Experiments in Enabling Automated Migration Testing

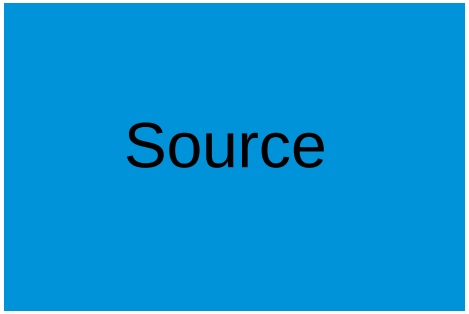
Amit Shah
Red Hat
22 Oct 2013

Thanks

- Juan
- Markus
- Orit

Migration

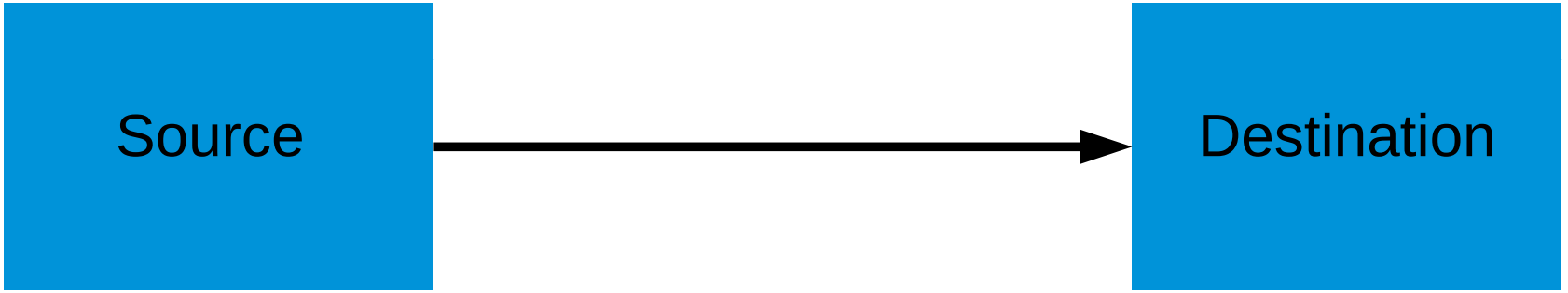
Migration




```
$ qemu <cmdline>
```

```
$ qemu <cmdline>
  -incoming <...>
```

Migration

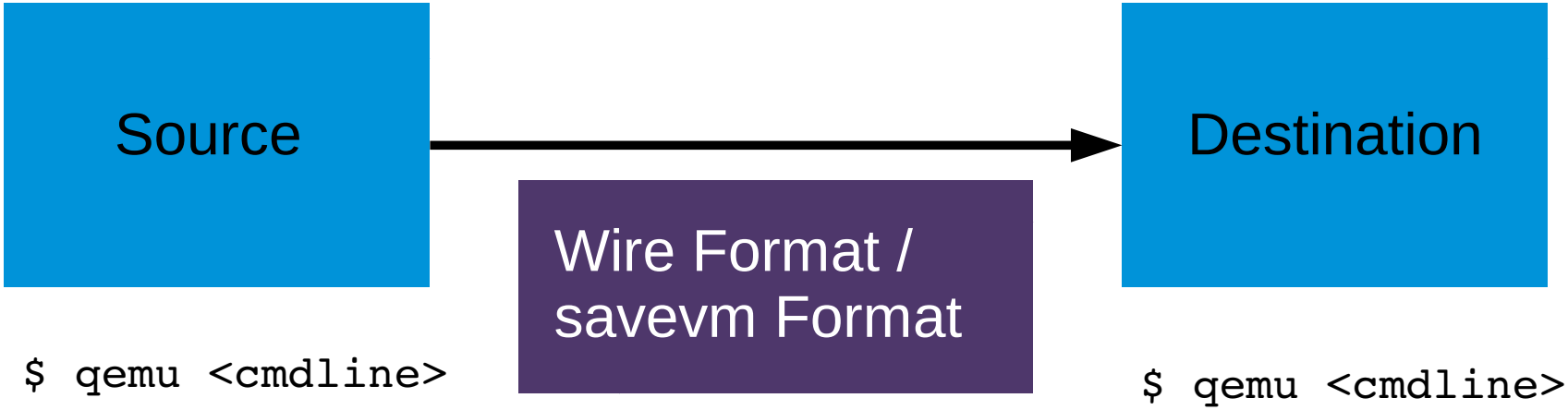



```
$ qemu <cmdline>
```

```
(qemu) migrate <...>
```

```
$ qemu <cmdline>
  -incoming <...>
```

Migration




```
$ qemu <cmdline>
```

```
(qemu) migrate <...>
```

```
$ qemu <cmdline>
  -incoming <...>
```

The Problem

- Very easy to break migration between different QEMU versions
- By the time breakage is found, it can be too late to fix
  - e.g. released versions have bugs
- Migration may erroneously succeed
- When migration fails, it can't tell much about the reason
- Impact of such breakages can be huge
- Currently, no way to prove migration compatibility

Can We Identify Problems Earlier?

Ways to Check Migration Breakage

- Dynamic
- Static

Ways to Check Migration Breakage: Dynamic

Dynamic Checking

- Needs a live state
- Only acts on devices present in the VM at the time of migration
- Subsections present based on device state

savevm file sanity checks

savevm format is...

savevm Format is a Blackbox

- savevm format is ugly – Juan Quintela
- Doesn't contain machine type information
- Doesn't contain array or list sizes
- Array sizes change based on configuration
- “01”: binary data or a new section?
  - No size information -> prone to lose sync
- savevm file by itself is indecipherable

savevm Format Checks: Solutions?

- Can send vmstate info before the actual vmstate so some analysis possible
- Fixing entirely essentially means '`qemu -incoming <...>`' is sufficient to accept migration
- Need to fix QEMU and the world before we can bring this to reality

Ways to Check Migration Breakage: Static

Static Checking

- Does not need a live state
- All compiled-in devices can be checked
- Bugs can be identified before committing patches
- Exact cause of potential failure can be pinpointed

Migration Metadata Checks

Migration Metadata

```
static const VMStateDescription vmstate_acpi = {
    .name = "piix4_pm",
    .version_id = 3,
    .minimum_version_id = 3,
    .minimum_version_id_old = 1,
    .load_state_old = acpi_load_old,
    .post_load = vmstate_acpi_post_load,
    .fields      = (VMStateField []) {
        VMSTATE_PCI_DEVICE(parent_obj, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.evt.sts, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.evt.en, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.cnt.cnt, PIIX4PMState),
        VMSTATE_STRUCT(apm, PIIX4PMState, 0, vmstate_apm, APMState),
        VMSTATE_TIMER(ar.tmr.timer, PIIX4PMState),
        VMSTATE_INT64(ar.tmr.overflow_time, PIIX4PMState),
        VMSTATE_STRUCT(ar.gpe, PIIX4PMState, 2, vmstate_gpe,ACPIGPE),
        VMSTATE_STRUCT(pci0_status, PIIX4PMState, 2,
                       vmstate_pci_status, struct pci_status),
        VMSTATE_END_OF_LIST()
    }
};
```

Migration Metadata: Subsections

```
.subsections =(VMStateSubsection[]) {
    {
        .vmsd = &usbredir_bulk_receiving_vmstate,
        .needed = usbredir_bulk_receiving_needed,
    },
```

- Optional sections
- Based on device state at time of migration
- 'needed' check at source to determine eligibility

Migration Metadata Checker

- Look at migration metadata
- Output metadata information for all devices
- Diff that output from one QEMU binary with another
- Tell whether migration from version x to y will break, (and how).

Sample Output

```
piix4_pm
   Name: apm
      Version id: 0
      Size: 224
      Type: Struct
   APM State
      Name: apmc
         Version id: 0
         Size: 1
         Type: Single
      Name: apms
         Version id: 0
         Size: 1
         Type: Single
```

Bugs a Static Checker Can Flag

Bugs a Static Checker Can Flag

```
static const VMStateDescription vmstate_acpi = {
    .name = "piix4_pm",
    .version_id = 3,
    .minimum_version_id = 3,
    .minimum_version_id_old = 1,
    .load_state_old = acpi_load_old,
    .post_load = vmstate_acpi_post_load,
    .fields      = (VMStateField []) {
        VMSTATE_PCI_DEVICE(parent_obj, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.evt.sts, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.evt.en, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.cnt.cnt, PIIX4PMState),
        VMSTATE_STRUCT(apm, PIIX4PMState, 0, vmstate_apm, APMState),
        VMSTATE_TIMER(ar.tmr.timer, PIIX4PMState),
        VMSTATE_INT64(ar.tmr.overflow_time, PIIX4PMState),
        VMSTATE_STRUCT(ar.gpe, PIIX4PMState, 2, vmstate_gpe, ACPIGPE),
        VMSTATE_STRUCT(pci0_status, PIIX4PMState, 2, vmstate_pci_status,
                       struct pci_status),
        VMSTATE_END_OF_LIST()
    }
};
```

Bugs a Static Checker Can Flag

```
static const VMStateDescription vmstate_acpi = {
    .name = "piix4_pm",
    .version_id = 4,
    .minimum_version_id = 3,
    .minimum_version_id_old = 1,
    .load_state_old = acpi_load_old,
    .post_load = vmstate_acpi_post_load,
    .fields      = (VMStateField []) {
        VMSTATE_PCI_DEVICE(parent_obj, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.evt.sts, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.evt.en, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.cnt.cnt, PIIX4PMState),
        VMSTATE_STRUCT(apm, PIIX4PMState, 0, vmstate_apm, APMState),
        VMSTATE_TIMER(ar.tmr.timer, PIIX4PMState),
        VMSTATE_INT64(ar.tmr.overflow_time, PIIX4PMState),
        VMSTATE_STRUCT(ar.gpe, PIIX4PMState, 2, vmstate_gpe, ACPIGPE),
        VMSTATE_STRUCT(pci0_status, PIIX4PMState, 2, vmstate_pci_status,
                       struct pci_status),
        VMSTATE_END_OF_LIST()
    }
};
```

- If version changes without any other field changes, flag it as a bug

Bugs a Static Checker Can Flag

```
static const VMStateDescription vmstate_acpi = {
    .name = "piix4_pm",
    .version_id = 3,
    .minimum_version_id = 3,
    .minimum_version_id_old = 1,
    .load_state_old = acpi_load_old,
    .post_load = vmstate_acpi_post_load,
    .fields      = (VMStateField []) {
        VMSTATE_PCI_DEVICE(parent_obj, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.evt.sts, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.evt.en, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.cnt.cnt, PIIX4PMState),
        VMSTATE_STRUCT(apm, PIIX4PMState, 0, vmstate_apm, APMState),
        VMSTATE_TIMER(ar.tmr.timer, PIIX4PMState),
        VMSTATE_INT64(ar.tmr.overflow_time, PIIX4PMState),
        VMSTATE_STRUCT(ar.gpe, PIIX4PMState, 2, vmstate_gpe, ACPIGPE),
        VMSTATE_STRUCT(pci0_status, PIIX4PMState, 2, vmstate_pci_status,
                       struct pci_status),
        VMSTATE_END_OF_LIST()
    }
};
```

Bugs a Static Checker Can Flag

```
static const VMStateDescription vmstate_acpi = {
    .name = "piix4_pm",
    .version_id = 3,
    .minimum_version_id = 3,
    .minimum_version_id_old = 1,
    .load_state_old = acpi_load_old,
    .post_load = vmstate_acpi_post_load,
    .fields      = (VMStateField []) {
        VMSTATE_PCI_DEVICE(parent_obj, PIIX4PMState),
        VMSTATE_UINT32(ar.pm1.evt.sts, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.evt.en, PIIX4PMState),
        VMSTATE_UINT16(ar.pm1.cnt.cnt, PIIX4PMState),
        VMSTATE_STRUCT(apm, PIIX4PMState, 0, vmstate_apm, APMState),
        VMSTATE_TIMER(ar.tmr.timer, PIIX4PMState),
        VMSTATE_INT64(ar.tmr.overflow_time, PIIX4PMState),
        VMSTATE_STRUCT(ar.gpe, PIIX4PMState, 2, vmstate_gpe, ACPIGPE),
        VMSTATE_STRUCT(pci0_status, PIIX4PMState, 2, vmstate_pci_status,
                       struct pci_status),
        VMSTATE_END_OF_LIST()
    }
};
```

- If some field changes without version change, flag it as a bug

Bugs a Static Checker Can Flag

- Subsections
  - If one is introduced and version is bumped, flag it

Src	Dest	Action
Present	Present	Normal subsection processing
Present	Absent	Warning: this device might break; audit all ways this device gets in this state
Absent	Present	Nothing to worry about

Substructures

Substructures

```
piix4_pm
   Name: apm
      Version id: 0
      Size: 224
      Type: Struct
   APM State
      Name: apmc
         Version id: 0
         Size: 1
         Type: Single
      Name: apms
         Version id: 0
         Size: 1
         Type: Single
```

Substructures

```
piix4_pm
   Name: apm
      Version id: 0
      Size: 224
      Type: Struct
   APM State
      Name: apmc
         Version id: 0
         Size: 1
         Type: Single
      Name: apms
         Version id: 0
         Size: 1
         Type: Single
```

Substructures

```
piix4_pm
   Name: apm
      Version id: 0
      Size: 224
      Type: Struct
APM State
      Name: apmc
         Version id: 0
         Size: 1
         Type: Single
      Name: apms
         Version id: 0
         Size: 1
         Type: Single
```

Substructures

```
piix4_pm
    Name: apm
        Version id: 0
        Size: 224
        Type: Struct
    APM State
        Name: apmc
            Version id: 0
            Size: 1
            Type: Single
        Name: apms
            Version id: 0
            Size: 1
            Type: Single
```

```
const VMStateDescription vmstate_apm =
{
    .name = "APM State",
    .version_id = 1,
    .minimum_version_id = 1,
    .minimum_version_id_old = 1,
    .fields = (VMStateField[]) {
        VMSTATE_UINT8(apmc, APMState),
        VMSTATE_UINT8(apms, APMState),
        VMSTATE_END_OF_LIST()
    }
};
```

Substructures: Problems

- Version field in a substructure is ignored
- Currently need to add a new subsection for each new field
- Prone to be broken easily

```
const VMStateDescription vmstate_apm =
{
    .name = "APM State",
    .version_id = 1,
    .minimum_version_id = 1,
    .minimum_version_id_old = 1,
    .fields = (VMStateField[]) {
        VMSTATE_UINT8(apmc, APMState),
        VMSTATE_UINT8(apms, APMState),
        VMSTATE_END_OF_LIST()
    }
};
```

Next Steps

To Do

- Not everything is converted to vmstate yet
- Fix substructures
- We need something like
  - `qemu -M pc-1.6 –dump-vmstate`
  - (and / or)
  - QMP command to dump vmstate
- Place vmstate metadata for released versions and corresponding machine types somewhere in tests/, run checks before committing / before releasing

To Do

- Longer term
  - Make vmstate definitions an IDL
    - Helps in keeping vmstate info in one place
    - Helps reviewing
    - Newer state fields added / removed are immediately identified

Thank You