OPENFABRICS ALLIANCE

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DYNAMICALLY-CONNECTED TRANSPORT

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AGENDA

- **Motivation for a new transport**
- **Introducing: Dynamically-connected transport (DC)**
- **A bit about Direct Verbs (DV)**
- **API Proposal**
- **Examples and use cases**

MOTIVATION

	UD	UC	RC
Send/Recv	V	V	V
RDMA Write	X	V	V
RDMA Read / Atomic	X	X	V
Max. send size	MTU	2GB	2GB
Reliability, Ordering	X	X	V
Scalability (per-process, for N processes)	1	N	N

- **UD doesn't support RDMA (but is very scalable).**
- **RD doesn't scale well (but supports RDMA).**

MOTIVATION

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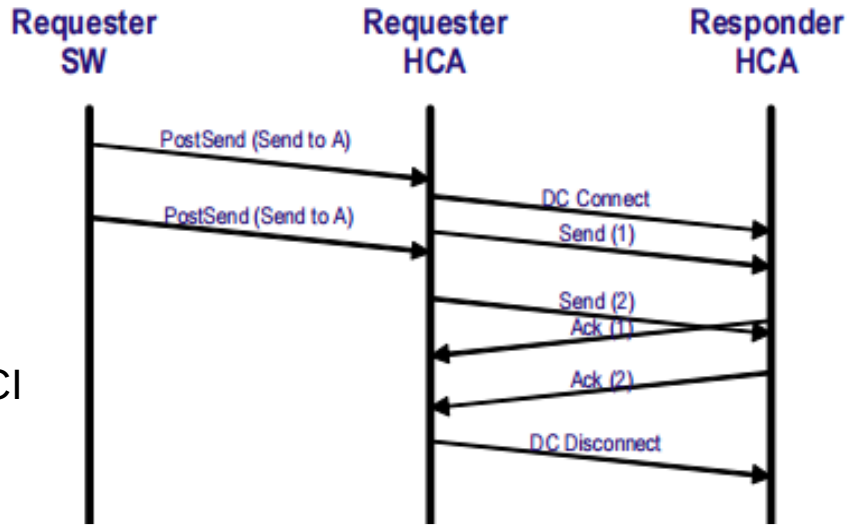
- **UD doesn't support RDMA (but is very scalable).**
- **RD doesn't scale well (but supports RDMA).**
- **Enter Dynamically-connected transport (DC).**
  - The best of both worlds
  - Supports RDMA, RC-like capabilities
  - Scalable, single QP object with multiple destinations (via AD, UD-like)

DYNAMICALLY-CONNECTED TRANSPORT

- **DC (Dynamically Connected) Scalable Transport Service**
  - Reduces #QPs per node
  - RC-like reliability semantics

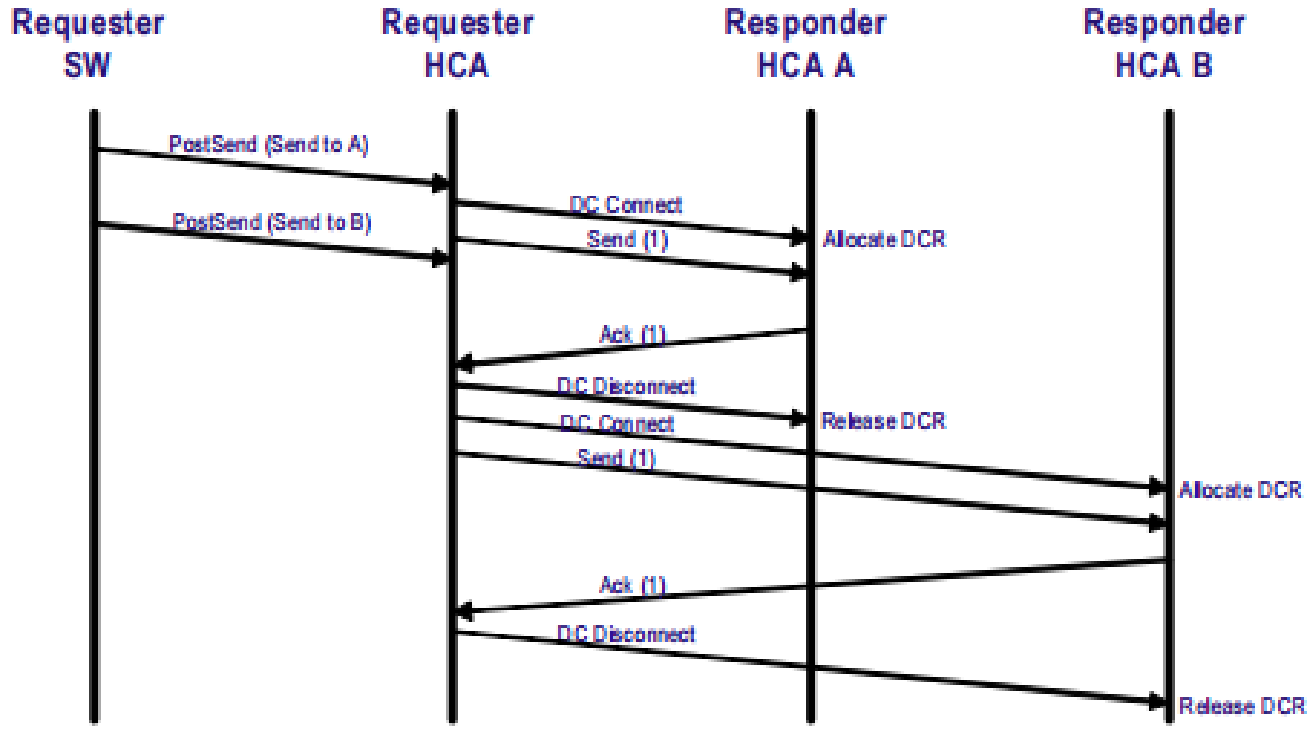


- **DC has asymmetric API:**
  - On the recv-side we have DC Target, or DCT
    - How many? One is enough
  - On the send-side we have DC Initiators, or DCI
    - How many? Less than #targets, but >1

- **Internally, DC forms "temporary connections":**
  - First send-WR on a DCI, connects this DCI to a remote DCT
  - Second send-WR uses this open connection
  - DCI disconnects after some idle period without sends
  - What if the second send-WR is to a different destination? *next slide…*

DYNAMICALLY-CONNECTED TRANSPORT

- **A DCI can "switch destinations"**
  - If the next send-WR has a different destination specified
- **A DCT has a pool of "responders" (DCRs)**
  - Each incoming DC connection is allocated a DCR



DCI RECYCLING TRADEOFFS

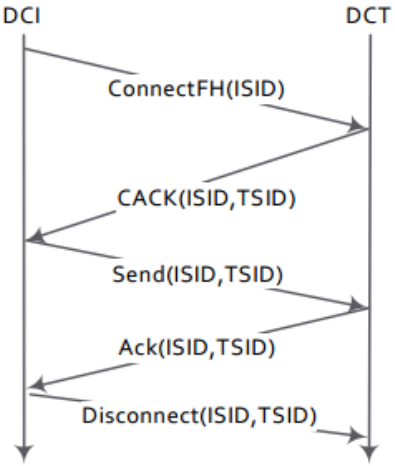
- **Too few DCIs**
  - Same DCI switches back-and-forth between destinations
  - Redundant connect/disconnect flows (worst case: per-send)
  - Hurts latency
- **Too many DCIs**
  - Still not as bad as N^2 RC QPs…
  - Consumes resources and is bad for caching
- **Best practice**
  - Maintain a <DCI dest> hash-table, reducing connection re-establishment
  - LRU recycling policy, to increase the odds of picking a disconnected DCI to send on

DC HANDSHAKE TYPES

- **Half Handshake**
  - “speculative” data sent right after the CONNECT message
  - Improves latency, especially of small messages
  - *seen in previous slides*

- **Full Handshake**
  - Like a 3-way TCP handshake
  - Prevent potential race conditions…

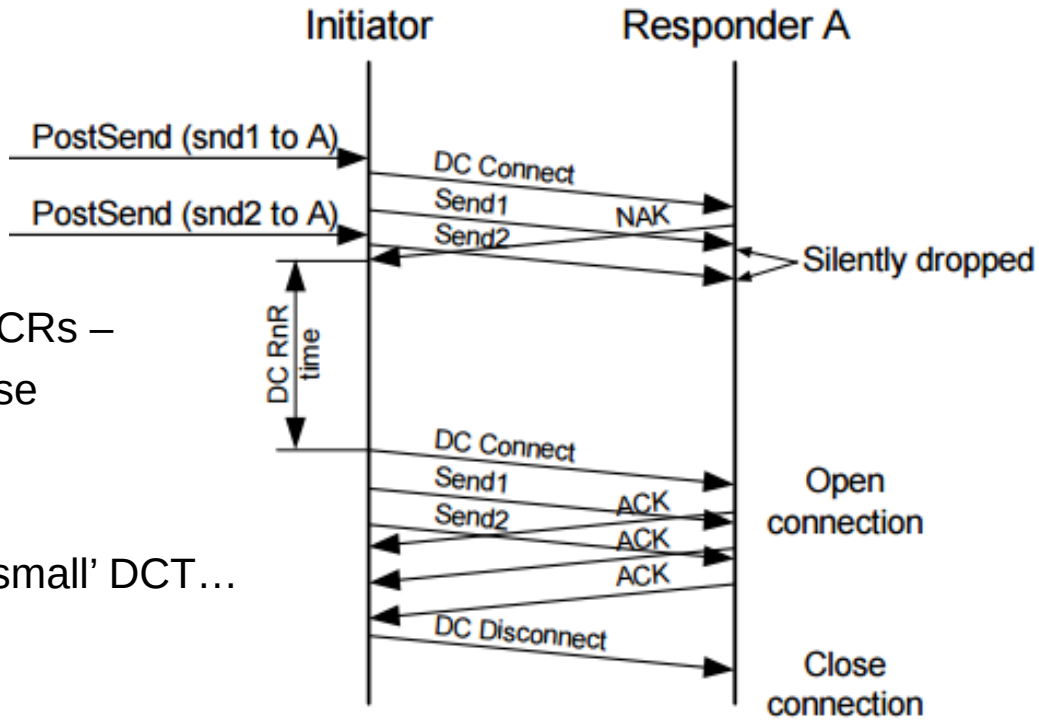
Figure 9 DC Full Handshake Communication



DCT RESOURCES

- **A DC connection request could be denied:**
  - If the DCT does not have enough resources (DCRs) to honor it
  - All DC Responders are currently in use…
  - In this case, the target may send a connection NAK (CNAK) to the DCI

- **API lets you set pool size**
  - Maximum DC Responders
    - Size of the pool
  - Minimum DC Responders
    - Below this number of available DCRs –
      DCRs send CNAKs and release
  - No DC Responders?
    - No Response (timeout).
    - Only happens if you bombard a ‘small’ DCT…



API

DIRECT VERBS

- **Direct Verbs (DV) is a new place for vendor-specific API**
  - Distributed as part of the provider (libmlx5): `providers/mlx5/mlx5dv.h`
  - Exposes HW registers/definition
  - Good for non-IB-spec, configuration flags and objects, like DC

- **DV contains (today):**
  - DC
  - Advanced CQ
  - “Bare-metal” Data Path Access

- **Verbs/DV overlapping**
  - Both have QP object
  - DV needs to “bypass” verbs
    - QP state checks
  - “Vendor QP” passes control

```
@@ -1069,7 +1069,9 @@ enum ib_qp_type {
      IB_QPT_RAW_PACKET = 8,
      IB_QPT_XRC_INI = 9,
      IB_QPT_XRC_TGT,
      IB_QPT_MAX,
+     IB_QPT_VENDOR = 0xFFF,

@@ -1196,6 +1196,9 @@ int ib_modify_qp_is_ok(…
 {
      enum ib_qp_attr_mask req_param, opt_param;

+     if (type >= IB_QPT_MAX)
+           return 0;
```

DC QP CREATION

```
struct ibv_qp *mlx5dv_create_qp(struct ibv_context *context,
                                struct ibv_qp_init_attr_ex *qp_attr,
                                struct mlx5dv_qp_init_attr *mlx5_qp_attr);

struct mlx5dv_qp_init_attr {
        uint64_t comp_mask;     /* Use enum mlx5dv_qp_init_attr_mask */
        uint32_t create_flags;  /* Use enum mlx5dv_qp_create_flags */
        struct mlx5dv_dc_init_attr  dc_init_attr;
};

struct mlx5dv_dc_init_attr {
        enum mlx5dv_dc_type     dc_type;
        uint64_t dct_access_key;
};

enum mlx5dv_dc_type {
        MLX5DV_DCTYPE_DCT     = 1,
        MLX5DV_DCTYPE_DCI,
};

enum mlx5dv_qp_init_attr_mask {
        MLX5DV_QP_INIT_ATTR_MASK_QP_CREATE_FLAGS        = 1 << 0,
        MLX5DV_QP_INIT_ATTR_MASK_DC                     = 1 << 1,
};
```

WHERE'S THE REST OF THE API?

- `mlx5dv_create_qp()` returns a standard `struct ibv_qp*`
  - Verbs API applies, e.g. `ibv_modify/destroy_qp`

- **DCI Post Send**
  - Requires extension of `struct ibv_send_wr` to get both:
    - RDMA/Atomic [Not Possible]
    - DC AH
  - Refactor the QP Post Send API:
    - Registered provider functions per QP Type
    - Separate operations according to SendOpCode
    - Allow send DV extensions: setter for DC AH

```
struct ibv_send_wr {
  union {
    struct {
      uint64_t      remote_addr;
      uint32_t      rkey;
    } rdma;
    struct {
      uint64_t      remote_addr;
      uint64_t      compare_add;
      uint64_t      swap;
      uint32_t      rkey;
    } atomic;
  }
  struct {
    struct ibv_ah  *ah;
    uint64_t        dct_access_key;
    uint32_t        dct_number;
  } dc;
}
```

- **Poll CQ**
  - Additional DV getters based on `struct ibv_cq_ex`

- **Other DV API allows a user to create his own `ibv_post_send()`**
  - Reference implementation is available in UCX, an open-source P2P library https://github.com/openucx/

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THANK YOU

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