Attestation and Confidential Dump for IBM® Secure Execution on Linux

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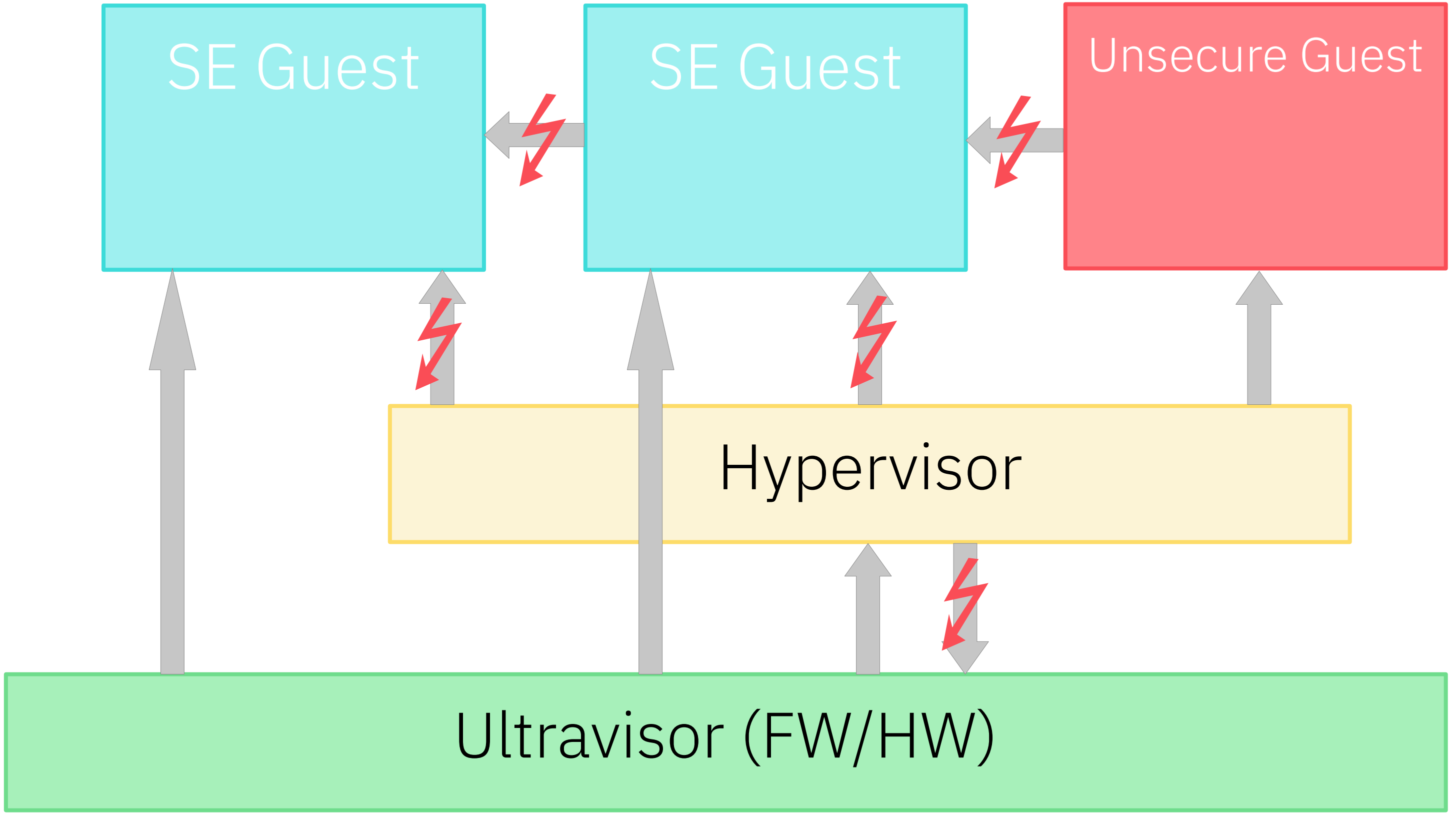


IBM® Secure Execution

Guest owner prepares a SE boot image including:

– Guest owner public ECDH key. This key is used for establishing a shared secret between UV and guest owner:

$$ECDH(pub_{owner}, priv_{UV}) = secret_{shared} = ECDH(priv_{owner}, pub_{UV})$$

→ **Only Ultravisor (UV)** can decrypt and **execute** the SE image

– Guest owner secrets in SE header:

- Customer Communication Key (CCK)
- Keys for components decryption

Kernel, cmdline and initrd are always encrypted, authenticated and integrity protected

→ **Allows** the **storage of secrets** in these components

Attestation

Implicit Attestation

IBM Secure Execution does not require external attestation to prove that a guest is secure.

If the image contains a unique secret, a successful login implicitly *attests* a SE guest image.

The problem. Is there one?

Why nevertheless?

Explicit attestation on IBM z16™ is useful when

- Proving to a 3rd party without passing image secrets
- Verify that the guest is a specific image instance
- Needing trusted information about
  - SE guest image instance
  - Execution environment

Use cases

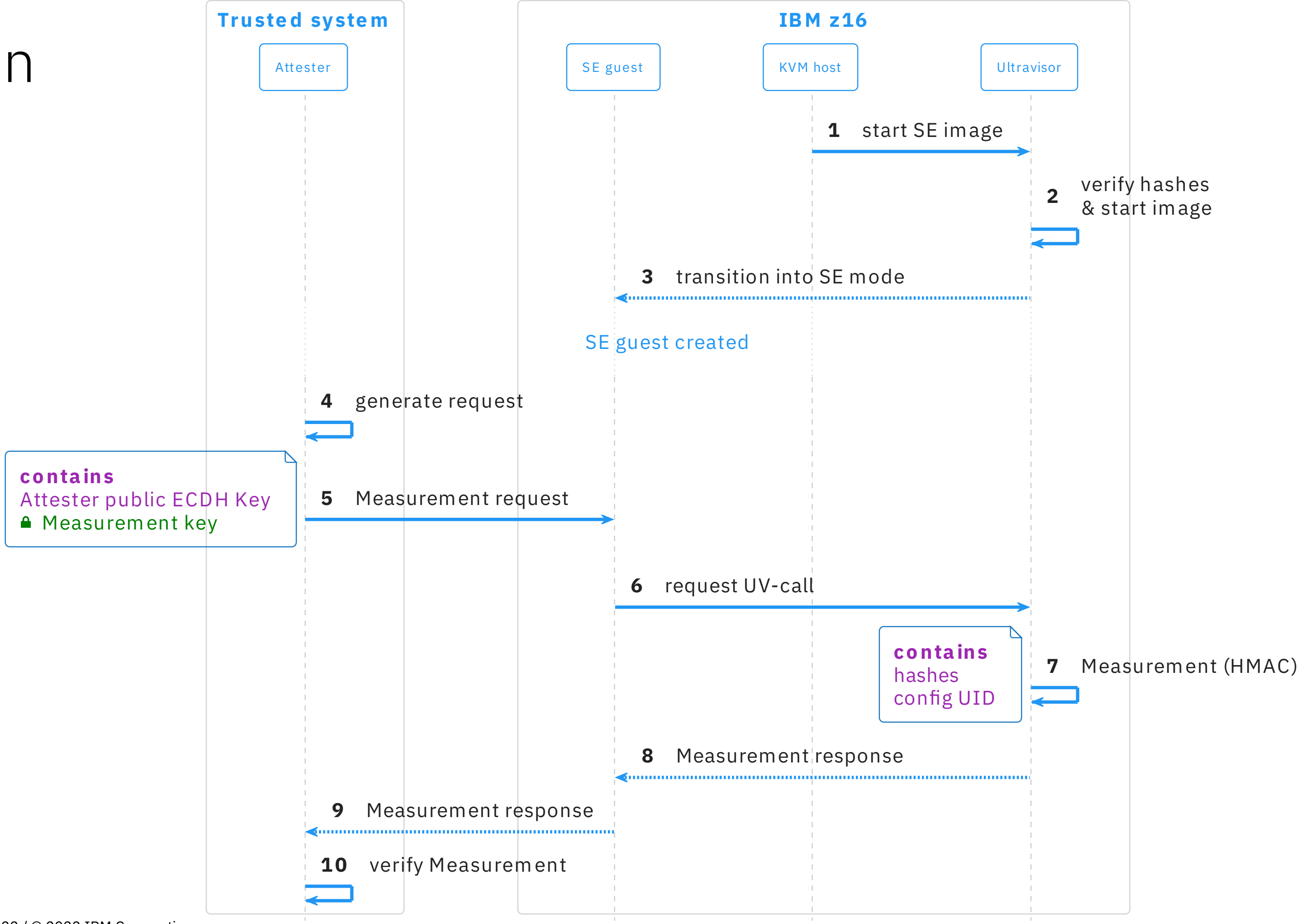
Become compliant

- Attestation request by 3rd party

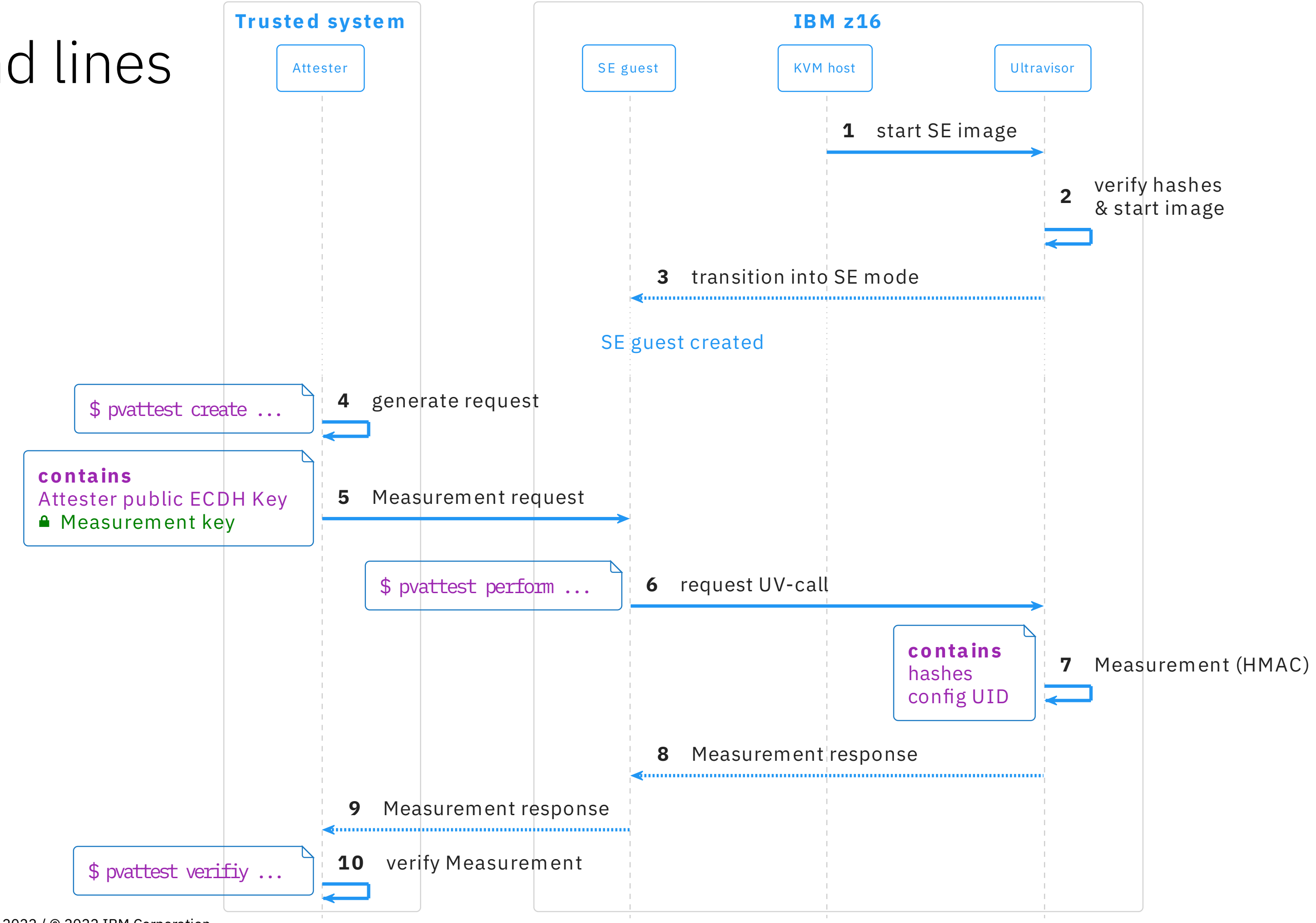
Customize an already prepared generic SE image

1. Attest image
2. Deploy own instance-dependent secrets

Attestation



Command lines



Trusted system

Attester

IBM z16

SE guest

KVM host

Ultravisor

1 start SE image

2 verify hashes & start image

3 transition into SE mode

SE guest created

`$ pvattest create ...`

4 generate request

contains
Attester public ECDH Key
🔒 Measurement key

5 Measurement request

`$ pvattest perform ...`

6 request UV-call

contains
hashes
config UID

7 Measurement (HMAC)

8 Measurement response

9 Measurement response

`$ pvattest verifiy ...`

10 verify Measurement

Current state

Hardware:

IBM z16

Kernel:

v5.19

QEMU, libvirt and genprotimg (s390-tools):

No changes – just works

pvattest (s390-tools):

v2.22.0

Confidential Dump

Guest vs. hypervisor initiated guest dumping

Guest initiated

Pro

- No hypervisor interaction required
- Guest knows its data best

Contra

- Not always possible, e.g. bug in memory management, early boot problem, ...
- Dumping modifies guest state
- Needs extra memory for dumper
- Must be set-up (e.g. kdump)

Hypervisor initiated

Pro

- Reliability
- Doesn’t modify guest state
- Guest initiated dumping is not always available

Contra

- Hypervisor interaction required
- Transport of dump
- Hypervisor needs access to guest state

→ Under SE, hypervisor does not have access to guest state, so how can you do hypervisor initiated dumps?

Problem: We don’t trust the hypervisor

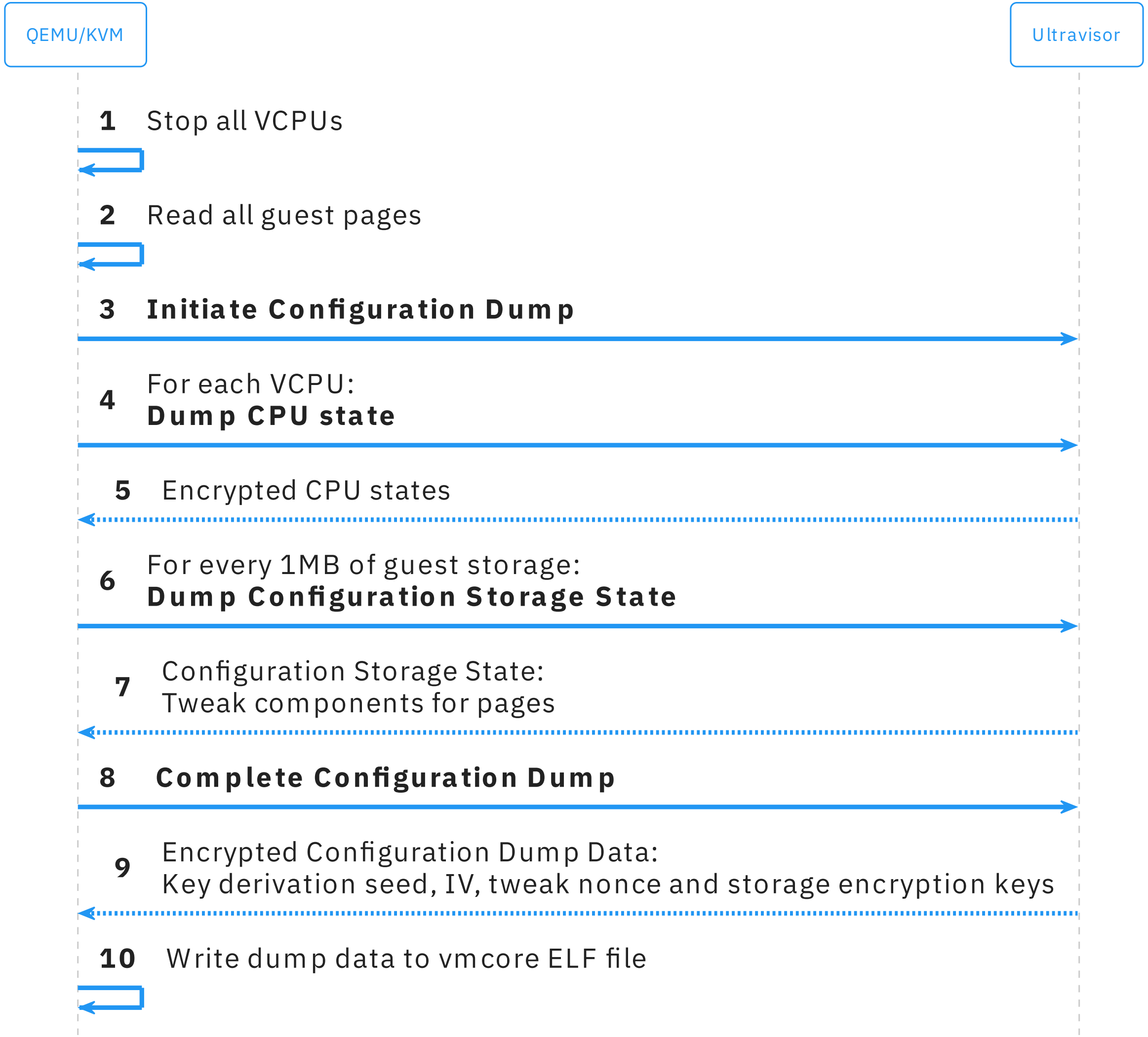
⇒ New Hardware/Firmware support

- Opt-in to enable confidential dump support via SE-header flag
- New Ultravisor calls (uses CCK for dump data protection and encryption)

1. Initiate Configuration Dump
2. Dump CPU state
3. Dump Configuration Storage[1] State
4. Complete Configuration Dump

[1] For s390x *storage* means *memory*

Dumping: QEMU/KVM perspective



1 Stop all VCPUs

2 Read all guest pages

3 **Initiate Configuration Dump**

4 For each VCPU:
Dump CPU state

5 Encrypted CPU states

6 For every 1MB of guest storage:
Dump Configuration Storage State

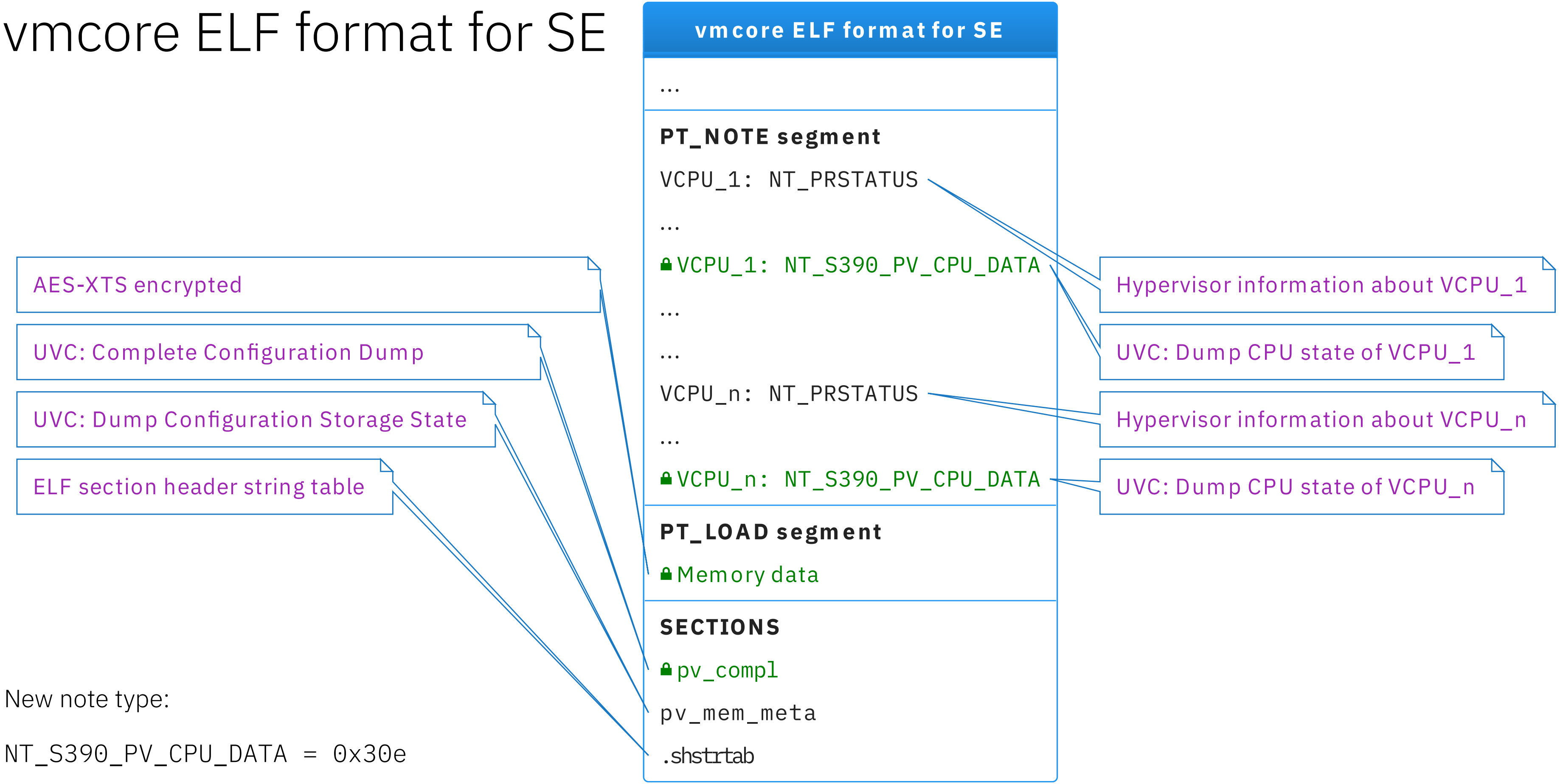
7 Configuration Storage State:
Tweak components for pages

8 **Complete Configuration Dump**

9 Encrypted Configuration Dump Data:
Key derivation seed, IV, tweak nonce and storage encryption keys

10 Write dump data to vmcore ELF file

vmcore ELF format for SE



vmcore ELF format for SE

...

PT_NOTE segment

VCPU_1: NT_PRSTATUS

...

🔒VCPU_1: NT_S390_PV_CPU_DATA

...

...

VCPU_n: NT_PRSTATUS

...

🔒VCPU_n: NT_S390_PV_CPU_DATA

PT_LOAD segment

🔒Memory data

SECTIONS

🔒pv_compl

pv_mem_meta

.shstrtab

AES-XTS encrypted

UVC: Complete Configuration Dump

UVC: Dump Configuration Storage State

ELF section header string table

Hypervisor information about VCPU_1

UVC: Dump CPU state of VCPU_1

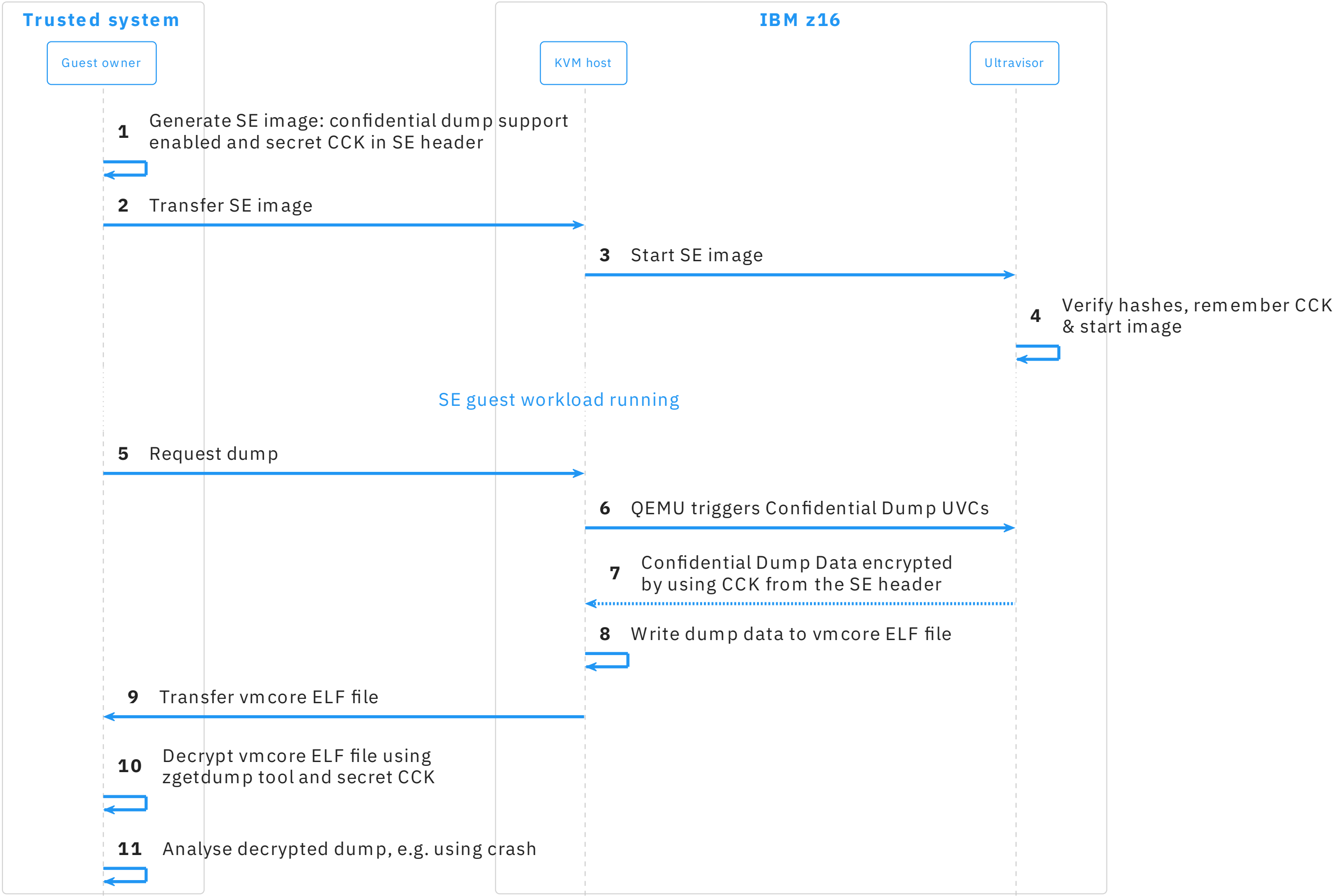
Hypervisor information about VCPU_n

UVC: Dump CPU state of VCPU_n

New note type:

`NT_S390_PV_CPU_DATA = 0x30e`

Life Cycle



Trusted system

Guest owner

IBM z16

KVM host

Ultravisor

1 Generate SE image: confidential dump support enabled and secret CCK in SE header

2 Transfer SE image

3 Start SE image

4 Verify hashes, remember CCK & start image

SE guest workload running

5 Request dump

6 QEMU triggers Confidential Dump UVCs

7 Confidential Dump Data encrypted by using CCK from the SE header

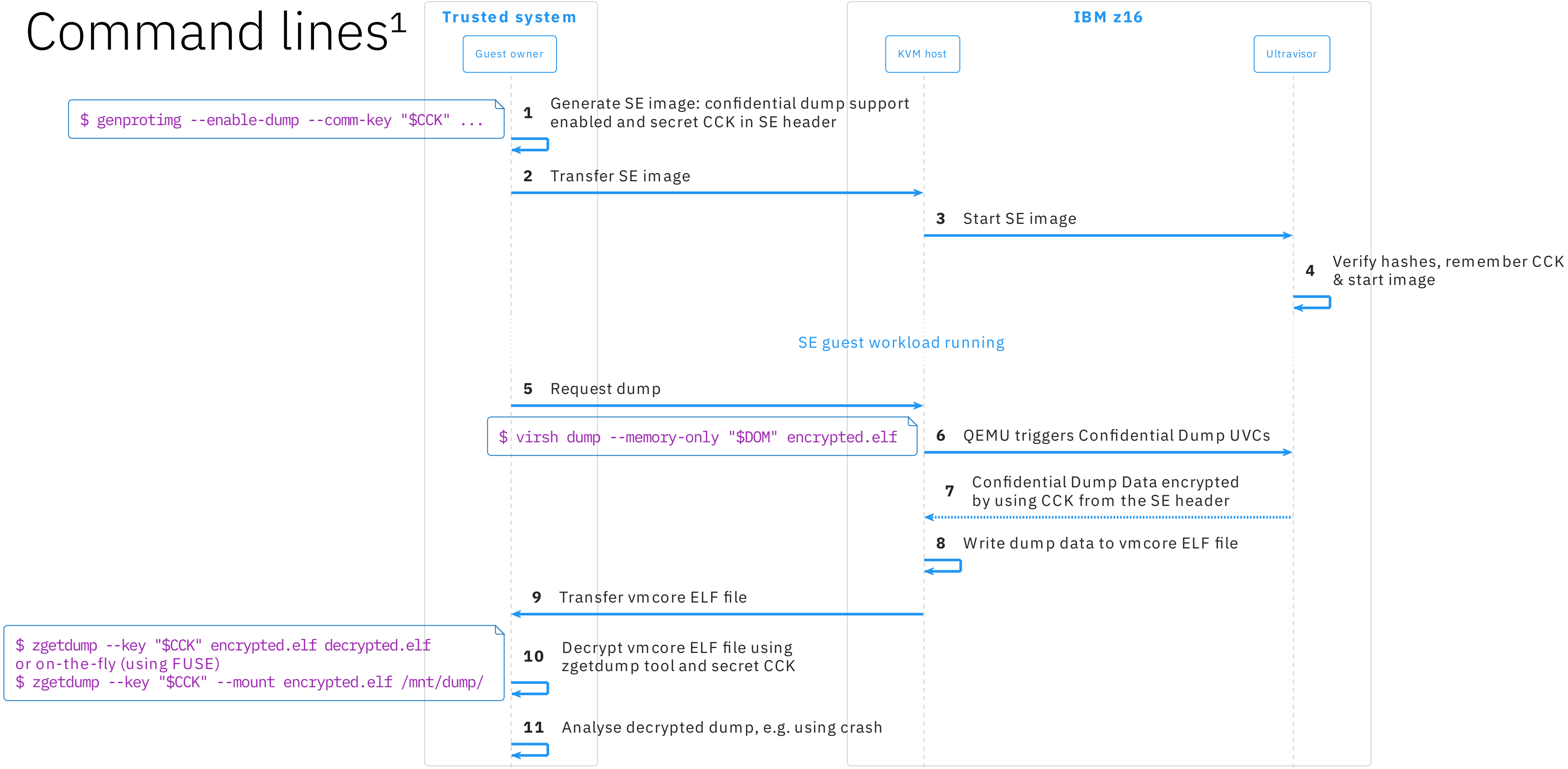
8 Write dump data to vmcore ELF file

9 Transfer vmcore ELF file

10 Decrypt vmcore ELF file using zgetdump tool and secret CCK

11 Analyse decrypted dump, e.g. using crash

Command lines[1]



Trusted system

Guest owner

IBM z16

KVM host

Ultravisor

```
$ genprotimg --enable-dump --comm-key "$CCK" ...
```

1 Generate SE image: confidential dump support enabled and secret CCK in SE header

2 Transfer SE image

3 Start SE image

4 Verify hashes, remember CCK & start image

SE guest workload running

5 Request dump

```
$ virsh dump --memory-only "$DOM" encrypted.elf
```

6 QEMU triggers Confidential Dump UVCs

7 Confidential Dump Data encrypted by using CCK from the SE header

8 Write dump data to vmcore ELF file

9 Transfer vmcore ELF file

```
$ zgetdump --key "$CCK" encrypted.elf decrypted.elf
or on-the-fly (using FUSE)
$ zgetdump --key "$CCK" --mount encrypted.elf /mnt/dump/
```

10 Decrypt vmcore ELF file using zgetdump tool and secret CCK

11 Analyse decrypted dump, e.g. using crash

[1] QEMU and zgetdump under review, can therefore change

Current state

Hardware:

IBM z16

Kernel:

v6.0-rc1

QEMU:

Under review[1]

Libvirt:

No changes – just works

genprotimg (s390-tools):

v2.21.0

zgetdump (s390-tools):

WIP

[1] https://lists.gnu.org/archive/html/qemu-devel/2022-08/msg01772.html

Summary

Attestation

Verify integrity of SE image instance

- Implicit Attestation on IBM Secure Execution
- Explicit Attestation after transition into SE mode
  - Identify specific image instance
  - Attest without revealing secrets

Confidential Dump

- Opt-in required by setting a SE-header flag
- Reliable and secure way for hypervisor initiated dumping
  - Actual guest state is encrypted
- No *QEMU Monitor Protocol* API changes[1]
  - → No changes in libvirt
- `zgetdump` tool will handle decryption
  - On-the-fly decryption using FUSE possible
  - Decrypted dump can be analysed, e.g. using `crash`

[1] Still under review, can therefore change

Thank you!

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