Trusted Execution Environment: what it is and what it is not

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Outline

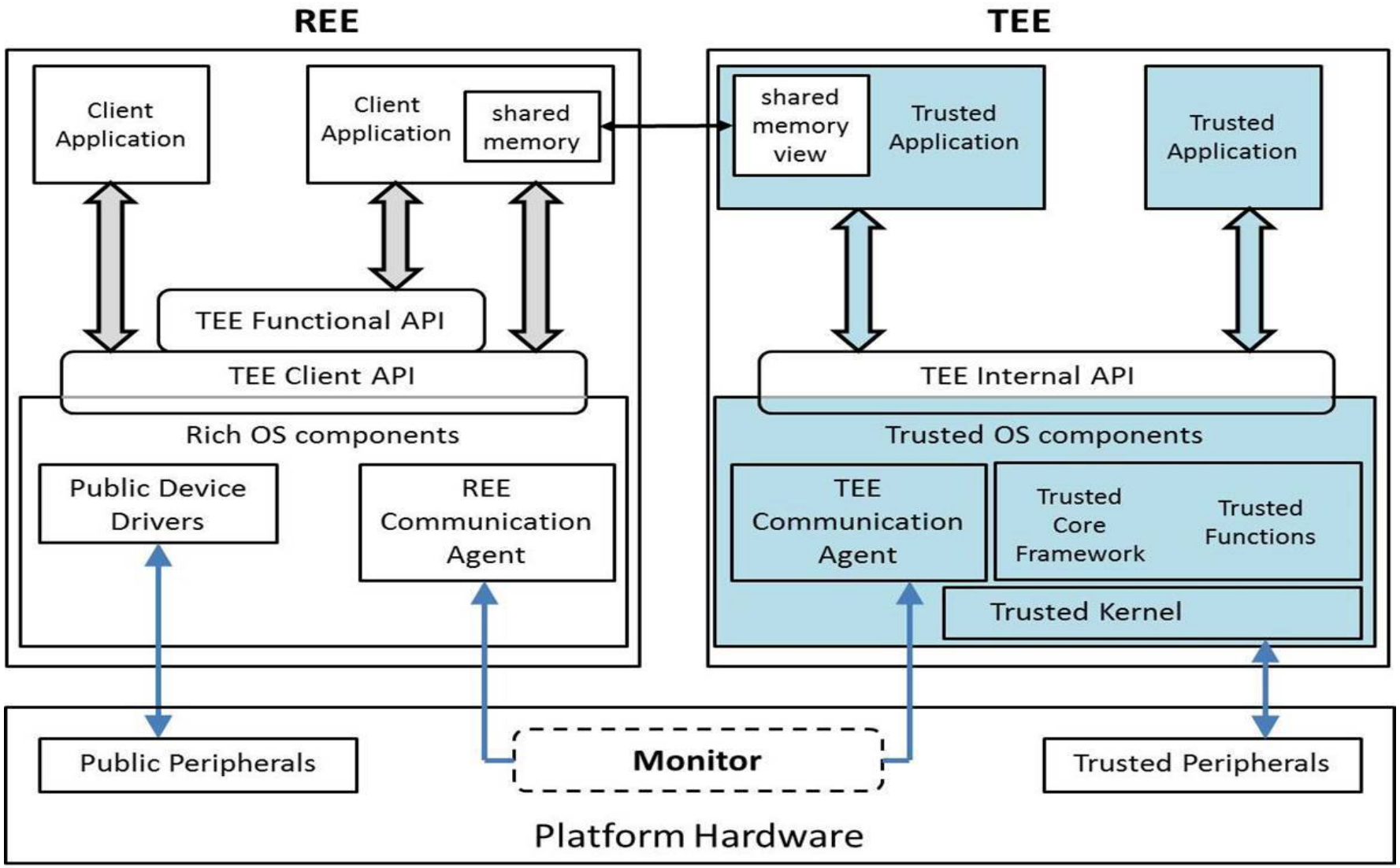
"The time has come," the Walrus said,
"To talk of many things;
Of shoes–and ships–and sealing wax–
Of cabbages—and kings–
And why the sea is boiling hot–
And whether pigs have wings."

— Lewis Carroll, Through the Looking-Glass

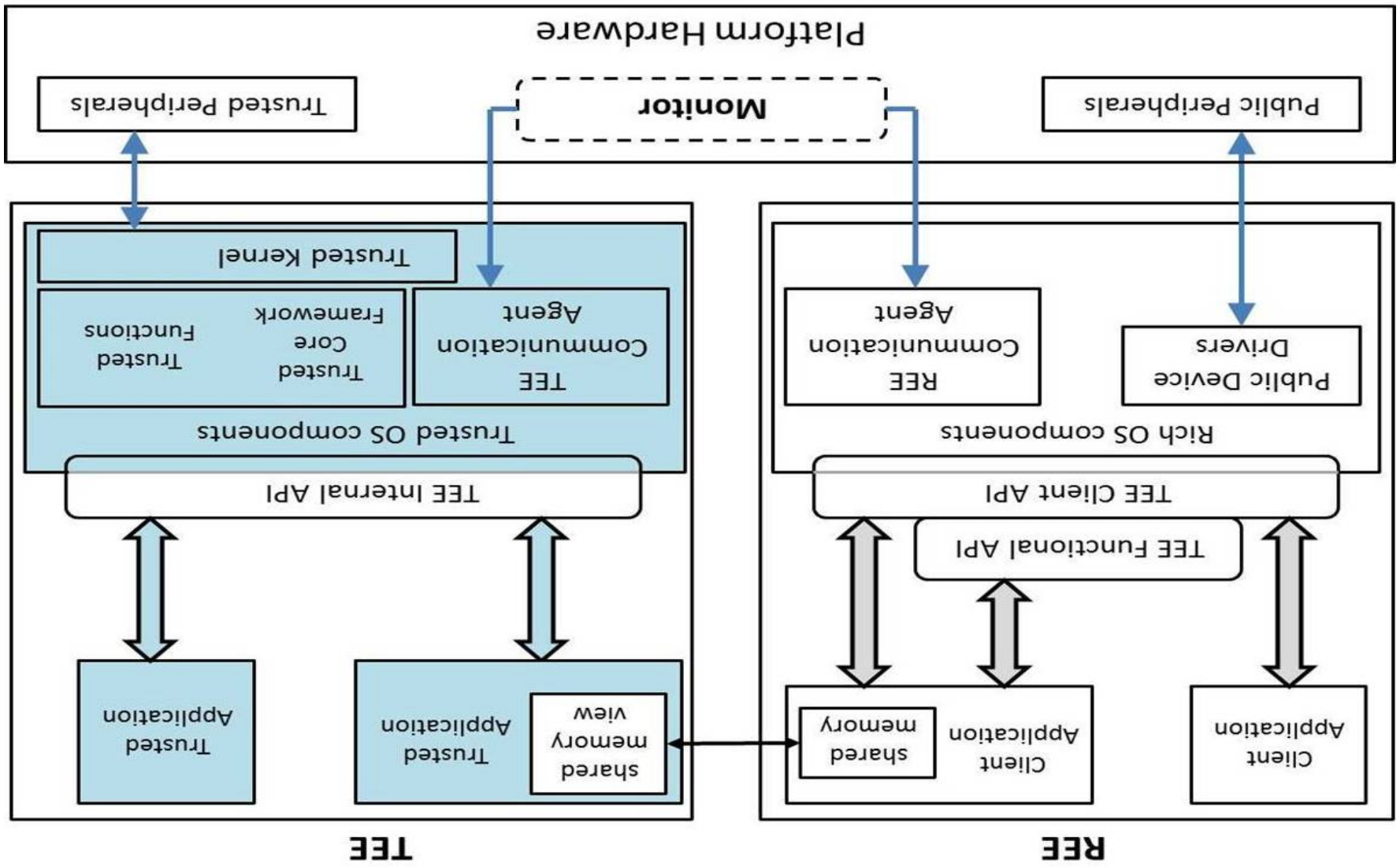
Ubiquitous TEE

- Virtual TPM [Trust 2009];
- Privacy-Preserving Mobile Payment [TrustCom 2012];
- Sensors [MobiSys 2012];
- Two Factor Authentication [NDSS 2014];
- Introspection [CCS 2014];
- Software Obfuscation [ARES 2014];
- Mobile Advertisement [MobiSys 2015];
- Autonomic Systems [ICAC 2015].

Once upon a time



From different directions



Come, listen, my men, while I tell you again
The five unmistakable marks
By which you may know, wheresoever you go,
The warranted genuine Snarks.

— Lewis Carroll, The Hunting of the Snark

Let's start at the very beginning...

Practical Need

Execute a highly-sensitive app on an off the shelf smartphone.

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- special hardware processor: AEGIS and CHERI;
- micro-kernel: SeL4;
- separation kernel: TLR.

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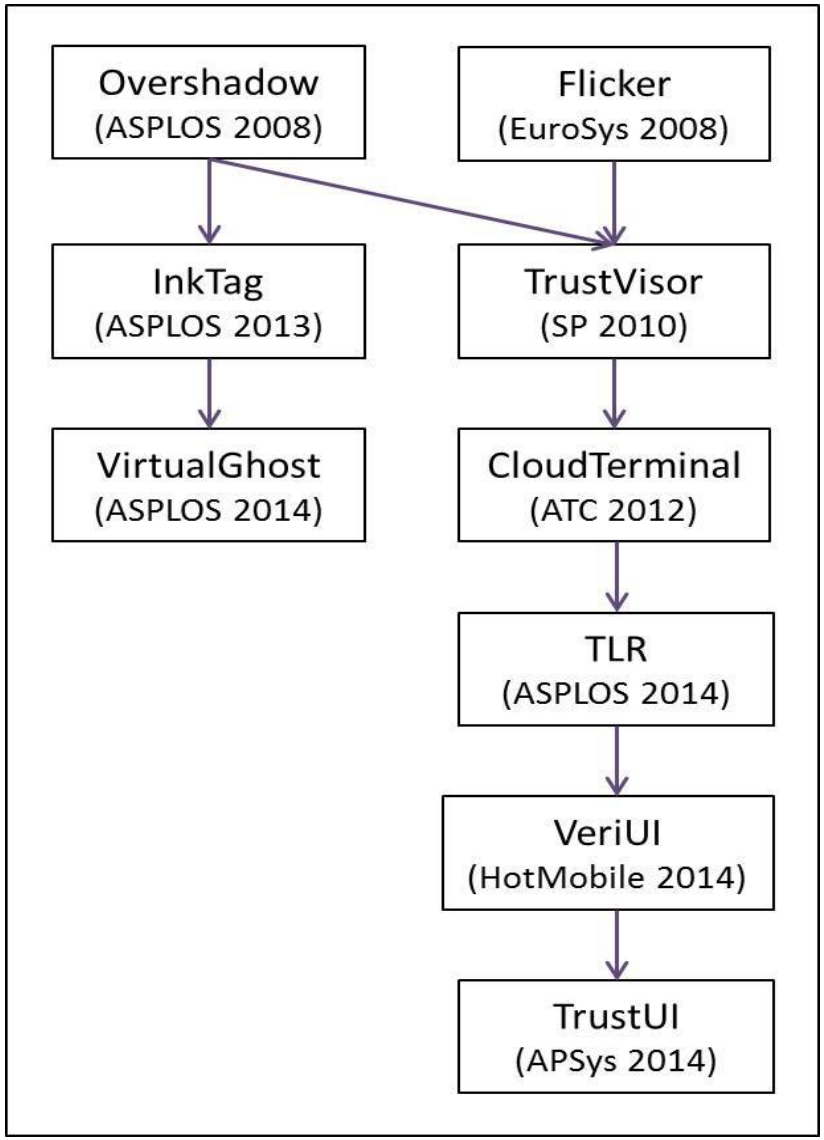
State of the art



Definitions

Separation Kernel

Security kernel that enables the coexistence of different systems requiring different levels of security on the same platform.

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Secure Execution Environment

Processing environment that guarantees the following properties:

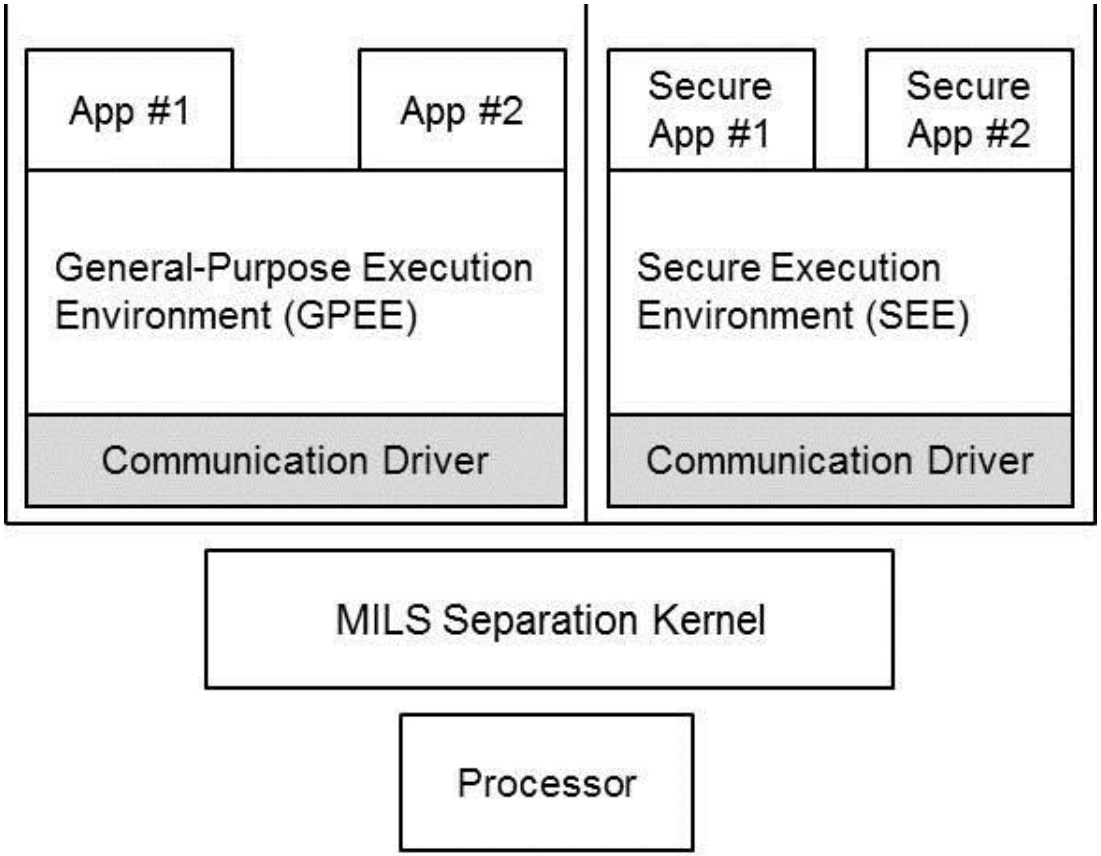
- *authenticity*: the code under execution should not have been changed;
- *integrity*: runtime states should not have been tampered with;
- *confidentiality*: code, data and runtime states should not have been observable by unauthorized applications.

The Dual-Execution-Environment Approach

Definition

The Dual-Execution-Environment is a security architecture where both a Separation Kernel and a Secure Execution Environment play the role of Security Kernel. As its name indicated, only two processing environments run above the defined separation kernel.

Overview


App #1
App #2
General-Purpose Execution Environment (GPEE)
Communication Driver
Secure App #1
Secure App #2
Secure Execution Environment (SEE)
Communication Driver
MILS Separation Kernel
Processor

Isolation

1. **Data separation**: Data within one partition cannot be read or modified by other partitions;
2. **Sanitization**: Shared resources cannot be used to leak information into other partitions;
3. **Control of information flow**: Communication between partitions cannot occur unless explicitly permitted;
4. **Fault isolation**: Security breach in one partition cannot spread to other partitions.

Inter-EE Communication

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Attacks

- message overload attacks;
- control data corruption attacks;
- memory faults caused by shared pages being removed.

Secure Scheduling

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Attacks

- non-responsive event-driven operations;
- unbound waits caused by the non-cooperation of the untrusted part of the system.

"When I use a word," Humpty Dumpty said, in rather a scornful tone, "It means just what I choose it to mean–neither more nor less."

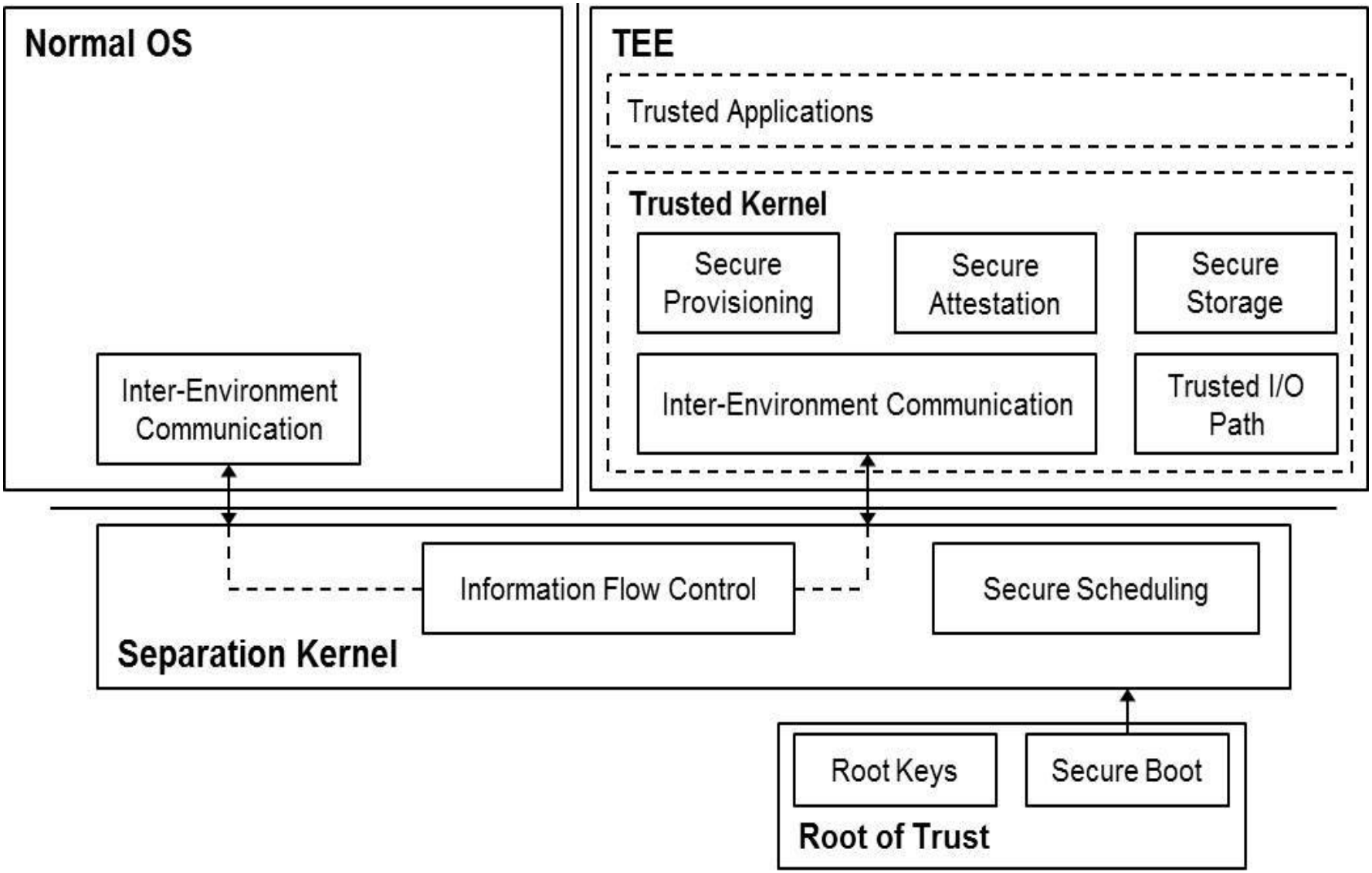
— Lewis Carroll, Through the Looking-Glass

The War of Terminologies

The Existential Question

Does the **TEE** exist before the existence of the *TEE* ?

Building Blocks



Attacks

Adversary model

a powerful attacker who is able to execute an arbitrary code in the kernel privileges.

Attack Classes

- bypassing security features;
- executing arbitrary code in the secure zone;
- overwriting part of the secure region of the memory with certain values;
- Denial-of-service attacks are not included.

Small Survey

TEE	License	Normal World	Hardware Platform
ObC	Close	Symbian OS	300 MHz OMAP 2420
<t-base	Close	Android	Samsung Exynos platforms
Andix OS	Open	Linux	iMX53 QSB
TLK	Open	Android	Tegra SoCs
TLR	Close	.NET CLR	Tegra 250 Dev Kit
SafeG	Open	TOPPERS/ASP	PB 1176 JZF-S board

Summary

- TEE is a promising security technology;
- Formal model can be defined with the Dual-EE approach;
- TEE could be shown as a security architecture, rather than just a technology in order to have enough theoretical basis to answer basic issues related to TEE.

Building Blocks

Thank you for your attention!