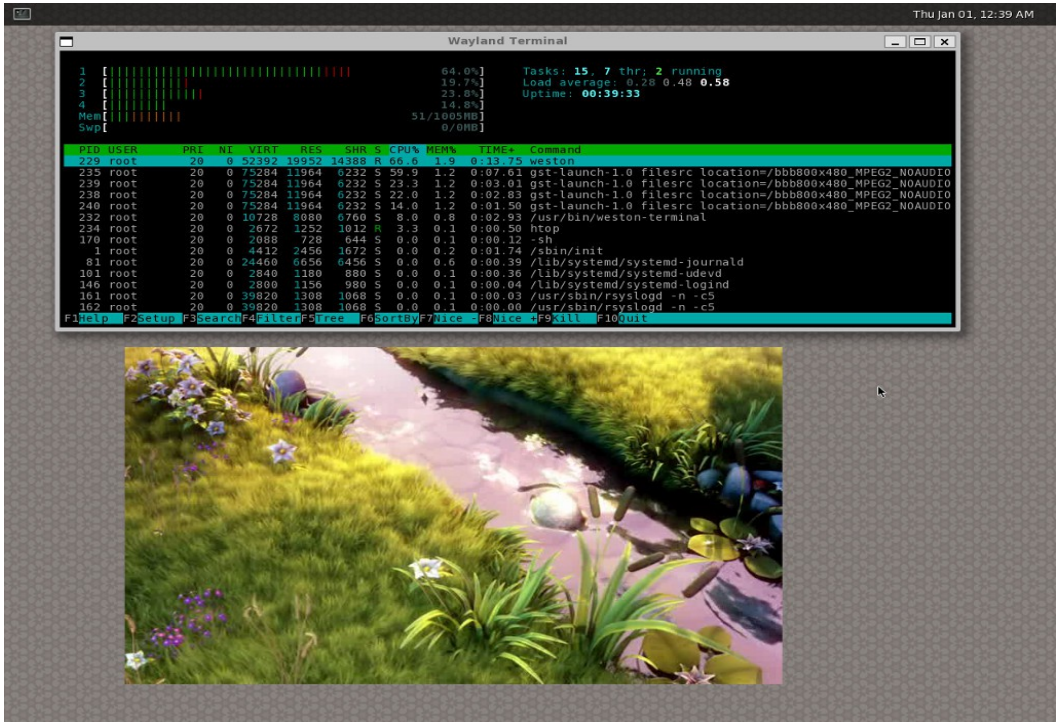
Next-Generation DMABUF

How To Efficiently Play Back Video on Embedded Systems



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Lucas Stach <l.stach@pengutronix.de>
Philipp Zabel <p.zabel@pengutronix.de>

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Agenda

- Simple videoplayback using Gstreamer
- Adding hardwareunits in the mix
- DMA-BUF – why and how
- Current DMA-BUF flaws
  → our solution


gstreamer


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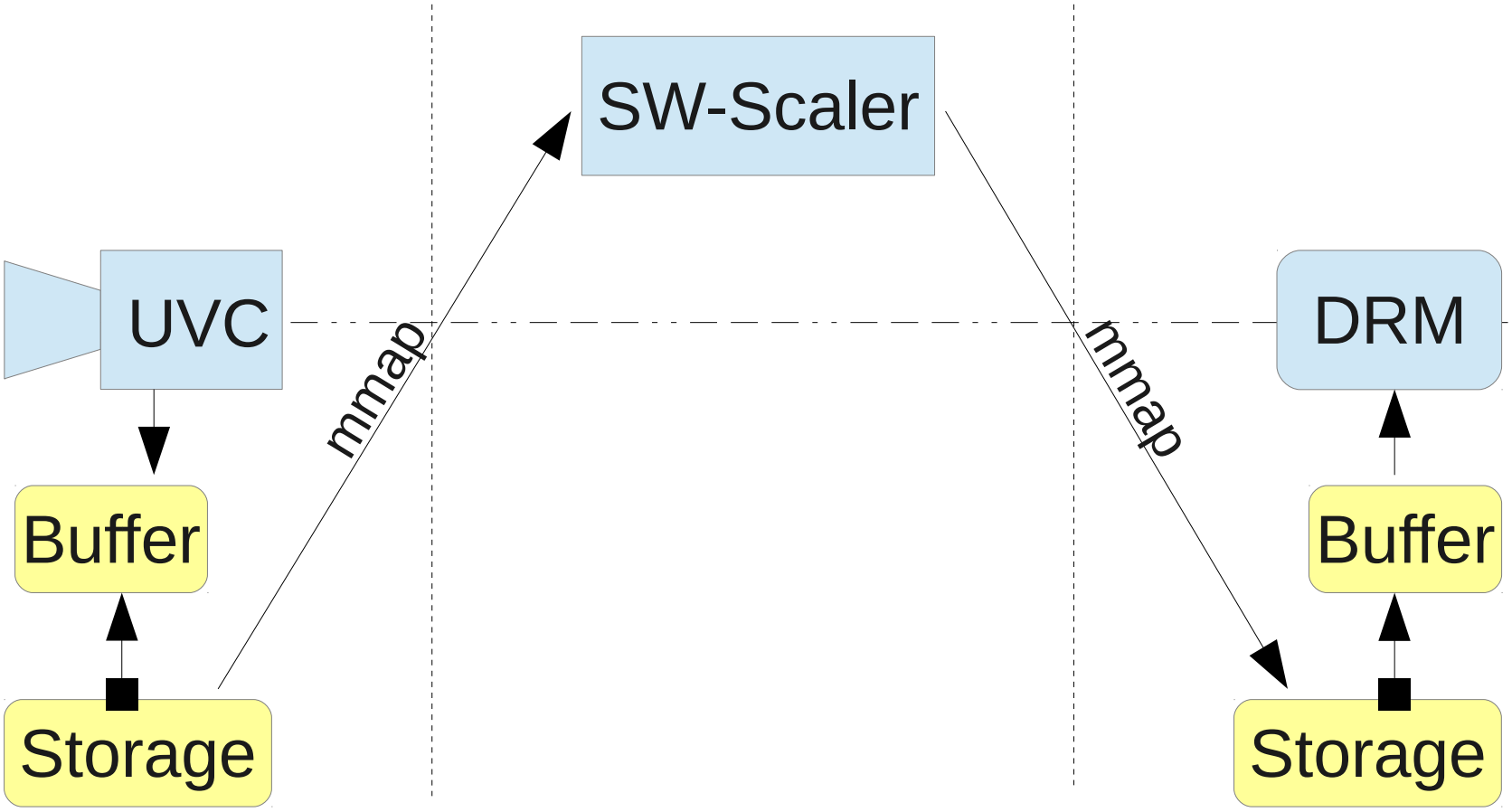
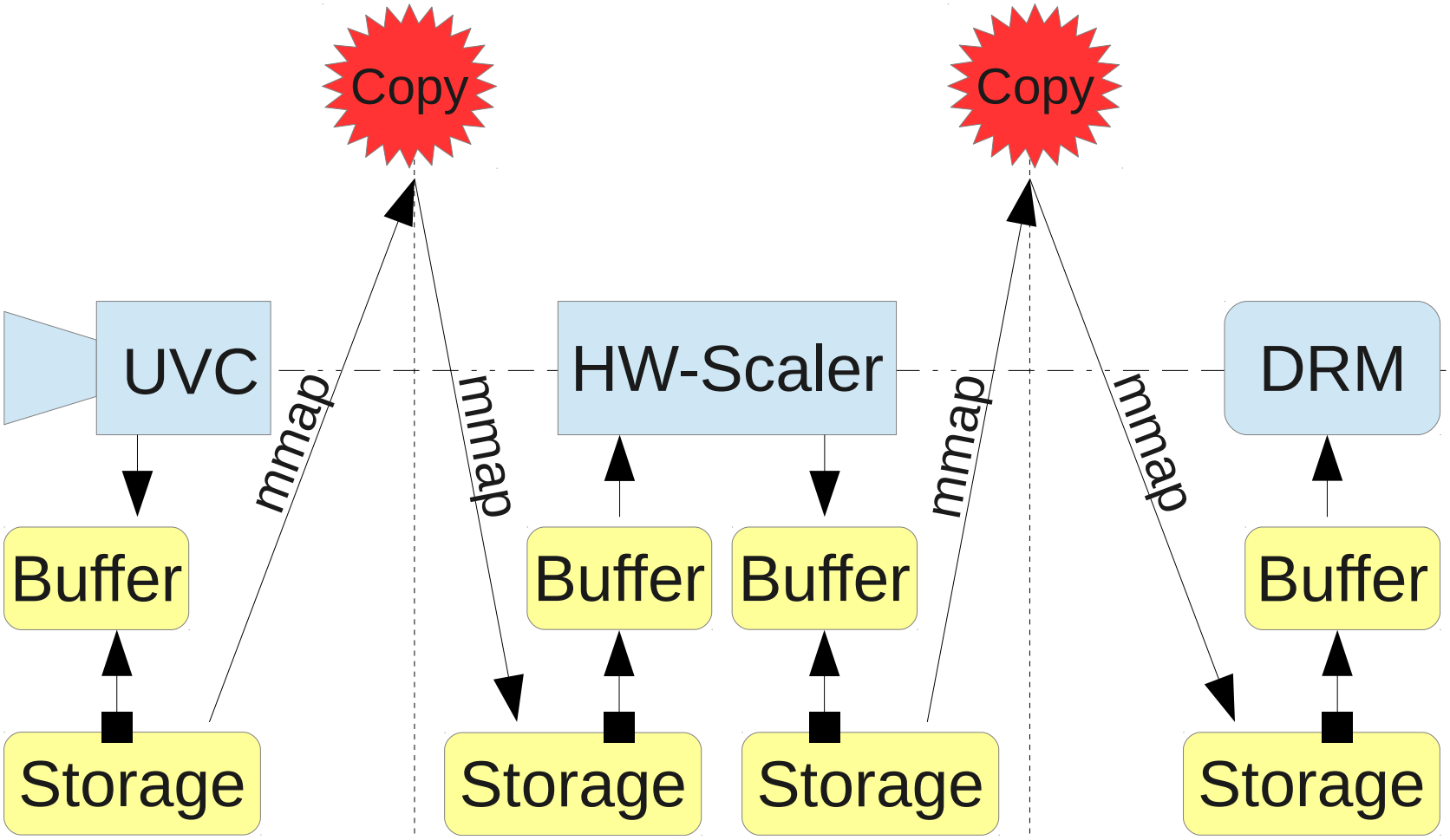
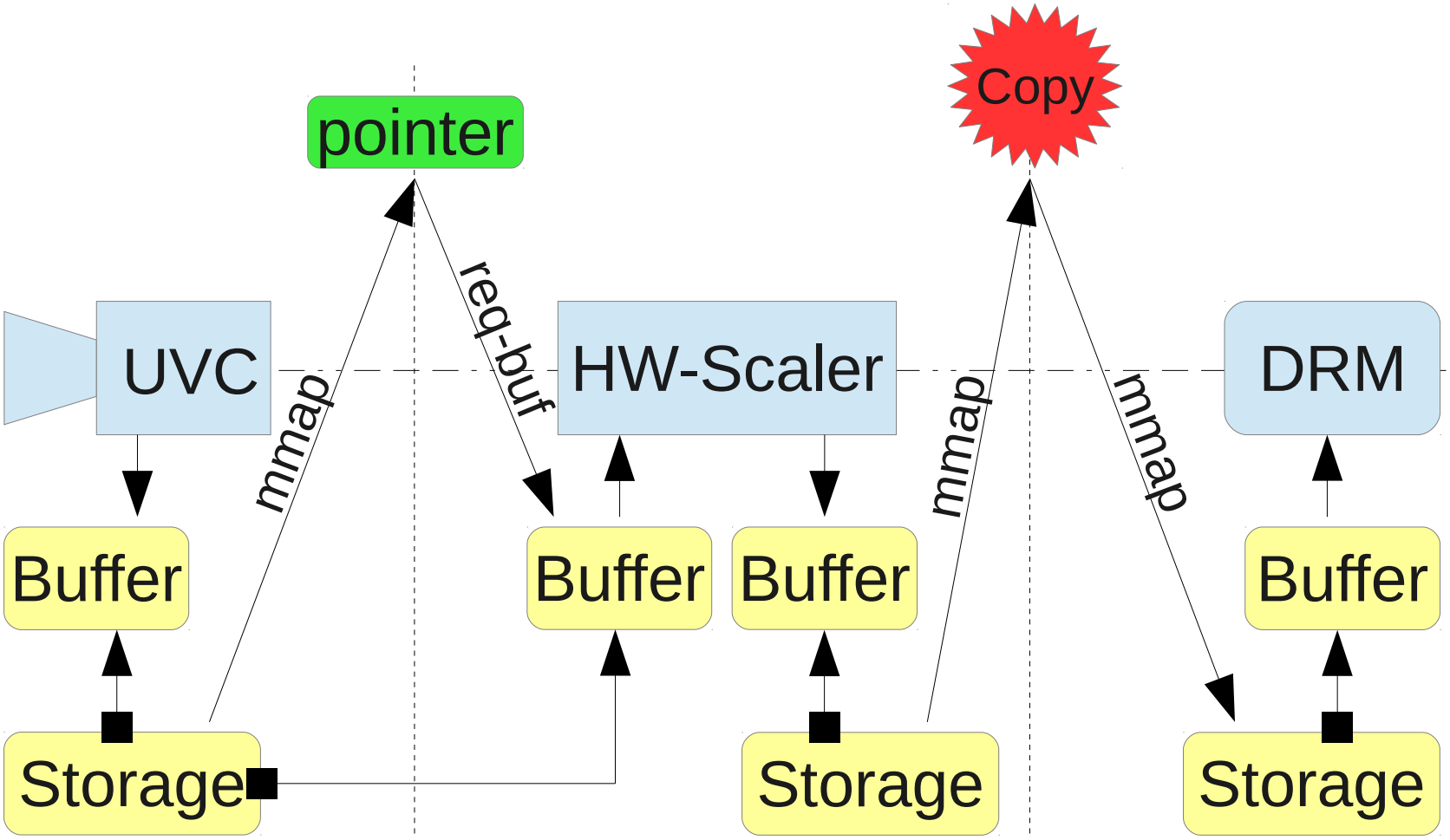
Gstreamer software pipeline



Now add another HW element



Video4Linux UserPTR



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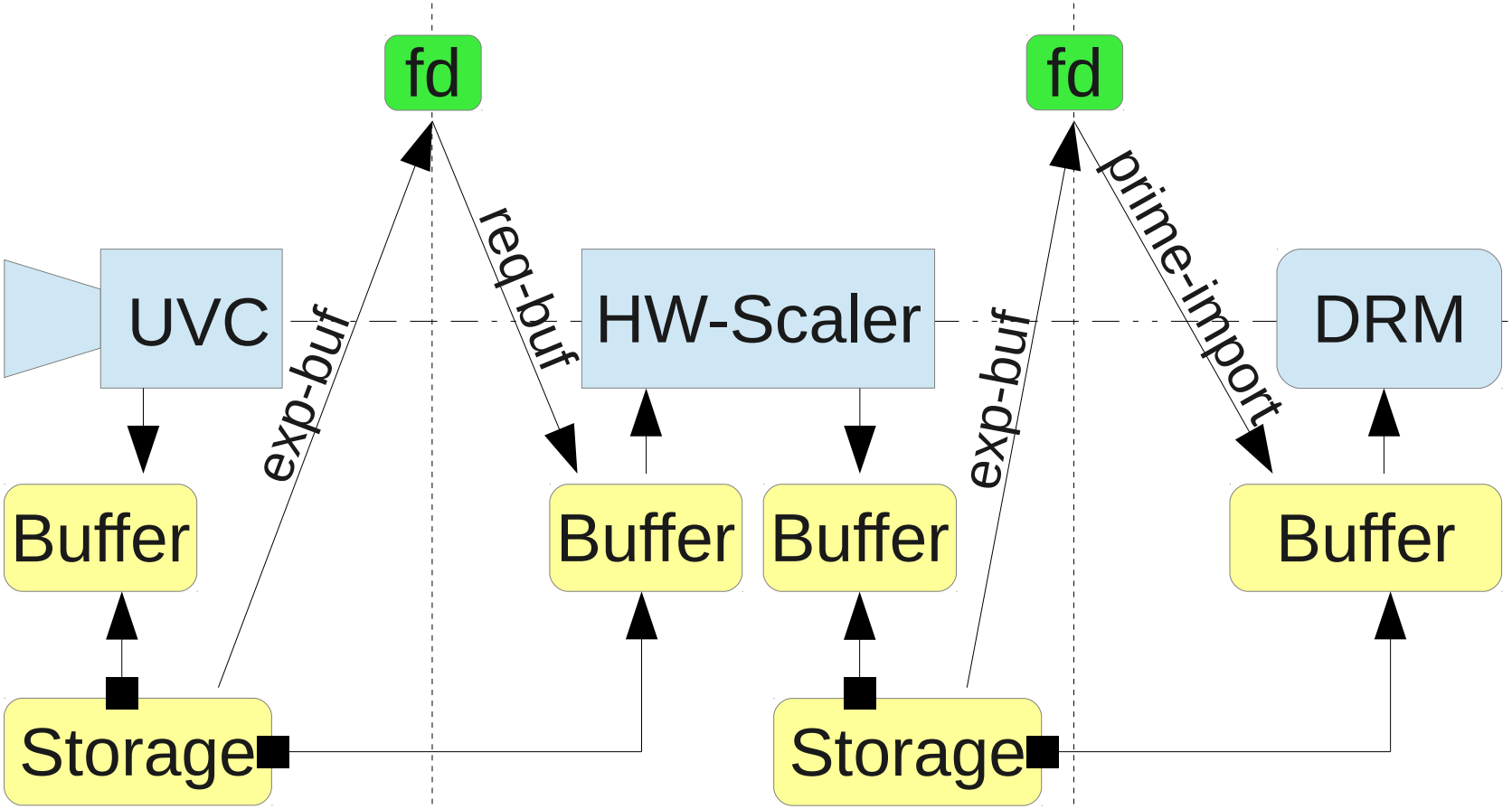
Introducing DMABUF



Fundamental DMABUF API

```
struct dma_buf_attachment *
dma_buf_attach(struct dma_buf  *dmabuf, struct device  *dev);


struct dma_buf_attachment {
        struct dma_buf  *dmabuf;
        struct device  *dev;
        struct list_head  node;
        void  *priv;
};


void dma_buf_detach(struct dma_buf  *dmabuf,
                                struct dma_buf_attachment  *dmabuf_attach);
```

Fundamental DMABUF API

```
struct sg_table *
dma_buf_map_attachment(struct dma_buf_attachment *,
                       enum dma_data_direction);


void
dma_buf_unmap_attachment(struct dma_buf_attachment *,
                         struct sg_table *,
                         enum dma_data_direction);
```

Sounds like a good idea and reasonably easy, but ...

Possible memory constraints

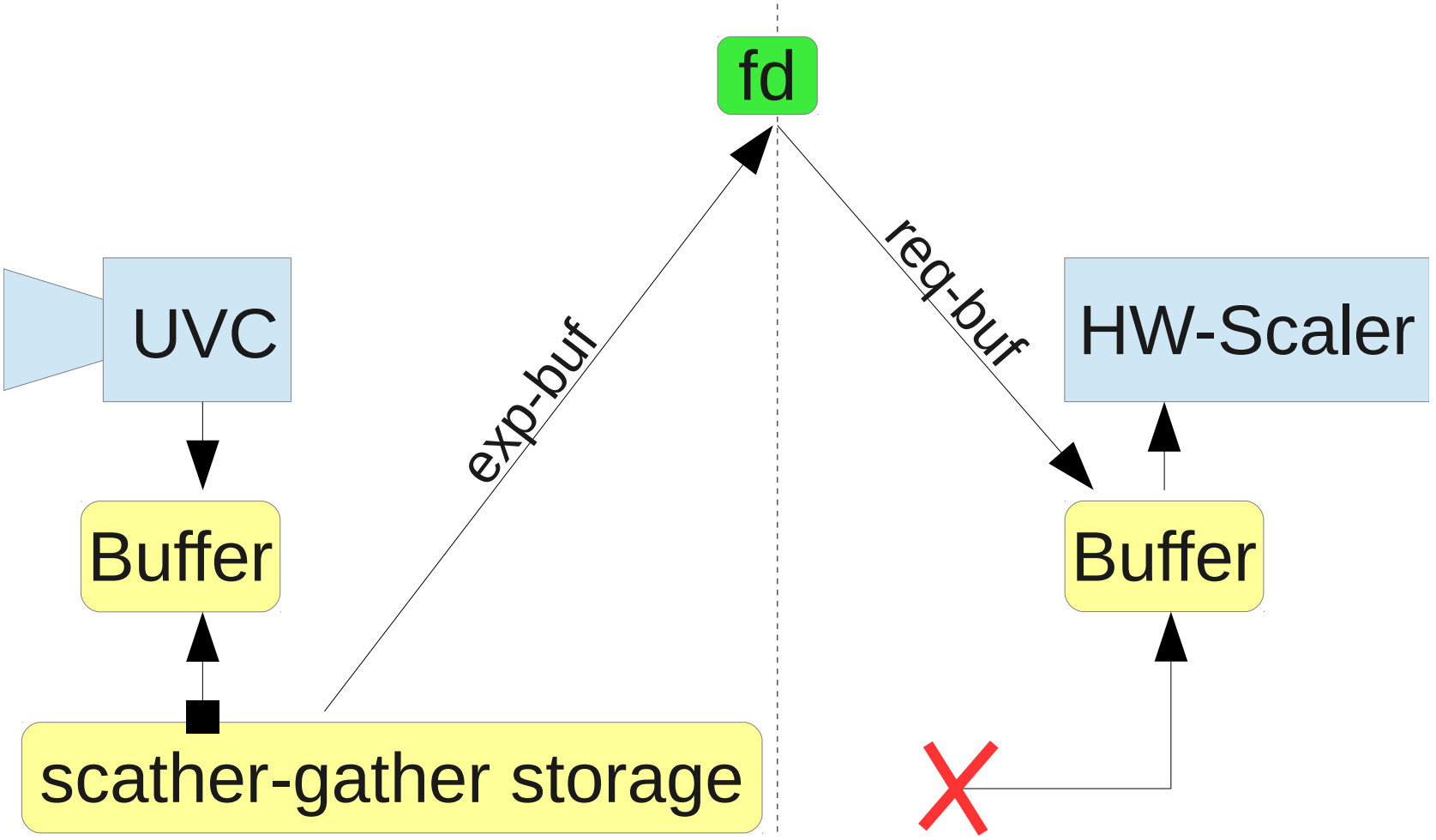
- different DMA windows
- contiguous vs. paged
- different MMU page sizes

Common restriction on embedded systems

- devices unable to do scather-gather DMA
- no IOMMU available

  → DMA memory needs to be physically contiguous

Mixed systems...



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Our solution

Transparent backing store migration

Prerequisites

- drivers need to be able to describe their device's DMA capabilities
- commonly known: dma_mask
- there's more:

```
struct device_dma_parameters {
        unsigned int            min_segment_size;
        unsigned int            max_segment_size;
        unsigned long           segment_boundary_mask;
        unsigned int            max_segments;
};
```

Prerequisites

- drivers need a more generic way for allocating backing store
- traditional DMA-API:

void *
dma_alloc_attrs(*struct* device * dev, size_t size, dma_addr_t *dma_handle, gfp_t flag, *struct* dma_attrs * attrs)

What's wrong with that?

Prerequisites

- new way to allocate DMA memory

```
int
arm_dma_alloc_sgtable(struct device  *dev, size_t  size,
                      struct sg_table  *sgt, gfp_t gfp,
                      struct device_dma_parameters  *dma_parms);
```

```
struct sg_table {
    struct scatterlist {
            unsigned long  page_link;
            unsigned int    length;
            dma_addr_t    dma_address;
    }  *sgl;
    unsigned int  nents;
};
```

Prerequisites

- map for device with well-known DMA-API

```
int
dma_map_sg(struct device  *dev, struct scatterlist  *sg, int  nents,
                    enum dma_data_direction  dir, struct dma_attrs  *attrs)
```

- map for CPU with new function

```
void *
dma_cpumap_sgtable(struct device  *dev, struct sg_table  *sgt,
                                pgprot_t  prot);
```

Migration

- dma_buf_map_attachment
  - current storage compatible with attachment?
    - Yes
      → return sg_table
    - No
      → wait for other maps to go away
      → **reallocate storage**

Reallocation

- try to find storage dma parameters compatible with all currently attached devices

```
int
dma_coalesce_constraints(int  num_parms,
                         struct device_dma_parameters  **in_parms,
                         struct device_dma_parameters  *out_parms)
```

- if not possible use parameters from device currently trying to map and exporter only
- last resort: parameters from mapping device only

- use parameters to alloc new storage

Migration

- dma_buf_map_attachment
  - current storage compatible with attachment?
    - Yes
      → return sg_table
    - No
      → wait for other maps to go away
      → reallocate storage
      → **move current content to new storage**

Move buffer content

- simple and almost always working:
  - map both buffers to CPU
  - memmove()

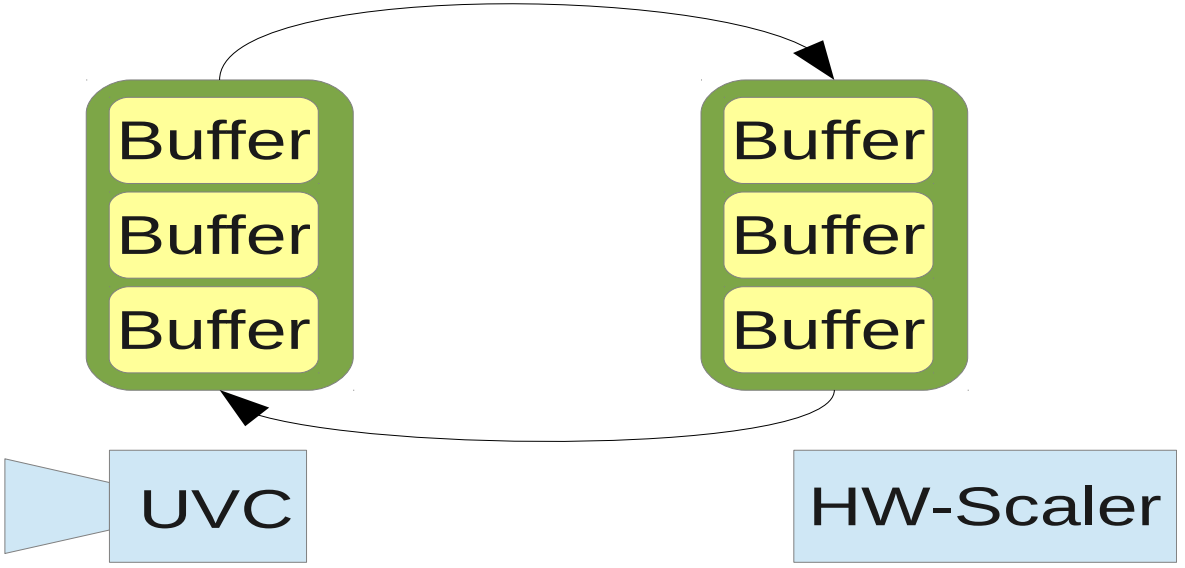
- exporter is free to implement optimized move
  - examples:
    - GPU behind MMU can blit content
    - usage of dedicated on-chip DMA engines

Migration

- dma_buf_map_attachment
  - current storage compatible with attachment?
    - Yes
      → return sg_table
    - No
      → wait for other maps to go away
      → reallocate storage
      → move current content to new storage
      → **return sg_table to new storage**

Why isn't this dead slow?

- Gstreamer reuses allocated buffers – and you should too



Corner cases

- sharing a buffer between devices with no overlap in device_dma_parameters

  → will work, but leads to ping-pong

- devices with memory not accessible to CPU and no way to migrate a buffer on it's own

  - Do you know of any real world example?
  - If you can't access a common memory region, why are you sharing a buffer?

Possible optimization

- Delay allocation to last possible point in time
  → alloc when first user wants to read/write

- Userspace hands buffer handle to all devices before starting the pipeline
  → all users attach before usage

→ exporter is able to allocate matching storage right from the start