Dynamic mbuf

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Features require metadata

- offloads in NIC
  - load balancing (flow steering)
  - segmentation (LRO, TSO)
  - checksums
  - classification
  - tunneling, inline protocol processing (IPsec, NVMe)
- lookaside or inline processing
  - crypto symmetric/asymmetric
  - lossless compression/decompression (stateless or stateful)
  - pattern matching

- Note: software emulation can fill some gaps

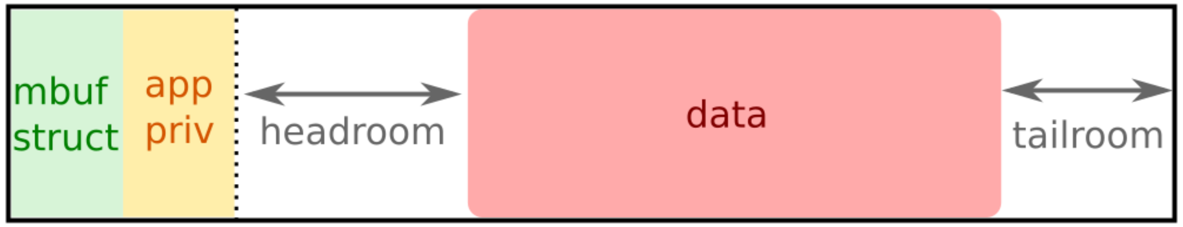
struct rte_mbuf

- Metadata for a network packet segment

- **Data** size, pointer (virtual and IOVA), private data size, external buffer metadata pointer
- **Segment** size, total count and pointer to next
- **Protocol** data (packet type, layer sizes, tunnels, checksums, VLAN, LRO, TSO, IPsec...)
- Flow **classification** (port id, queue id, hash, traffic class...)
- Timestamp, PTP
- User metadata
- **Offload** flags

Private Data for Applications

- Space can be reserved on mempool allocation



- Application configures mempool
- Transparent for DPDK

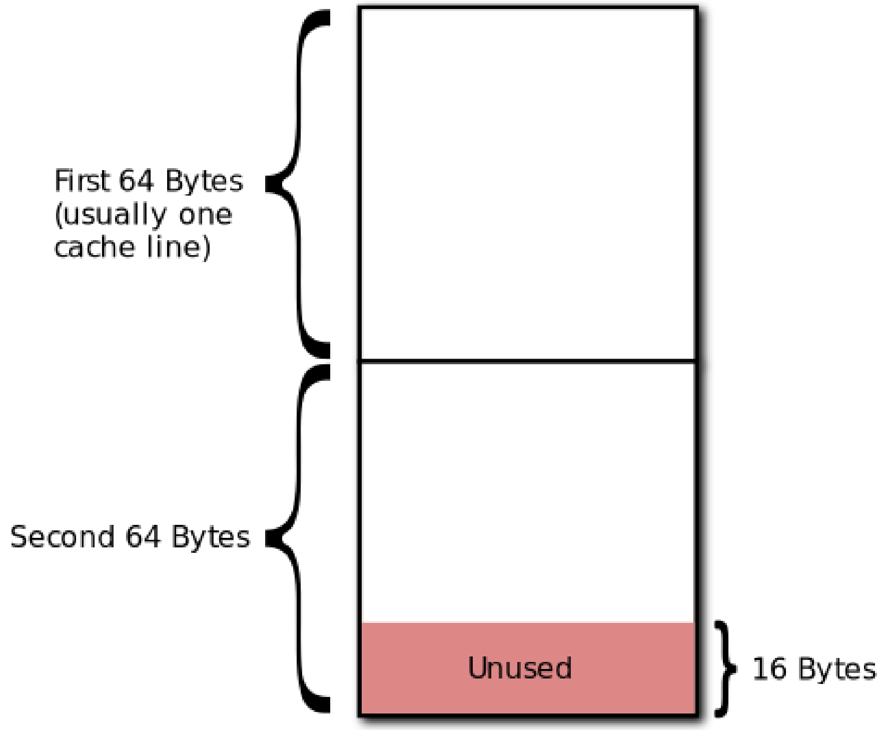
Current mbuf Limitations

Limited Space

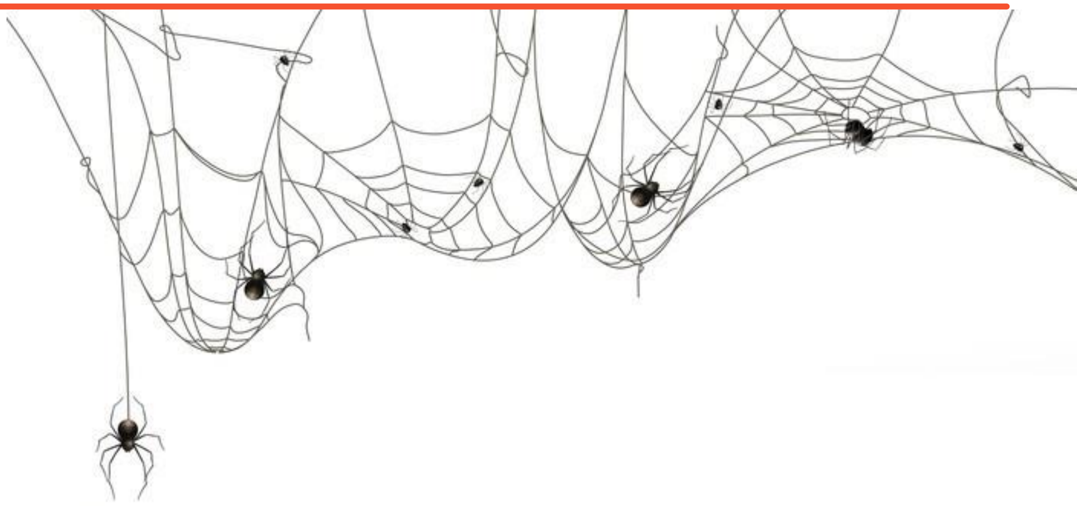
- Small mbuf == Less cache misses

- Only 2 cache lines
  - 2 x 64 = **128** Bytes
  - depends on architecture

- Last free space
  - pahole finds **16** Bytes at the end



Wasted Space



For one application,

For one use case,

Some mbuf fields are not used.

Some features are **rarely** used.

Mutually Exclusive Features

- Long term, features using the same bytes will clash
  - **Placeholders** with vague description are **bad**

    `seqn, tx_metadata, userdata, usr`

  - **Unions** of separate features are **bad**

32-bit	RSS	FDIR low	sched queue		user tag (distributor)	Tx metadata
32-bit		FDIR high	sched class + color	eventdev Tx queue		

Stability

- Removal or move in mbuf is a strong **ABI** break

- **Vector** implementations are tied to mbuf layout

- Slow evolution
- Target: no layout change at all in future

Elsewhere

- Same issue in Linux XDP
  - http://vger.kernel.org/netconf2019_files/xdp-metadata-discussion.pdf
- FreeBSD m_tag
  - https://www.freebsd.org/cgi/man.cgi?query=mbuf_tags

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Extend with Dynamic Fields

Why not Allocating External Structure?

- Flexible
  - any length
  - chained
- Performance impact
  - allocate / free
  - cache miss
- Needs specific pools

Why not Increasing Size?

- Simple
- Performance impact
- Does not avoid ABI breakage each time layout is changed
- Space is still wasted (many unused fields)

Why not Selective Layout?

Application would choose between different mbuf layouts depending on its needs

- Requires as many structures as use cases
- Difficult to adapt and optimize drivers for all possible layouts

Design of Dynamic Fields

- **Register**
  - on demand, depending on use case
  - unused fields don't use space in mbuf

name
size
alignment
flags

$\Rightarrow$ offset

- Drivers and applications access to a **dynamic offset** in the mbuf
  - small performance impact
- System-wide
  - impacts all mbufs in all pools
- Same logic for **dynamic bits** in offload flags

name
count

$\Rightarrow$ bit number

API

```
const struct rte_mbuf_dynfield rte_mbuf_dynfield_my_feature = {
        .name = "rte_mbuf_dynfield_my_feature",
        .size = sizeof(uint64_t),
        .align = __alignof__(uint64_t),
        .flags = 0,
};
```

Register the field

```
offset = rte_mbuf_dynfield_register(&dynfield);
if (offset < 0)
     /* error */
```

Read/Write the field

```
*RTE_MBUF_DYNFIELD(mbuf, offset, uint64_t *) = 0x1337beef;
```

Example of Field

- Helper to register flag and field together
  - `rte_mbuf_dyn_timestamp_register()`

- Feature-specific accessors
  - `rte_mbuf_dyn_timestamp_get(mbuf)`
  - `rte_mbuf_dyn_timestamp_set(mbuf, value)`
  - `rte_mbuf_dyn_timestamp_avail(mbuf)`

Drawbacks / Limitations

- Lower **performance** than accessing a static field
  - Early benchmark:

    +2 cycles for write access
    +3 cycles for read access

- Cannot unregister dynamic fields

- No magic: space is still limited (but more flexible)

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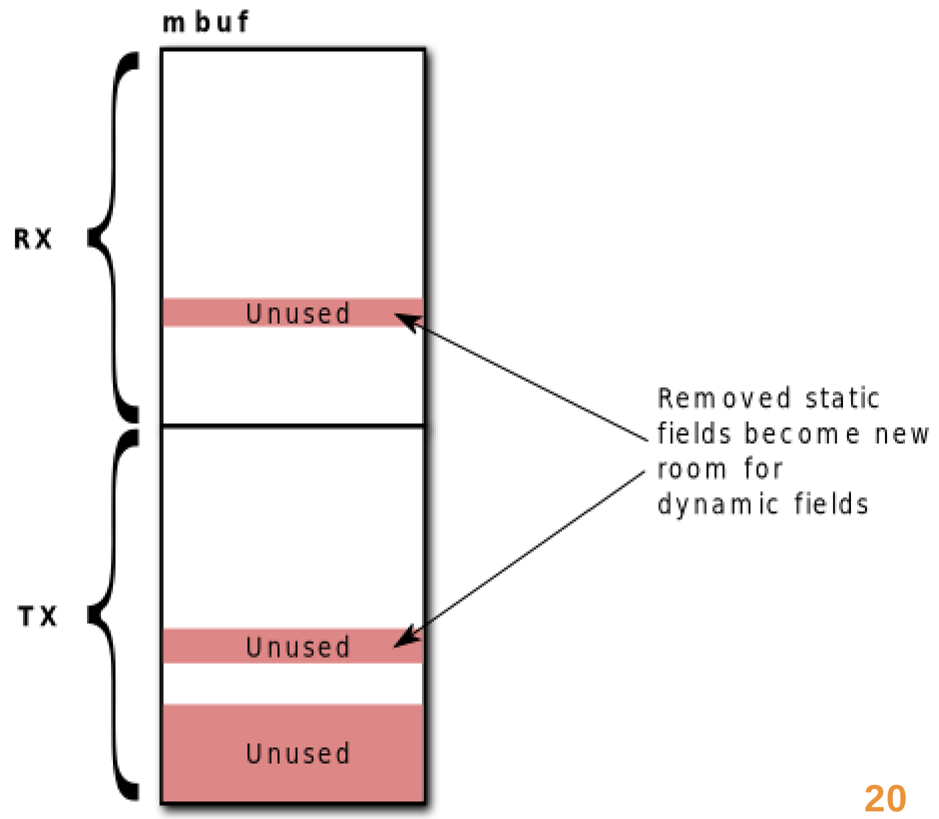
Get even More Space

Plan for Future

- **Sustainable** if enough space to combine a lot of features
- **Convert** some fields from static to dynamic
- Would add room in Rx (first) cache line
    - performance gain for fields moved in Rx part
    - registration flags to choose the cache line



Criteria for Dynamic Field

- Uncommon use
- Vendor-specific
- Performance degradation by a couple of cycles not critical
- Union'ed (exclusive) feature

Remove User Data

- mbuf field (in second half)
  - `void *userdata`
  - `uint64_t udata64`
- Application can register its own well-defined field

Remove User Tag

- mbuf field (union'ed in first half)
  - `uint32_t usr`

- Cannot be used together with RSS hash

- Used only by distributor library
  - could use a well-defined dynamic field

Convert External Buffer Data Pointer

- mbuf field (in second half)
  - `struct rte_mbuf_ext_shared_info *shinfo`

- Accessed only on external buffer attach

- Part of mbuf API
  - Difficult to convert

Convert PTP

- Offload flags
  - `PKT_RX_IEEE1588_PTP`
  - `PKT_RX_IEEE1588_TMST`
  - `PKT_TX_IEEE1588_TMST`
- mbuf field (in second half)
  - `uint16_t timesync`

- IEEE1588 PTP is a payload on top of UDP
- Why is it part of mbuf API?

Convert Timestamp

- mbuf field (in first half)
  - `uint64_t timestamp`

- Not performance critical?
- Not widely used
- In first half (Rx part)

Convert Sequence Number

- mbuf field (in second half)
  - `uint32_t seqn`

- Not enough defined
- Not widely used

Convert Hierarchical Scheduler

- mbuf sub-struct (union'ed in first half)
  - `uint32_t queue_id`
  - `uint8_t traffic_class`
  - `uint8_t color`

- Feature union'ed with RSS
- QoS not always done

Convert eventdev Tx Adapter

- mbuf field (union'ed in first half)
  - `uint16_t txq`

- Feature union'ed with RSS
- eventdev not always in use

Convert Tx Metadata

- mbuf field (union'ed in first half)
  - `uint32_t tx_metadata`

- Feature union'ed with RSS
- Application-specific usage

More?

Other fields could be discussed.

The conversion may be a long way
happening as jumps when ABI breakage window is open.

Conclusion

TO REVIEW (for 19.11)

Add dynamic mbuf API.

TODO (for 20.11)

Migrate some static fields to dynamic.

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Questions?