Part 1

Q1: What's the purpose of using hugepage?

Using hugepage can store more data in a single entry of TLB and thus decrease the number of TLB miss.

Q2: Take examples/helloworld as an example, describe the execution flow of DPDK programs?

A DPDK program first initialize its run time environment, done by the function rte_eal_init() in this example. This function performs a series of tasks like initialize the configuration, memory, threads, etc.

Then the program tries to utilize multiple logical CPU cores by starting multiple threads, and perform its tasks on those threads. In this example it uses the function RTE_LCORE_FOREACH_SLAVE(lcore_id) to iterate available logical cores and uses the function rte_eal_remote_lunch(lcore_hello, NULL, lcore_id) to start threads on logical cores and run lcore_hello() on those threads

Q3: Read the codes of examples/skeleton, describe DPDK APIs related to sending and receiving packets.

Sending: static inline uint16_t rte_eth_tx_burst(uint8_t port_id, uint16_t queue_id, struct rte_mbuf **rx_pkts, const uint16_t nb_pkts)

Receiving: static inline uint16_t rte_eth_rx_burst(uint8_t port_id, uint16_t queue_id, struct rte_mbuf **tx_pkts, uint16_t nb_pkts)

These functions are used for sending and receiving packets rapidly, and they just take port id, queue id, buffered area and number of packets sent/received as parameters. The sending function uses the designated port and queue to send nb_pkts packets in buffer, and the receiving function uses the queue in the port to receive nb_pkts packets and stores them in buffer.

Q4: Describe the data structure of 'rte_mbuf'

rte_mbuf structure consists various information about data and buffer itself:
buffer information (address, length, etc.)
reference counter (denote the offset on buffer)
packet (data) information (type, length, etc.)
hash information
and many other information…

The source code is shown below:

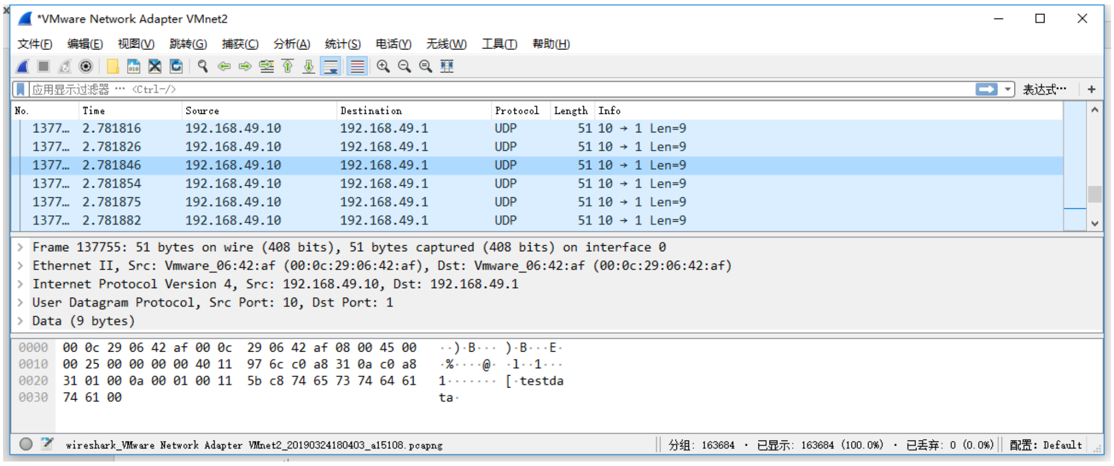
```c
/**
 * The generic rte_mbuf, containing a packet mbuf.
 */
struct rte_mbuf {
    MARKER cacheline0;

    void *buf_addr;           /**< Virtual address of segment buffer. */
    phys_addr_t buf_physaddr; /**< Physical address of segment buffer. */

    uint16_t buf_len;         /**< Length of segment buffer. */

    /* next 6 bytes are initialised on RX descriptor rearm */
    MARKER8 rearm_data;
    uint16_t data_off;

    /**
     * 16-bit Reference counter.
     * It should only be accessed using the following functions:
     * rte_mbuf_refcnt_update(), rte_mbuf_refcnt_read(), and
     * rte_mbuf_refcnt_set(). The functionality of these functions (atomic,
     * or non-atomic) is controlled by the CONFIG_RTE_MBUF_REFCNT_ATOMIC
     * config option.
     */
    RTE_STD_C11
    union {
        rte_atomic16_t refcnt_atomic; /**< Atomically accessed refcnt */
        uint16_t refcnt;              /**< Non-atomically accessed refcnt */
    };
    uint8_t nb_segs;          /**< Number of segments. */
    uint8_t port;             /**< Input port. */

    uint64_t ol_flags;        /**< Offload features. */

    /* remaining bytes are set on RX when pulling packet from descriptor */
    MARKER rx_descriptor_fields1;

    /*
     * The packet type, which is the combination of outer/inner L2, L3, L4
     * and tunnel types. The packet_type is about data really present in the
     * mbuf. Example: if vlan stripping is enabled, a received vlan packet
     * would have RTE_PTYPE_L2_ETHER and not RTE_PTYPE_L2_VLAN because the
     * vlan is stripped from the data.
     */
    RTE_STD_C11
    union {
        uint32_t packet_type; /**< L2/L3/L4 and tunnel information. */
        struct {
            uint32_t l2_type:4; /**< (Outer) L2 type. */
            uint32_t l3_type:4; /**< (Outer) L3 type. */
            uint32_t l4_type:4; /**< (Outer) L4 type. */
            uint32_t tun_type:4; /**< Tunnel type. */
            uint32_t inner_l2_type:4; /**< Inner L2 type. */
            uint32_t inner_l3_type:4; /**< Inner L3 type. */
            uint32_t inner_l4_type:4; /**< Inner L4 type. */
        };
    };

    uint32_t pkt_len;         /**< Total pkt len: sum of all segments. */
    uint16_t data_len;        /**< Amount of data in segment buffer. */
    /** VLAN TCI (CPU order), valid if PKT_RX_VLAN_STRIPPED is set. */
    uint16_t vlan_tci;

    union {
        uint32_t rss;     /**< RSS hash result if RSS enabled */
        struct {
            RTE_STD_C11
            union {
                struct {
                    uint16_t hash;
                    uint16_t id;
                };
                uint32_t lo;
                /**< Second 4 flexible bytes */
            };
            uint32_t hi;
            /**< First 4 flexible bytes or FD ID, dependent on
                 PKT_RX_FDIR_* flag in ol_flags. */
        } fdir;           /**< Filter identifier if FDIR enabled */
        struct {
```

```
            uint32_t lo;
            uint32_t hi;
        } sched;          /**< Hierarchical scheduler */
        uint32_t usr;     /**< User defined tags. See rte_distributor_process() */
    } hash;                   /**< hash information */

    uint32_t seqn; /**< Sequence number. See also rte_reorder_insert() */

    /** Outer VLAN TCI (CPU order), valid if PKT_RX_QINQ_STRIPPED is set. */
    uint16_t vlan_tci_outer;

    /* second cache line - fields only used in slow path or on TX */
    MARKER cacheline1 __rte_cache_min_aligned;

    RTE_STD_C11
    union {
        void *userdata;   /**< Can be used for external metadata */
        uint64_t udata64; /**< Allow 8-byte userdata on 32-bit */
    };

    struct rte_mempool *pool; /**< Pool from which mbuf was allocated. */
    struct rte_mbuf *next;    /**< Next segment of scattered packet. */

    /* fields to support TX offloads */
    RTE_STD_C11
    union {
        uint64_t tx_offload;       /**< combined for easy fetch */
        __extension__
        struct {
            uint64_t l2_len:7;
            /**< L2 (MAC) Header Length for non-tunneling pkt.
             * Outer_L4_len + ... + Inner_L2_len for tunneling pkt.
             */
            uint64_t l3_len:9; /**< L3 (IP) Header Length. */
            uint64_t l4_len:8; /**< L4 (TCP/UDP) Header Length. */
            uint64_t tso_segsz:16; /**< TCP TSO segment size */

            /* fields for TX offloading of tunnels */
            uint64_t outer_l3_len:9; /**< Outer L3 (IP) Hdr Length. */
            uint64_t outer_l2_len:7; /**< Outer L2 (MAC) Hdr Length. */

            /* uint64_t unused:8; */
        };
    };

    /** Size of the application private data. In case of an indirect
     * mbuf, it stores the direct mbuf private data size. */
    uint16_t priv_size;

    /** Timesync flags for use with IEEE1588. */
    uint16_t timesync;
} __rte_cache_aligned;
```

Part 2

The program uses examples/skeleton as a framework, initializing ports and buffer. Then it constructs UDP/IP packets in the master core and send them over and over again.

The screenshot looks like this:



In which wireshark recognized the packet's format (UDP/IP), along with different parts within like port numbers, addresses, data, etc. Besides, the checksums are correct.

```
    Protocol: UDP (17)
    Header checksum: 0x976c [correct]
    [Header checksum status: Good]
    [Calculated Checksum: 0x976c]
    Source: 192.168.49.10
    Destination: 192.168.49.1
✔ User Datagram Protocol, Src Port: 10, Dst Port: 1
    Source Port: 10
    Destination Port: 1
    Length: 17
  > Checksum: 0x5bc8 [correct]
    [Checksum Status: Good]
    [Stream index: 0]
  > [Timestamps]
```