DEBUG support for Confidential Guest

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DEBUG support for Confidential Guests

- Encrypted guest has it's memory and/or register context encrypted by Vendor specific technology (AMD SEV / Intel TDX).

- Encrypted guest memory breaks down QEMU's built-in debugging features because it cannot do direct guest memory access (memcpy() from HVA).

- Introduce a basic framework and common x86 implementation to handle encrypted guest memory reading/writing to support QEMU's built-in debugging features like monitor xp command and gdbstub.

DEBUG support for Confidential Guests

- QEMU debug support for Confidential VM/guests
- Debug requires access to guests pages which are encrypted for example when SEV is enabled
- SEV APIs

➢ DBG_ DECRYPT

➢ DBG_ENCRYPT

for decryption/encryption of guest pages if guest policy allows for debugging

Extension of MemTxAttrs

- Extend the MemTx Attrs to include a “debug” flag to indicate that the operation is triggered by a debugger

```
typedef struct MemTxAttrs {
...
...
/* Memory access requested from the debugger */
+ unsigned int debug : 1;
} MemTxAttrs;
```

Memory Debug Ops

- Introduce new “MemoryDebugOps” which hook into guest virtual & physical memory debug interfaces such as cpu_memory_rw_debug() to allow vendor specific assist/hooks for debug access to guest memory.

```
typedef struct MemoryDebugOps {

hwaddr (*translate) (CPUState *.., target_ulong addr, MemTxAttrs *attrs);

MemTxResult (*read) (AddressSpace *as, hwaddr phys_addr, MemTxAttrs attrs, void *buf, hwaddr len);

MemTxResult (*write) (AddressSpace *as, hwaddr phys_addr, MemTxAttrs attrs, const void *buf,  hwaddr len);

uint64_t (*pte_mask) (void);

}
MemoryDebugOps;
```

- These ops would be used by cpu_memory_rw_debug() and would default to:

```
static const MemoryDebugOps default_debug_ops= {

        .translate = cpu_get_phys_attrs_debug,
        .read = address_space_read,
        .write = address_space_write_rom,
        .pte_mask = address_space_pte_mask,

};

static const MemoryDebugOps *debug_ops= &default_debug_ops;

cpu_memory_rw_debug (. . * cpu, . . addr) {
...

+/* Set debug attrs to indicate memory access is from debugger */

+ attrs.debug=1;

  If (is_write) {

-  res = address_space_write_rom (..., phys_addr, attrs,..)

+ res = debug_ops↣write (...phys_addr, attrs, ...);

 } else {
- res = address_space_read (..,phys_addr, attrs,..);

+ res = debug _ops↣ read (.., phys_addr, attrs, ...);
```

Additionally, introduce new MemoryRegion debug ops.

Extend ‘struct MemoryRegion’ to include new callbacks that can be used to override use of memcpy() with something appropriate for SEV/ confidential memory guests.

```
/* MemoryRegion RAM debug callbacks*/

typedef struct MemoryRegionRAMReadWriteOps MemoryRegionRAMReadWriteOps;

struct MemoryRegionRAMReadWriteOps {
/* write data into guest memory*/

int (*write) (uint8_t *dest, ..src, ..len, ..attrs);

/* read data from guest memory */

int (*read) (..dest, ..src, ..len, ..attrs);

};

/** MemoryRegion ...

...

struct MemoryRegion {
...

+  const MemoryRegionRAMReadWriteOps* ram_debug_ops;
```

Debug API flow for SEV guests

cpu_memory_rw_debug()

debug_ops->read (..)

sev_address_space_read_debug(..)

/* invoke address_space_rw_debug helpers */

address_space_read_debug (as, addr, attrs, ptr, len),

...

mr = address_space_translate (..);

...

//RAM case

ram_ptr = ... ;

if (attrs.debug && mr-> ram_debug_ops)

    mr->ram_debug_ops->read (but,ram_ptr, l, attrs):

else

    memcpy (buf, ram_ptr, I):

continued.....

sev_mem_read (..)

sev_dbg_enc_dec (..)


```
sev_ioctl (sev_fd,
        write ? KVM_SEV_DBG_ENCRYPT : KVM_SEV_DBG_DECRYPT),
        & dbg, ...);
```

Add debug versions of physical memory read & write APIs
-cpu_physical_memory_read_debug
-cpu_physical_memory_write_debug
-cpu_physical_memory_rw_debug
-ldl_phys_debug
-ldq_phys_debug

-these internally invoke MemoryDebugOps

- use above debug APIs when accessing guest memory.

for example:

```
tlb_info_32(..)
{
        for (l1=0; l1<1024; l1++) {
-               cpu_physical_memory_read (pgd+l1*4, &pde, 4);
+               cpu_physical_memory_read_debug (pgd+l1*4, &pde, 4);
.
.
```

Guest Page Table Walk

In SEV-enabled guest, the pte entry will have c-bit set, need to clear the c-bit when walking the page table, to ensure that proper page address translation occurs & with c-bit reset, the true physical address is retrieved.

```
tlb_info_pae32(..)

{
+ uint64_t me_mask;

+ me_mask = cpu_physical_memory_pte_mask_debug();

/* debug_ops ↣ pte_mask(); */

...

pdp_addr=...

+ pdp_addr &= me_mask;

for  (I1=0', I1<4; I1++) {
        cpu_physical_memory_rw_debug (pdp_addr + I1*8, &pdpe, 8);

-       pdpe = le64_to_cpu (pdpe);

+       pdpe = le64_to_cpu(pdpe & me_mask);

/*similarly for pde & pte's */
```

Currently (*translate) in MemoryDebugOps is not used….

```
sev_cpu_get_phys_attrs_debug(..)
{
.
}
```

this is invoked by directly overriding cpu class page table walker :

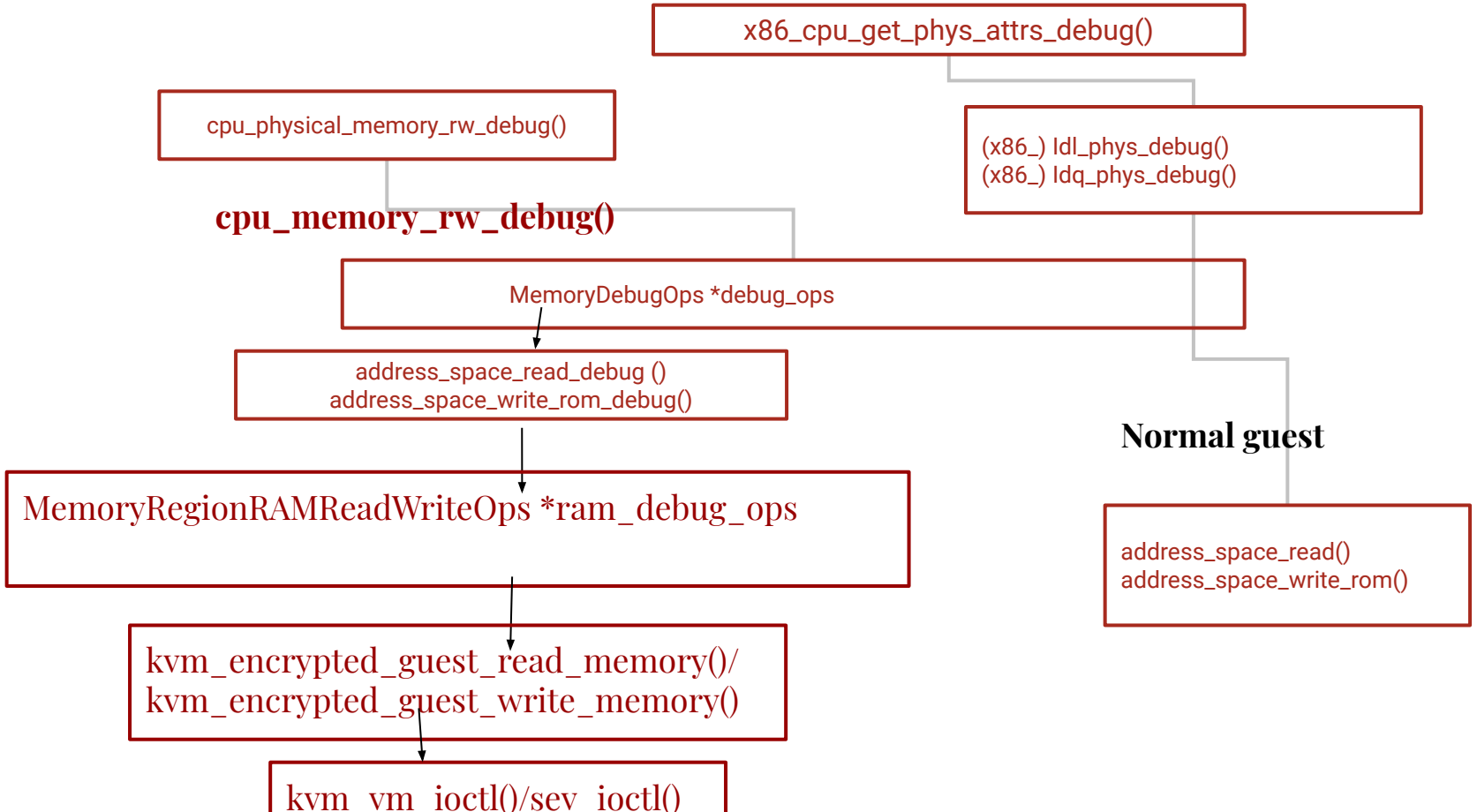
```
sev_set_debug_ops_cpu_state (..*handle, CPUState *cs)
{
CPUClass *cc;

/*If policy does not allow debug then no need to register ops*/
If (s↠ policy & SEV_POLICY_NODBG) {
        return;
}
cc = CPU_GET_CLASS(cs);

/* override guest mmu lookup/page table walker with SEV specific callback to handle encrypted memory*/
cc↠ get _phys_page_attrs_debug = sev_cpu_get_phys_attrs_debug();

address_space_set_debug_ops (& sev_debug_ops);
```

Summary: Relationship diagram of the APIs & Interface



Limitations:

- Encrypted Register State Access and Debugging

  Device Access / Debugging (device emulation issues)

  Guest awareness ?

  Virtual INT1/INT3 injection ?

  VC# handler and GHCB extensions ?