Machine-type Introspection and Configuration

Where Are We Going?

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KVM Forum 2016

Agenda

Concepts

Current Needs

Possible Solutions

Previous Work

Some overlap with KVM Forum 2015 talks:

- *Rethinking machine types* – David Gibson
- *QEMU interface introspection: from hacks to solutions* – Markus Armbruster

Slightly different problems are addressed here.

Concepts

Machine Types

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- Goals:
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  - Backwards compatibility (command-line, migration, guest ABI)

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- Goals:
  - Emulation of different machines by the same QEMU binary
  - Backwards compatibility (command-line, migration, guest ABI)
- Encapsulates:
  - Construction of basic/default devices
  - Migration stream format options
  - Other default options

2005: QEMUMachine

```
struct QEMUMachine {
    const char *name;
    const char *desc;
    QEMUMachineInitFunc *init;
    struct QEMUMachine *next;
};
```

2005: 5 machines

2016: MachineClass

```
struct MachineClass {
    ObjectClass parent_class;
    const char *family;
    const char *name;
    const char *alias;
    const char *desc;
    BlockInterfaceType block_default_type;
    int units_per_default_bus;
    int max_cpus;
    unsigned int no_serial:1, no_parallel:1, use_virtcon:1, use_sclp:1, no_floppy:1,
        no_cdrom:1, no_sdcard:1, has_dynamic_sysbus:1, pci_allow_0_address:1, legacy_fw_cfg_order:1;
    int is_default;
    const char *default_machine_opts;
    const char *default_boot_order;
    const char *default_display;
    GArray *compat_props;
    const char *hw_version;
    ram_addr_t default_ram_size;
    bool option_rom_has_mr;
    bool rom_file_has_mr;
    void (*init)(MachineState *state);
    void (*reset)(void);
    void (*hot_add_cpu)(const int64_t id, Error **errp);
    int (*kvm_type)(const char *arg);
    HotplugHandler *(*get_hotplug_handler)(MachineState *machine, DeviceState *dev);
    unsigned (*cpu_index_to_socket_id)(unsigned cpu_index);
    CPUArchIdList *(*possible_cpu_arch_ids)(MachineState *machine);
    HotpluggableCPUList *(*query_hotpluggable_cpus)(MachineState *machine);
};
```

2016: **120+** machines

Where differences are encoded

Most machine type differences are encoded at:

- `MachineClass::init()` function
  (e.g. `ppc_spapr_init()`, `pc_q35_init()`, `pc_init1()`, ...)
- `MachineClass` fields
  (e.g. `max_cpus`, `default_machine_opts`, `compat_props`, ...)

Current Needs

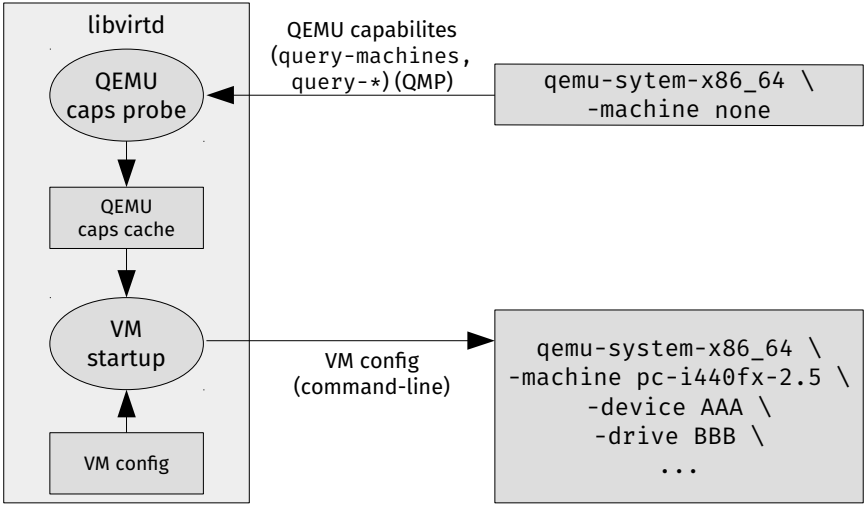
Current Needs: libvirt

```
[libvirt]$ git grep '\<STR.*machine' src/qemu
src/qemu/qemu_capabilities.c:            STREQ(def->os.machine, "ppce500"))
src/qemu/qemu_capabilities.c:            STREQ(def->os.machine, "prep"))
src/qemu/qemu_capabilities.c:            STREQ(def->os.machine, "bamboo"))
src/qemu/qemu_capabilities.c:        if (STREQ(def->os.machine, "mpc8544ds"))
src/qemu/qemu_capabilities.c:        if (STREQ(machines[i]->name, "none"))
src/qemu/qemu_capabilities.c:        STREQ(def->os.machine, "isapc");
src/qemu/qemu_capabilities.c:        (STRNEQ(machine, "pseries") && !STRPREFIX(machine, "pseries-")))
src/qemu/qemu_capabilities.c:        (STRNEQ(machine, "pseries") && !STRPREFIX(machine, "pseries-")))
src/qemu/qemu_capabilities.c:    if (STRNEQ(domCaps->machine, "virt") &&
src/qemu/qemu_capabilities.c:        !STRPREFIX(domCaps->machine, "virt-"))
src/qemu/qemu_command.c:    if (STRPREFIX(def->os.machine, "s390-virtio") &&
src/qemu/qemu_domain.c:        if (STREQ(def->os.machine, "isapc")) {
src/qemu/qemu_domain.c:        if (STREQ(def->os.machine, "versatilepb"))
src/qemu/qemu_domain.c:    return (STRPREFIX(def->os.machine, "pc-q35") ||
src/qemu/qemu_domain.c:            STREQ(def->os.machine, "q35"));
src/qemu/qemu_domain.c:    return (STREQ(def->os.machine, "pc") ||
src/qemu/qemu_domain.c:            STRPREFIX(def->os.machine, "pc-0.") ||
src/qemu/qemu_domain.c:            STRPREFIX(def->os.machine, "pc-1.") ||
src/qemu/qemu_domain.c:            STRPREFIX(def->os.machine, "pc-i440") ||
src/qemu/qemu_domain.c:            STRPREFIX(def->os.machine, "rhel"));
src/qemu/qemu_domain.c:    char *p = STRSKIP(def->os.machine, "pc-q35-");
src/qemu/qemu_domain.c:    return STRPREFIX(def->os.machine, "s390-ccw");
src/qemu/qemu_domain.c:    if (STRNEQ(def->os.machine, "virt") &&
src/qemu/qemu_domain.c:        !STRPREFIX(def->os.machine, "virt-"))
src/qemu/qemu_domain.c:    if (STRNEQ(def->os.machine, "pseries") &&
src/qemu/qemu_domain.c:        !STRPREFIX(def->os.machine, "pseries-"))
src/qemu/qemu_domain.c:        STREQ(def->os.machine, "malta") ||
src/qemu/qemu_domain.c:        STREQ(def->os.machine, "sun4u") ||
src/qemu/qemu_domain.c:        STREQ(def->os.machine, "g3beige");
src/qemu/qemu_domain_address.c:    if (!(STRPREFIX(def->os.machine, "vexpress-") ||
src/qemu/qemu_domain_address.c:    if (STREQ(def->os.machine, "versatilepb"))
```

Current Needs: libvirt

```
bool qemuDomainMachineIsQ35();
bool qemuDomainMachineIsI440FX();
bool qemuDomainMachineNeedsFDC();
bool qemuDomainMachineIsS390CCW();
bool qemuDomainMachineIsVirt();
bool qemuDomainMachineIsPSeries();
bool qemuDomainMachineHasBuiltinIDE();
const char *qemuDomainDefaultNetModel();
bool virQEMUCapsHasPCIMultiBus();
bool virQEMUCapsSupportsVmport();
bool qemuDomainSupportsPCI();
```

Current Situation



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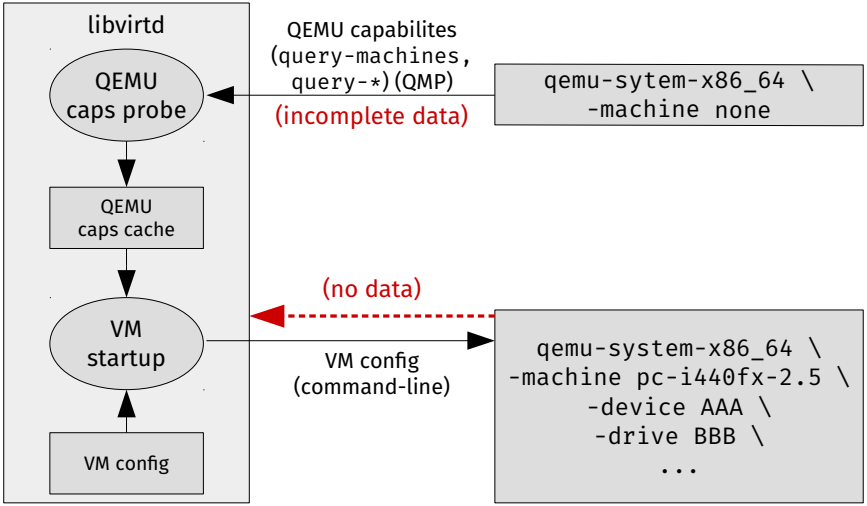

query-machines QMP command

```
{ 'command': 'query-machines', 'returns': ['MachineInfo'] }

{ 'struct': 'MachineInfo',
  'data': { 'name': 'str', '*alias': 'str',
            '*is-default': 'bool', 'cpu-max': 'int',
            'hotpluggable-cpus': 'bool'} }
```

Extending `query-machines`

Extending `query-machines` is easy:

1. Move data to `MachineClass`
2. Add new fields to `MachineInfo`

Types of Queries

Some information depend on:

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2. Machine type + machine options (including accelerator)
   - Can't be queried today
3. Machine type + other QEMU options
   - Can't be queried today

Example 1: CPU slots

How to convert:

```
$ qemu-system-x86_64 -smp 4 -cpu Haswell \
  -numa node,cpus=0-1 -numa nodes,cpus=2-3
```

to:

```
$ qemu-system-x86_64 \
  -numa node -numa node \
  -device Haswell-x86_64-cpu,socket=0,node=0 \
  -device Haswell-x86_64-cpu,socket=1,node=0 \
  -device Haswell-x86_64-cpu,socket=2,node=1 \
  -device Haswell-x86_64-cpu,socket=3,node=1
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  -device Haswell-x86_64-cpu,socket=2,node=1 \
  -device Haswell-x86_64-cpu,socket=3,node=1
```

- Set of available CPU slots is arch-dependent, machine-dependent
- See `query-hotpluggable-cpus`

Example 2: Address Assignment

- Device address assignment depend on:
  - The default devices for the machine type
  - Additional devices configured for the VM
- Current solution: `libvirt/src/qemu/qemu_domain_address.c`
  - A large collection of special cases (1.2k LOC)
  - Duplicates QEMU logic

Example 2: Address Assignment

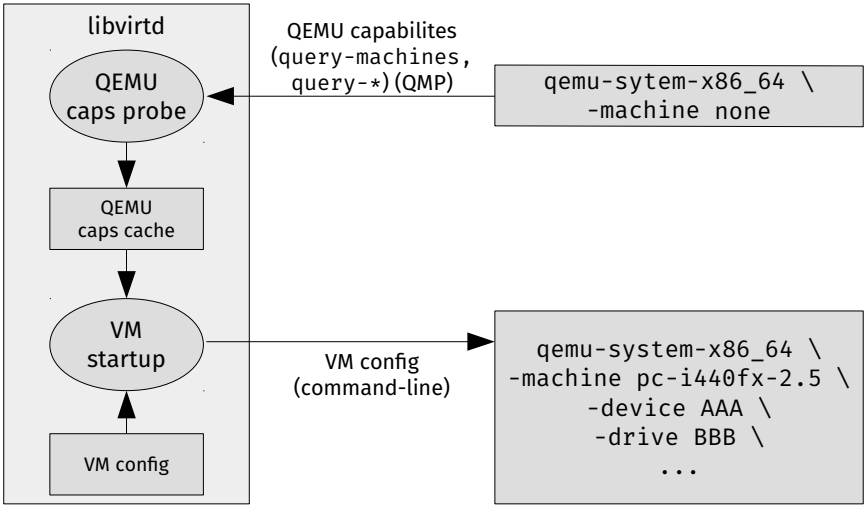
```
static int
qemuDomainValidateDevicePCISlotsChipsets(virDomainDefPtr def,
                                         virQEMUCapsPtr qemuCaps,
                                         virDomainPCIAddressSetPtr addrs)
{
    if (qemuDomainMachineIsI440FX(def) &&
        qemuDomainValidateDevicePCISlotsPIIX3(def, qemuCaps, addrs) < 0) {
        return -1;
    }

    if (qemuDomainMachineIsQ35(def) &&
        qemuDomainValidateDevicePCISlotsQ35(def, qemuCaps, addrs) < 0) {
        return -1;
    }

    return 0;
}
```

Example 2: Address Assignment

```
for (i = 0; i < def->nserials; i++) {
    if (def->serials[i]->deviceType == VIR_DOMAIN_CHR_DEVICE_TYPE_SERIAL &&
        qemuDomainMachineIsPSeries(def))
        def->serials[i]->info.type = VIR_DOMAIN_DEVICE_ADDRESS_TYPE_SPAPRVIO;
    if (qemuDomainAssignSpaprVIOAddress(def, &def->serials[i]->info,
                                        VIO_ADDR_SERIAL) < 0)
        goto cleanup;
}
```

Possible Solutions

Solution 1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QEMU
caps probe
QEMU
caps cache
VM
startup
VM config
QEMU capabilites
(query-machines,
query-*) (QMP)
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-machine none
VM config
(command-line)
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-machine pc-i440fx-2.5 \
-device AAA \
-drive BBB \
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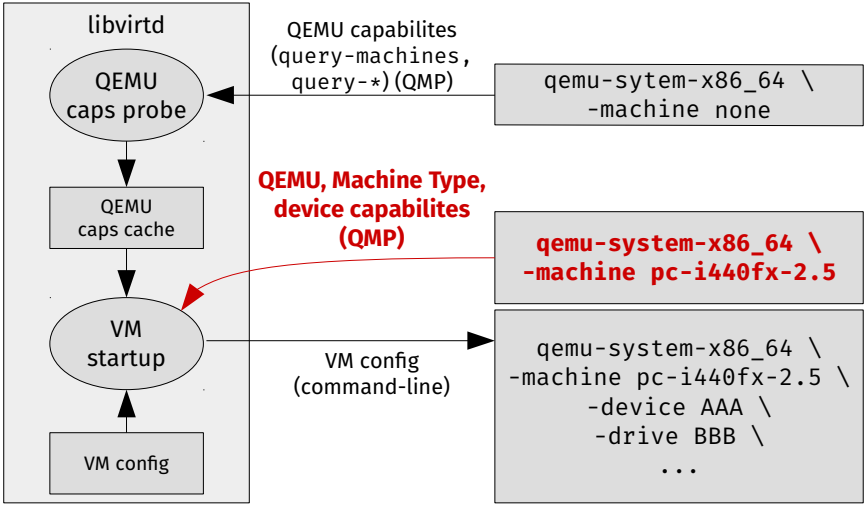
Solution 1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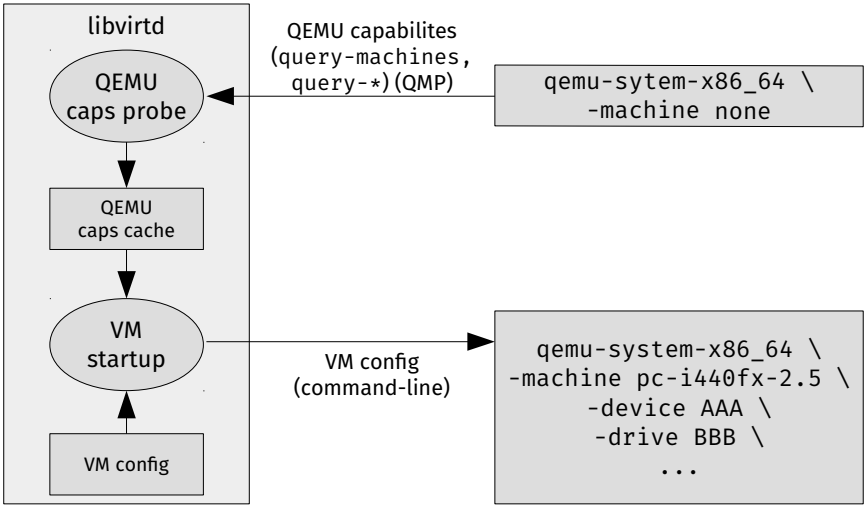
Solution 2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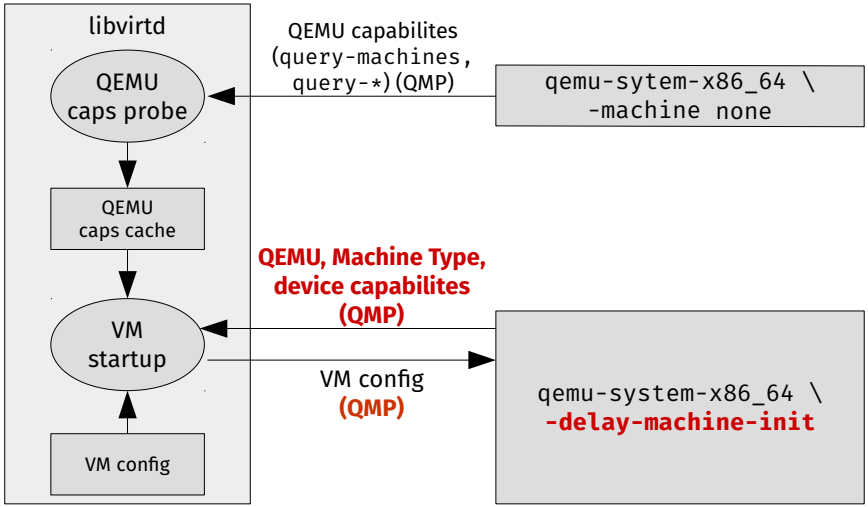
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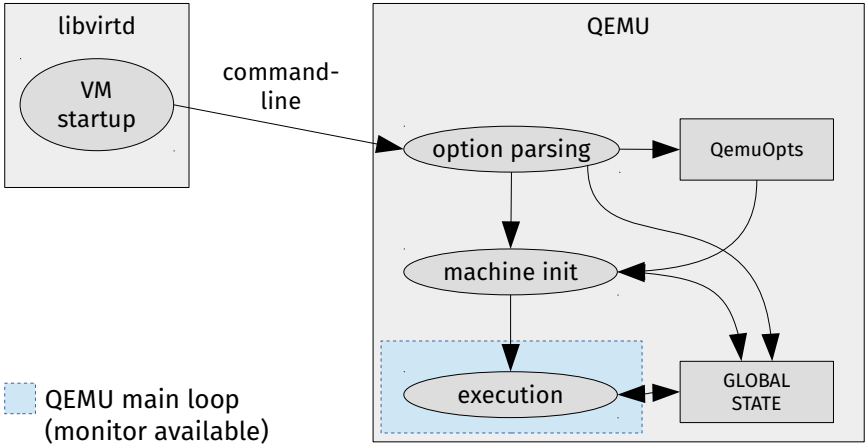
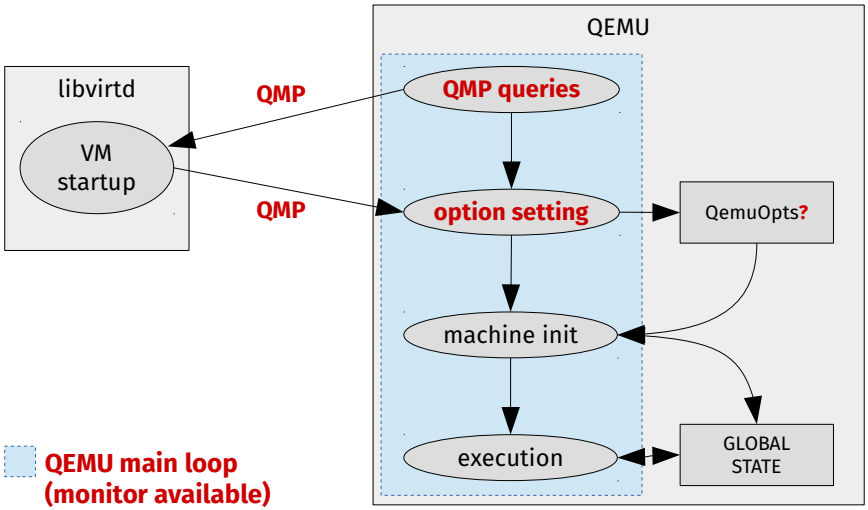
QEMU, Machine Type, device capabilites (QMP)
VM config (QMP)
qemu-system-x86_64 \ -delay-machine-init

Solution 2: VM configuration



Solution 2: VM configuration



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2. Extend `query-machines` where appropriate (easy)
3. Design/implement new QMP queries (hard)
4. `-delay-machine-init`:
   - Make QMP monitor available before machine init (doable?)
   - QMP commands to replace QEMU command-line options (doable?)

Open Questions

- Configuration commands: `QemuOpts`, QOM-based, QAPI-based?
- How to encode more complex rules. e.g.:
  - Address allocation
  - Machine+bus+device types compatibility (PCI, PCIe)
- Is there a limit on the complexity of `query-machines`?

Future Work

- Simplify libvirt QEMU capability probing (on-demand probing?)
- Machine-friendly error reporting from machine init
- Split/refactor machine initialization and execution steps further
- Machine types as data: exporting/loading complete machine types definitions (far future?)

The End

Thanks for listening.

Questions?

Answer the KVM Forum poll: **http://goo.gl/SCCpky**

Some History

How machine types evolved:

- 2005: `struct QEMUMachine` — 5 machines
- 2009: `QEMUMachine::compat_props` (*pc-0.10* is born)
- 2012: `query-machines` QMP command
- 2012: “none” machine type introduced
- 2013: `pc_init_pci_X_Y()`
- 2013: `cpu-max` field on `query-machines`
- 2014: *pseries-2.1* is born
- 2014: `TYPE_MACHINE` QOM class.
- 2015: `QEMUMachine` replaced by QOM `TYPE_MACHINE` subclasses (`MachineClass`) — 120+ machines
- 2015: Portions of `QEMUMachine::init` code moved to `MachineClass` fields
- 2016: `query-machines` return CPU hotplug information

Config Options

2009: `-readconfig` and `-writeconfig` options introduced.

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From the commit message:

> *In theory you should be able to do:*
>
> ```
> qemu <machine config cmd line switches here> -writeconfig vm.c
> qemu -readconfig vm.cfg
> ```
>
> ***In practice it will not work**. Not all command line switches are converted to* `QemuOpts`*, so you'll have to keep the not-yet converted ones on the second line. Also there might be bugs lurking which prevent even the converted ones from working correctly.*

Initialization: Execution of QEMU binary

Done by management software (libvirt).

Input:

- VM configuration
- Capabilities of each QEMU binary

Output:

- QEMU binary path
- Command-line options and/or config file

Initialization: Option Parsing

Input:

- Command-line options
- Config file(s) (`-readconfig`)

Output:

- Static and global variables
- Local variables in `main()`
- `QemuOpts` sections

Initialization: Machine Type Lookup

Input:

- `QemuOpts`' `"machine"` section

Output:

- Local variable: `MachineClass *machine_class`

Initialization: Machine Initialization

`MachineClass::init()` function runs.

Input:

- Global variables
- Local variables
- `QemuOpts` sections

Output:

- Global and static variables
- QOM global properties
- `MachineState` fields
- Device tree
- `QemuOpts`?
- More?