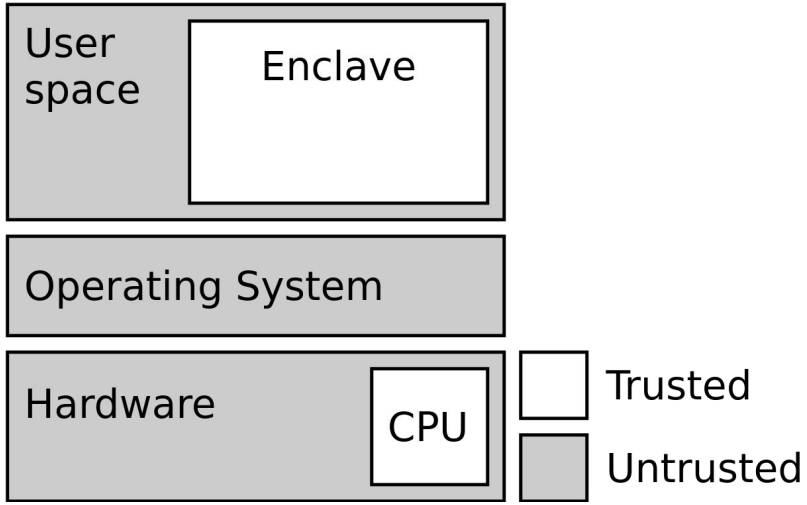
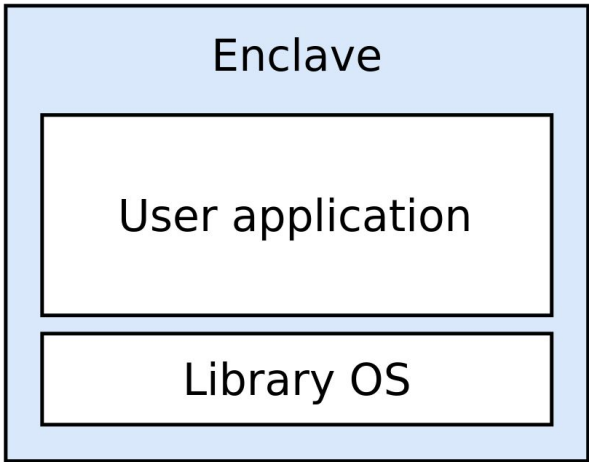
# Software Guard Extensions (SGX)

- Untrusted system
- Trusted enclave
- Attestation
- Encrypted & isolated memory
- Integrity, confidentiality, isolation



# Graphene-SGX

- Library OS
- Standard C library
- Unmodified applications
- Multi-process support
- Dynamic shared libraries
- Manifest



# Related work
# Use-cases

- SGX
  - DRM, Anti-cheat
  - Compilers
  - TLS termination
  - Databases
  - System logs
  - Middleboxes
- Graphene
  - No modifications required
  - Reduced development effort
  - Facilitate SGX research

# Related work
# Existing attacks on SGX

- Cache side channel attacks
  - Foreshadow
  - SgxPectre
  - BranchScope
  - CacheZoom
- Asyncshock
- Controlled channel

*What are the practical implications of running arbitrary applications in Intel SGX using Graphene-SGX?*

# Security implications

# Misaligned threat model

- Intel SGX
  - Operating system = untrusted
- Most applications
  - Operating system = trusted

Arbitrary applications are often not designed to guard against a malicious operating system.

# Iago attacks

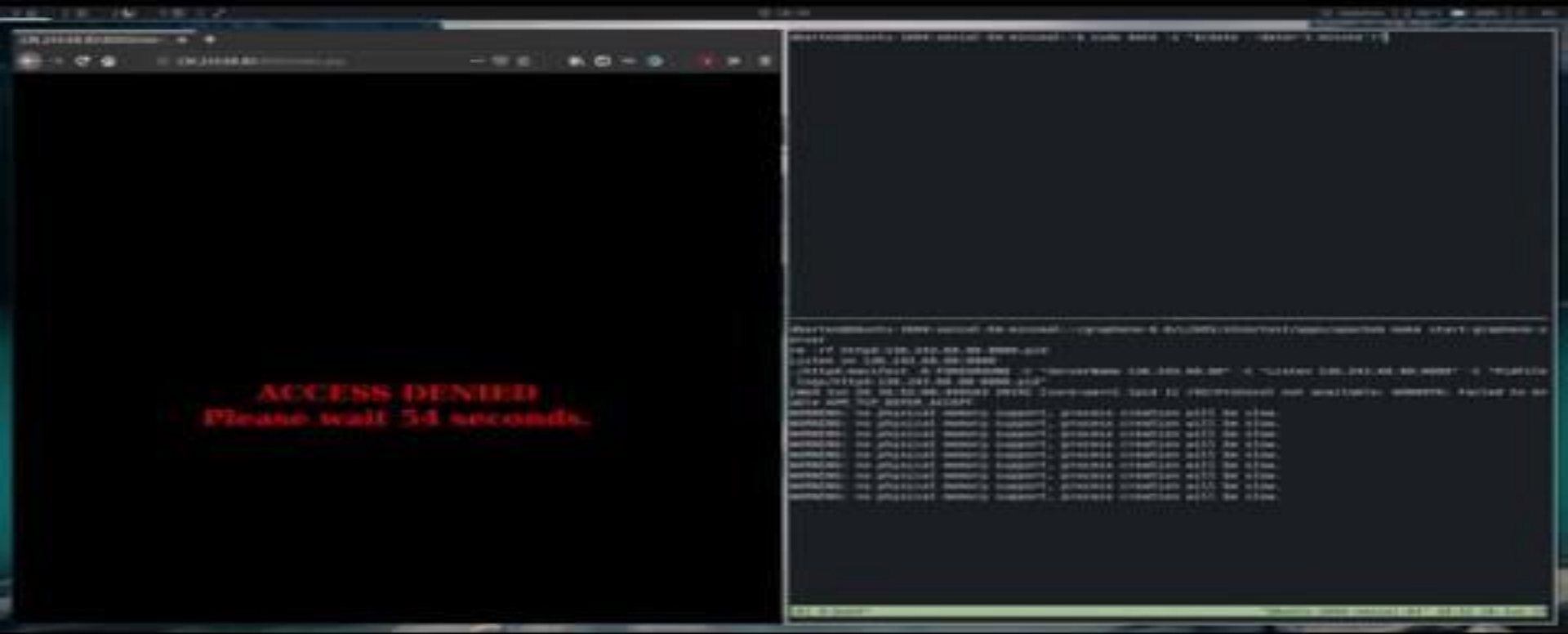
- Attacks by malicious kernel
- System calls

- Mitigation
  - Verification

# Date / time manipulation

- *gettimeofday()*
- Reliant on OS supplied vDSO
- Not verified by Graphene

- Implications
  - Transaction order
  - Kerberos
  - 2FA token validity
  - Rate limiting




Date / time manipulation demo

# Environment variable manipulation

- Arbitrary environment vars
- Not present in manifest
- Not checked by Graphene
- Easily overlooked

- Implications
  - Influence execution
  - GCC Epoch

# Framework maturity

# Running applications in Graphene

- OS version support
- Framework bugs
- Disk writes
- Non trivial to port complex applications

# Discussion & conclusions

# Discussion

- Security may be compromised
- Can be mitigated
- Graphene as research project
- Not ready for production

*Developers should take care when running arbitrary applications in SGX using Graphene, as there may be non-trivial security implications and framework bugs.*

# Future work

- Explore additional system calls
- Environment variable dependent applications
- Investigate SCONE/Panoply

# Sources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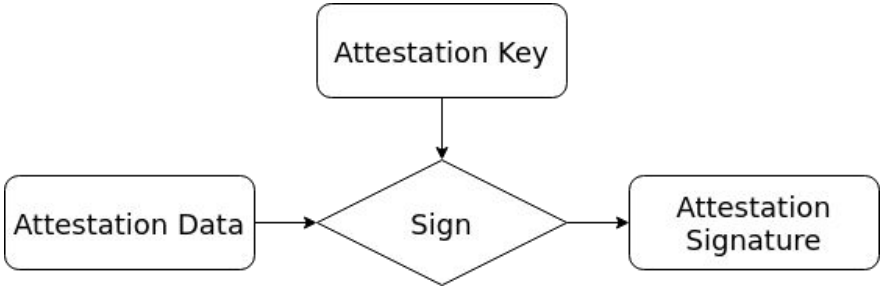
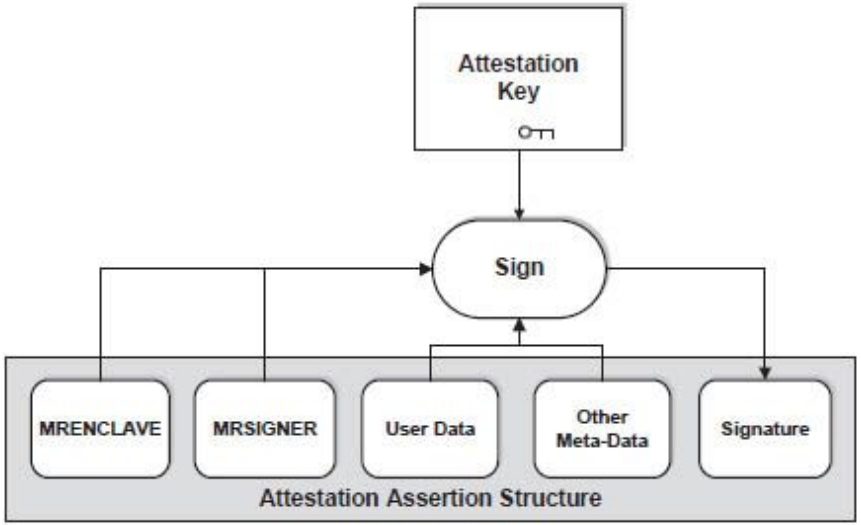
# Software Attestation

- Attestation data
- Attestation key
- Attestation signature



# Software Attestation SGX

- MRENCLAVE - Enclave Identity
- MRSIGNER - Sealing Authority Public key hash
- Attestation Key in µcode




Source: Intel documentation