Proposed Specification of a Distributed XML-Query Network

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October 8th 2003

This document specifies Distributed XML-Query (DXQ), a method to query distributed XML-databases and XML-representations via a central interface.

W3C’s XML-Query language [1] offers a powerful instrument for information retrieval on XML repositories. Here we describe an implementation of this retrieval in a real world’s scenario. Distributed XML-Query processing reduces load on every single attending node to an acceptable level. The network allows every participant to control their computing load themselves. Furthermore XML-repositories may stay at the rights holder, so every Data-Provider can decide, whether to process critical queries or not. If Data-Providers keep redundant information, this distributed network improves reliability of information with duplicates removed.

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1. Architecture

Every Distributed XML-Query Network (DXQ-Network) consists of at least one XML-Query Distributor and at least one XML-Document Provider. The XML-Document Provider places an XML document \[^4\] at the DXQ-Network’s disposal. The XML-Query Distributor enables the simultaneous execution of XML-Queries \[^2\] on all XML-repositories in the DXQ-Network and aggregates the individual XML-Query results. The DXQ-Network is being used via a DXQ-Client interface.

Any instance within the DXQ-Network such as DXQ-Client, XML-Document Provider, and XML-Query Distributor, is a DXQ-Node.

1.1. XML-Document Provider

The XML-Document Provider (XDP) is the instance exporting its XML-database or XML-representation into the DXQ-Network. It offers an interface to receive XML-Queries from the DXQ-Network to be executed on the exported XML-document. The query result will be serialized to XML \[^3\] and returned to the XQD.

1.2. XML-Query Distributor

The XML-Query Distributor (XQD) is the instance offering an interface to receive XML-Queries from DXQ-Clients. The XQD distributes the XML-Queries to the XDPs in the DXQ-Network. It also collects and joins the query-results. To join the results, the XQD uses an algorithm (see section \[^8\] on page \[^13\] being specified by the DXQ-Client. The XQD sends the joined results as the result of the received XML-Query back to the DXQ-Client.

Those XDP which receive XML-Queries from the XQD are listed in the Distribution List. To be listed, the XDPs have to register themselves. The XQD also offers an interface for the registering communication with XDPs (see \[^2\].6.1 on page \[^10\].

1.3. DXQ-Client

The DXQ-Client is the instance sending XML-Queries into the DXQ-Network and specifying algorithms for joining result sets by the XQD.

2. Distributed XML-Query Protocol

The Distributed XML-Query Protocol (DXQP) is the basis for every communication between the DXQ-Nodes. This protocol is case sensitive and characters must\(^1\) be UTF-8 \[^6\] encoded.

2.1. Transport

The transportation method of the DXQP-messages between the DXQ-Nodes is implementation depending.

\(^1\)Words like 'may', 'must', 'should' are always meant in terms of RFC 2119.
Example HTTP: The transport of the DXQP-messages can be implemented by using (S)HTTP. For this all XQDs and XDPs have to implement their own HTTP-Server of course or be bound to an external server. The DXQ-Client connects an XQD (or the XQD connects an XDP) by sending an HTTP-POST-message (or GET-message, which is not recommended by the authors of the document) to the corresponding web-server. The message contains the DXQP-message in its body. Host, port and path information of the querying DXQ-Node are derived from the Identifier of the node. In this case the Identifier is an URL (see also: 2.2). The web-server responds with the DXQP-reply-message in the body of an HTTP-message.

Example TCP: TCP can also be used for transport directly by opening separated ports bound to the nodes in the DXQ-Network. The Identifier of each DXQ-Node contains the port-information (e.g. dxqp://physnet.isn-oldenburg.de:8750/). Those of the DXQ-Nodes initiating the communication, open channels to the port and send DXQP-messages. The communication accepting DXQ-Nodes respond with DXQP-messages. The communication channel may be kept open and can be reused for sending queries to reduce communication overhead.

2.2. Name and Identifier of a DXQ-Node

The Name is a string describing any DXQ-Node in a user-friendly way. The Name should be unique within the DXQ-Network. The Name may contain every character apart from `<CRLF>`, `{`, and `}`. The Identifier is used for unique identification of any DXQ-Node within the DXQ-Network.

\[
\text{NODE-NAME} ::= \text{[any character sequence not containing <CRLF>, '{' or '}']} \\
\text{NODE-IDENTIFIER} ::= (\text{URL} | "")
\]

For any XQD and XDP the URL [5] of the interface of the specific DXQ-Node is used as the Identifier (e.g. http://physnet.isn-oldenburg.de/dxq-xdp/ or dxqp://physnet.isn-oldenburg.de:8750/). The DXQ-Client uses the empty string as its Identifier, until an Identifier is assigned to the DXQ-Client by the XQD. The assigned Identifier is passed within the header variable \text{Msg-To} of the first message transferred from the XQD to the DXQ-Client as a reply to the empty string in the header variable \text{Msg-From} in the former message (see also: 2.3). The Identifier has to be a valid URL and unique for the DXQ-Client and the XQD. The following examples are valid Identifiers: http://a6bf278d, http://134.106.31.210/ab6bf278d or http://134.106.31.210/?sessid=a6bf278d.

2.3. Structure of a DXQP-Message

Every DXQP-message consists of a header and a body. The two parts are separated by <CRLF>. The header consists of the message’s ID-LINE and several header variables. The body of the message has to contain the number of bytes given in the header variable Content-Length. If Content-Length is empty or not a positive integer, the message will end with the <CRLF> closing the header part.
The general grammar for any DXQP-message is:

\[
\text{MESSAGE} ::= \text{HEADER} <\text{CRLF}> \text{BODY}
\]

\[
\text{HEADER} ::= \text{ID-LINE} <\text{CRLF}> (\text{VARIABLE})^*
\]

\[
\text{ID-LINE} ::= \"DXQP-\" \text{VERSION} \"\" \text{MSGTYPE}
\]

\[
\text{VERSION} ::= [0-9] \. [0-9]
\]

\[
\text{MSGTYPE} ::= (\"OK\" | \"ERROR\" |
\text{"XML-QUERY" | "MERGE-ALGORITHM" |
\text{"XML-QUERY-RESULT" | "XML-QUERY-MERGED-RESULT" |
\text{"REGISTER" | "UNREGISTER" |
\text{"ADDTODL" | "RMFROMDL" |
\text{"INFO-REQUEST" | "INFO-REPLY\")}
\]

\[
\text{VARIABLE} ::= \text{VNAME} \:"\" (\"\")+ \text{VVALUE} <\text{CRLF}>
\]

\[
\text{VNAME} ::= [A-Za-z-]+
\]

\[
\text{VVALUE} ::= [\text{any byte sequence not containing } <\text{CRLF}>]
\]

\[
<\text{CRLF}> ::= 0xOD 0x0A
\]

\[
\text{BODY} ::= [\text{any byte sequence}]
\]

The number, meaning and content of header variables in a message are implementation depending. Header variables in this document are given as examples only, but implementations should not use variables with identical names but different semantics. This applies to the already defined variable \text{Content-Length} as well as to \text{Msg-From} and \text{Msg-To}.

The header variable \text{Msg-From} gives the Identifier of the DXQ-Node sending the message. \text{Msg-To} gives the Identifier of the DXQ-Node receiving the message. Without a valid Identifier (see also: \S 2.2 on the preceding page) in any of these variables the complete message becomes invalid.

\[
\text{VAR-Msg-From} ::= \"Msg-From: \" \text{NODE-IDENTIFIER} <\text{CRLF}>
\]

\[
\text{VAR-Msg-To} ::= \"Msg-To: \" \text{NODE-IDENTIFIER} <\text{CRLF}>
\]

\[
\text{VAR-Content-Length} ::= \"Content-Length: \" [0-9]+ <\text{CRLF}>
\]

\[
\text{VAR-Transaction-ID}?: <\text{CRLF}>
\]

2.4. DXQP-1.0 Messages

2.4.1. OK

The \text{OK}-message gives a positive acknowledgment.

\[
\text{MSG-OK} ::= \"DXQP-1.0 OK\" <\text{CRLF}>
\]

\[
\text{VAR-Msg-From} \text{VAR-Msg-To} (\text{VAR-Transaction-ID})? <\text{CRLF}>
\]

The header variable \text{Transaction-ID} is exclusive and mandatory for responses on XML-QUERY-messages only (see also: \S 2.4.3 on the next page and section \S 2.6.3 on page 12).

2.4.2. ERROR

The \text{ERROR}-message gives a negative acknowledgment and reports of errors. This message has to comprise the header variable \text{Error-Code} giving the value of the error-code as defined in \S 2.5 on page 9. The body of the message may contain further error information.
2.4.3. XML-QUERY

The XML-QUERY-message provides an XML-Query in its body for execution by the receiving DXQ-Node. If this message is sent to an XQD it has to comprise the header variable Merge-Algorithm.

The header variable Transaction-ID gives a VVALUE arbitrarily chosen by the sender of the message to allow unique identification of this message in the context of multi-query processing. The Transaction-ID must not contain any white spaces.

2.4.4. MERGE-ALGORITHM

After the DXQ-Client sent an XML-QUERY-message to the XQD giving "user-defined" in Merge-Algorithm, it has to send the MERGE-ALGORITHM-message, giving an XML-Query in its body to join the query-results of the single XDP in the DXQ-Network.

The header variable Transaction-ID has to provide the same value as given in the corresponding XML-QUERY-message.

2.4.5. XML-QUERY-RESULT

The XML-QUERY-RESULT-message is the answer to an XML-QUERY-message. It is sent from every XDP to the XQD. The serialized query result is given in the body of this message. The header variable Transaction-ID has to give the same value as given in the corresponding XML-QUERY-message.
2.4.6. XML-QUERY-MERGED-RESULT

The XML-QUERY-MERGED-RESULT-message is the answer to the XML-QUERY-message. It is sent from the XQD to the DXQ-Client. The serialized joined result of the corresponding query is given in the body of the message. The header variable Transaction-ID has to give the same value as given in the corresponding XML-Query-message. The header variable Result-Sources should contain a list of Names of those XDPs which delivered parts of the result set.

```
MSG-XML-QUERY-MERGED-RESULT ::= "DXQP-1.0 XML-QUERY-MERGED-RESULT" <CRLF>
VAR-Msg-From VAR-Msg-To
VAR-Transaction-ID VAR-Result-Sources
VAR-Content-Length <CRLF> XML-DOCUMENT
VAR-Result-Sources ::= "Result-Sources: " ("{" NODE-NAME "}")*
                           "{" NODE-NAME "}" <CRLF>
```

2.4.7. REGISTER

By sending the REGISTER-message, the XDP registers itself at the XQD.

```
MSG-REGISTER ::= "DXQP-1.0 REGISTER" <CRLF>
VAR-Msg-From VAR-Msg-To
VAR-Node-Name <CRLF>
VAR-Node-Name ::= "Node-Name: " NODE-NAME <CRLF>
```

2.4.8. UNREGISTER

By sending the UNREGISTER-message, the XDP checks out from the XQD.

```
MSG-UNREGISTER ::= "DXQP-1.0 UNREGISTER" <CRLF>
VAR-Msg-From VAR-Msg-To
VAR-Node-Name <CRLF>
```

2.4.9. ADDTODL

The ADDTODL-message is used by the XDP to sign in to the Distribution List of the XQD. The XQD will distribute queries to those XDPs listed in the Distribution List only.

```
MSG-ADDTODL ::= "DXQP-1.0 ADDTODL" <CRLF>
VAR-Msg-From VAR-Msg-To
VAR-Node-Name <CRLF>
```

2.4.10. RMFROMDL

To sign off the Distribution List of the XQD, the XDP sends the RMFROMDL-message.

```
MSG-RMFROMDL ::= "DXQP-1.0 RMFROMDL" <CRLF>
VAR-Msg-From VAR-Msg-To
VAR-Node-Name <CRLF>
```
2.4.11. INFO-REQUEST

To get information about an XQD or XDP, every DXQ-Node can send the INFO-REQUEST-message. The header variable Request contains a list of inquired information. To inquire a sign of life only, the header variable Request may be empty. INFO-NAME is described in 2.4.12 in more detail. Instead of the detailed list of information, the Request variable can also contain "*" to ask for all information available.

MSG-INFO-REQUEST ::= "DXQP-1.0 INFO-REQUEST" <CRLF>
  VAR-Msg-From VAR-Msg-To
  VAR-Request
  <CRLF>
  VAR-Request ::= "Request: "
                 ("*" | (INFO-NAME " ")* INFO-NAME)? <CRLF>

2.4.12. INFO-REPLY

The INFO-REPLY-message is the answer to the INFO-REQUEST-message. This message contains all of the requested information in the corresponding header variables.

MSG-INFO-REPLY ::= "DXQP-1.0 INFO-REPLY" <CRLF>
  VAR-Msg-From VAR-Msg-To
  (VAR-INFO)*
  <CRLF>
  VAR-INFO ::= INFO-NAME ": " INFO-VALUE <CRLF>
  INFO-NAME ::= VNAME
  INFO-VALUE ::= VVALUE
  YESNO ::= ("yes" | "no")
  MALG-LIST ::= ((MALG-SPEC " ")* MALG-SPEC)?
  XDP-LIST ::= ((XDP-SPEC " ")* XDP-SPEC)?
  XDP-SPEC ::= (NODE-IDENTIFIER)? "{" NODE-NAME "}"
  TRANSACTION-ID-LIST ::= ((TRANSACTION-ID " ")* TRANSACTION-ID)?

Meaning and Values of INFO-NAME are implementation depending. Several INFO-NAMEs are pre-defined with this specification. If an INFO-REQUEST asks for an INFO-NAME which is not supported by the specific implementation, an empty value, not an error will be returned in INFO-REPLY.

Here several INFO-NAMEs are pre-defined, in parentheses the name of the grammar-production of the value in the INFO-REPLY-message is given.

Node-Name (NODE-NAME)
  Name of the DXQ-Node (see also: 2.2 on page 3).

Admin (VVALUE)
  Information on the administrator of the DXQ-Node (name, email, etc.)

Registered (YESNO)
  The value of this variable will be "yes", if it is asked by an XDP to an XQD and the XDP is registered at the XQD. Else the value will be "no".
Is-in-DL (YESNO)
The value of this variable will be "yes", if it is asked by an XDP to an XQD and the XDP is listed in the Distribution List of the XQD. Else the value will be "no".

Merge-Algorithms (MALG-LIST)
Delivers a list of implemented merging algorithms (including the mandatory algorithm user-defined). If the DXQ-Node to be asked is not an XQD, the value delivered by this variable will be the empty string.

Registered-XDPs (XDP-LIST)
Delivers a list of registered XDPs. It is optional to support this information.

Active-XDPs (XDP-LIST)
Delivers the list of XDPs from the Distribution List. It is optional to support this information.

Active-Queries (TRANSACTION-ID-LIST)
Delivers a list of the Transaction-IDs initiated by the DXQ-Node being asking and still in progress at the DXQ-Node to be asked. The list must only contain those Transaction-IDs processed under the same Identifier as those of the INFO-REQUEST-message. It is optional to support this information.

2.5. DXQP-1.0 Error-Codes

[100] Invalid message
The ID-LINE, the name of one of the header variables or the Identifier in the header variable Msg-From or Msg-To is invalid.

[101] Unexpected message
The message was not expected in the current context (e.g. REGISTER sent to an XDP), although it has the correct syntax.

[102] Missing header variable
The message lacks of at least one header variable, essential for the current context of the message. The body of this message contains the name of the missing variable.

[103] Missing content
Though it is essential for processing, the body part of the message is missing (e.g. in an XML-Query-message).

[200] XML-Query processor error
The XML-Query processor/interpreter gave an error. The body of this message contains the original error-message from the processor/interpreter.

[300] Unsupported merge algorithm
The XQD does not support the merging algorithm specified in the header variable Merge-Algorithm of an XML-QUERY-message.
If the Distribution List of an XQD is empty, this ERROR-message will be replied on XML-QUERY-messages.

An internal error occurred when processing the message.

All 9xx error codes are reserved for implementation defined error-codes.

2.6. Communication

Here the semantics of the DXQP-messages within several contexts are described.

2.6.1. XQD and XDP (Control)

Register: Communication is initiated by sending a REGISTER-message from the XDP to the XQD. If the XDP was registered at the XQD, the XQD replies the OK-message, else the ERROR-message will be replied.

When sending the UNREGISTER-message, the XQD removes the corresponding XDP from the list of registered XDPs and replies with the OK-message. In case of an error during processing the UNREGISTER-message, the ERROR-message will be sent. To leave the undefined registration status, the XDP may use the INFO-REQUEST-message.

The period between REGISTER-OK and UNREGISTER-OK is called a Session.

Distribution List: Every XQD runs a list of registered XDPs, which will get XML-Queries in the distribution process. XDPs have to sign themselves into this Distribution List explicitly.

To sign into the Distribution List, the XDP sends the ADDTODL-message to the XQD. The XQD will answer either with the OK- or with the ERROR-message.

To verify the status of the Distribution List, the XDP should use the INFO-REQUEST-message frequently (see also: 2.4.11 on page 8).
The XDP may sign off from the Distribution List (e.g. to reduce the server load in critical situations) by sending the \texttt{RMFROMDL}-message to the XQD. The XQD will reply with an \texttt{OK}-message. In case of an error the \texttt{ERROR}-message will be sent. To request its own status in the Distribution List, the XDP should use the \texttt{INFO-REQUEST}-message.

![Diagram](image.png)

\textbf{Figure 2:} Sign into and sign off the Distribution List

\textbf{Connectivity Care:} Every XQD should send \texttt{INFO-REQUEST}-messages with empty Request-variable to all registered XDP in regular intervals. Every XDP has to reply with an \texttt{INFO-REPLY}-message. In case of no reply message, a time-out, or an \texttt{ERROR}-reply, the XQD should remove the corresponding XDP from the Distribution List.

After removing an XDP from the Distribution List, an XQD may still send \texttt{INFO-REQUEST}-messages to the still registered XDPs. In the case of repeated time-outs the XQD may unregister the XDP.

Every XDP may send \texttt{INFO-REQUEST}-messages to verify being registered and signed into the Distribution List. After being removed from the Distribution List or unregistered, the XDP may register and sign in again.

![Diagram](image.png)

\textbf{Figure 3:} Ping via \texttt{INFO-REQUEST} and \texttt{INFO-REPLY}
2.6.2. XQD and XDP (Data)

Every XDP listed in the Distribution List of an XQD gets XML-QUERY-messages which contain the XML-Queries to be processed on the XML-Document, XML-Database or XML-Representation. The XDP will reply an XML-QUERY-RESULT- or an ERROR-message.

If the XML-Query succeeds, the XML-QUERY-RESULT-message will reply in its body part the result of the XML-Query executed. In case of any error during the processing of the XML-Query, the ERROR-message will be replied giving the respective Error-Code. The error-message of the XML-Query processor should be given in the body part of the ERROR-message.

![Datatransfer between XQD and XDP](image)

Figure 4: Datatransfer between XQD and XDP

2.6.3. DXQ-Client and XQD (Data)

The DXQ-Client (user) initiates the communication by sending the XML-QUERY-message to the XQD. This XML-QUERY-message contains the XML-Query to be processed by the XDP in its body. The further communication depends on the value of the header variable Merge-Algorithm of this message.

If the value of the header variable Merge-Algorithm is user-defined, then the XQD will reply an OK-message and will wait for the MERGE-ALGORITHM-message to be sent by the DXQ-Client. All messages of this query handling (XML-QUERY-message, OK-message, MERGE-ALGORITHM-message) have to give the same value in the Transaction-ID header variable, to allow unique assignment of the messages.

If the value of the header variable Merge-Algorithm is not user-defined, then the XQD will reply the XML-QUERY-MERGED-RESULT-message directly, joined with the selected of the pre-defined algorithms (see also: section 3 on the next page).

In the case of any error while processing the XML-Query, the XQD sends the ERROR-message, which closes the communication.

The DXQ-Client sends the MERGE-ALGORITHM-message with the XML-Query in its body to join the result sets. For further information see also section 3 on the following page. With the OK-message message the DXQ assigns an Identifier to the DXQ-Client within the Msg-To header variable. This Identifier has to be used in the further communication, for example in the Msg-From header variable of the MERGE-ALGORITHM-message.

The XQD will reply the XML-QUERY-MERGED-RESULT-message, which contains the joined result in its body. In the case of an error, the XQD replies the ERROR-message. If only some but not all of the XDP reply ERROR-messages, the XQD should process the available results. The header variable Result-Sources lists those XDPs only which delivered data for the joined result. In case of all XDPs replying an ERROR-message, the XQD will also reply an ERROR-message.
3. Merge-Algorithm

To join the different results of the single XDPs, the XQD uses a *Merge-Algorithm* which is specified by the DXQ-Client in the *XML-QUERY*-message (see also: §2.4.3 on page 6). The DXQ-Client can ask the XQD for a list of available pre-defined merging algorithms by sending an *INFO-REQUEST*-message (see also: §2.4.11 on page 8). The resulting list of algorithms is implementation depending.

Here two Merge-Algorithms are described in detail. While the *concatenate*-algorithm is mandatory for every XQD implementation, the *remove-duplicates*-algorithm is an example of an implementation depending, non-obligatory algorithm.

**concatenate**

The results of the XDPs are just sticked together and framed by a `<result>`-Tag.

**remove-duplicates**

Assuming the following pair of results was delivered by two XDPs:

```xml
<solarsystem>
  <planets>
    <planet>Mercury</planet>
    <planet>Venus</planet>
    <planet>Earth</planet>
  </planets>
</solarsystem>

<solarsystem>
  <planets>
    <planet>Venus</planet>
    <planet>Earth</planet>
    <planet>Mars</planet>
  </planets>
</solarsystem>
```

The `remove-duplicates`-algorithm will join these results into:

```xml
<solarsystem>
  <planets>
    <planet>Mercury</planet>
    <planet>Venus</planet>
    <planet>Earth</planet>
  </planets>
</solarsystem>
```
The XML-document is copied down to a specified depth. All elements of this or higher depth are sticked together, duplicates are removed. To specify this critical depth, this algorithm reads the header-variable *Depth*.

Every XQD has to support a mandatory *user-defined* algorithm. If selecting this algorithm, the DXQ-Client must send a *MERGE-ALGORITHM*-message to the XQD. This message contains an XML-Query which is able to join the results received from the XDPs together. (For detailed information on the communication between DXQ-Client and XQD see also: 2.6.3 on page 12.)

The XQD lists all XDP-results into the context-item to be processed with the user-defined merge-algorithm:

```xml
<context-item>
  <result>
    <xdp>
      <name>XDP-Name</name>
    </xdp>
    <xqres>XML-Query Result</xqres>
  </result>
  ...
</context-item>
```

The `<xdp>`-Tag can also contain further implementation depending information. *XML-Query Result* is the body of the *XML-QUERY-RESULT*-message as received from the specific XDP.

The result of the merging process will be sent to the DXQ-Client within the XQD’s *XML-QUERY-MERGED-RESULT*-message.

**References**

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A. Changes

August 25th 2003:

- To prevent misunderstandings about the header variable Query-ID it has been renamed to Transaction-ID.

August 29th 2003:

- To protect the privacy of the XDPs the <ident> tag in the context item of the user-defined merge algorithm has been removed. Implementations may reinsert this tag if they want to publish the XDPs’ Identifiers.

October 8th 2003:

- The information Active-Queries (in INFO-REQUEST/INFO-REPLY-messages) has been made optional.

- The NODE-IDENTIFIER in the grammar production XDP-SPEC (used for the information Registered-XDPs and Active-XDPs) has been made optional.

- A new header variable Node-Name has been inserted into the REGISTER-message passing the XDP’s Name to the XQD.
B. Example: DXQP-Communication

Here the communication within an example DXQ-Network is described. The DXQ-Network consists of one XDQ and two XDPs, both exporting the XML-document

\[
\text{<document>\text<a>5</a></document>}
\]

One DXQ-Client builds the interface of the DXQ-Network.

First both XDPs register themselves at the XQD, being included into the Distribution List of the XQD:\(^2\)

\[
\begin{align*}
\text{DXQP-1.0 REGISTER} & \quad \text{←} \\
\text{Msg-From: } & \text{http://physnet.isn-oldenburg.de/dxq-xdp/} \\
\text{Msg-To: } & \text{http://metasearch.isn-oldenburg.de/dxq-xqd/} \\
\text{Node-Name: } & \text{PhysNet} \\
\text{DXQP-1.0 OK} & \quad \text{←} \\
\text{Msg-From: } & \text{http://metasearch.isn-oldenburg.de/dxq-xqd/} \\
\text{Msg-To: } & \text{http://physnet.isn-oldenburg.de/dxq-xdp/} \\
\text{DXQP-1.0 ADDTODL} & \quad \text{←} \\
\text{Msg-From: } & \text{http://physnet.isn-oldenburg.de/dxq-xdp/} \\
\text{Msg-To: } & \text{http://metasearch.isn-oldenburg.de/dxq-xqd/} \\
\text{DXQP-1.0 OK} & \quad \text{←} \\
\text{Msg-From: } & \text{http://metasearch.isn-oldenburg.de/dxq-xqd/} \\
\text{Msg-To: } & \text{http://physnet.isn-oldenburg.de/dxq-xdp/} \\
\text{DXQP-1.0 REGISTER} & \quad \text{←} \\
\text{Msg-From: } & \text{http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/} \\
\text{Msg-To: } & \text{http://metasearch.isn-oldenburg.de/dxq-xqd/} \\
\text{Node-Name: } & \text{PhysNet (Mirror)} \\
\text{DXQP-1.0 OK} & \quad \text{←} \\
\text{Msg-From: } & \text{http://metasearch.isn-oldenburg.de/dxq-xqd/} \\
\text{Msg-To: } & \text{http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/} \\
\text{DXQP-1.0 ADDTODL} & \quad \text{←} \\
\text{Msg-From: } & \text{http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/} \\
\text{Msg-To: } & \text{http://metasearch.isn-oldenburg.de/dxq-xqd/} \\
\text{DXQP-1.0 OK} & \quad \text{←} \\
\text{Msg-From: } & \text{http://metasearch.isn-oldenburg.de/dxq-xqd/} \\
\text{Msg-To: } & \text{http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/}
\end{align*}
\]

\(^2\text{← = <CRLF>}\)
Following, the XQD inquires information about the XDPs:

```
DXQP-1.0 INFO-REQUEST←
Msg-From: http://metasearch.isn-oldenburg.de/dxq-xqd/
Msg-To: http://physnet.isn-oldenburg.de/dxq-xdp/
Request: Node-Name Admin←

DXQP-1.0 INFO-REPLY←
Msg-From: http://physnet.isn-oldenburg.de/dxq-xdp/
Msg-To: http://metasearch.isn-oldenburg.de/dxq-xqd/
Node-Name: PhysNet←
Admin: Max Mustermann <admin@physnet.isn-oldenburg.de>←

DXQP-1.0 INFO-REQUEST←
Msg-From: http://metasearch.isn-oldenburg.de/dxq-xqd/
Msg-To: http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/
Request: Node-Name Admin←

DXQP-1.0 INFO-REPLY←
Msg-From: http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/
Msg-To: http://metasearch.isn-oldenburg.de/dxq-xqd/
Node-Name: PhysNet (Mirror)←
Admin: Bert Beispiel <admin@physnet-mirror.isn-oldenburg.de>←

The DXQ-Client connects the XQD by sending an initial XML-Query:

```
DXQP-1.0 XML-QUERY←
Msg-From: ←
Msg-To: http://metasearch.isn-oldenburg.de/dxq-xqd/
Transaction-ID: 0←
Merge-Algorithm: user-defined←
Content-Length: 23←
let $a := ./a return $a

DXQP-1.0 OK←
Msg-From: http://metasearch.isn-oldenburg.de/dxq-xqd/
Msg-To: http://a6bf←
Transaction-ID: 0←
The XQD distributes the XML-Query to all XDPs which are listed in the Distribution List. It also collects the results:

**DXQP-1.0 XML-QUERY**

Msg-From: http://metasearch.isn-oldenburg.de/dxq-xqd/
Msg-To: http://physnet.isn-oldenburg.de/dxq-xdp/
Transaction-ID: 0
Content-Length: 23

→

let $a := ./a return $a

**DXQP-1.0 XML-QUERY-RESULT**

Msg-From: http://physnet.isn-oldenburg.de/dxq-xdp/
Msg-To: http://metasearch.isn-oldenburg.de/dxq-xqd/
Transaction-ID: 0
Content-Length: 8

→

<\a>5</\a>

**DXQP-1.0 XML-QUERY**

Msg-From: http://metasearch.isn-oldenburg.de/dxq-xqd/
Msg-To: http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/
Transaction-ID: 1
Content-Length: 23

→

let $a := ./a return $a

**DXQP-1.0 XML-QUERY-RESULT**

Msg-From: http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/
Msg-To: http://metasearch.isn-oldenburg.de/dxq-xqd/
Transaction-ID: 1
Content-Length: 8

→

<\a>5</\a>

The XQD receives the MERGE-ALGORITHM-message from the DXQ-Client and responds with the joined results:

**DXQP-1.0 MERGE-ALGORITHM**

Msg-From: http://a6bf/
Msg-To: http://metasearch.isn-oldenburg.de/dxq-xqd/
Transaction-ID: 0
Content-Length: 51

→

let $r := <\a>{sum(./result/xqres/a)}</\a> return $r

**DXQP-1.0 XML-QUERY-MERGED-RESULT**

Msg-From: http://metasearch.isn-oldenburg.de/dxq-xqd/
Msg-To: http://a6bf/
Transaction-ID: 0
Result-Sources: {PhysNet} {PhysNet (Mirror)}
Content-Length: 9

→

<\a>10</\a>
Finally the XDPs send an UNREGISTER-message to be removed from the network:

| DXQP-1.0 UNREGISTER ← |
|-----------------------|
| Msg-From: http://physnet.isn-oldenburg.de/dxq-xdp/  ← |
| Msg-To: http://metasearch.isn-oldenburg.de/dxq-xqd/  ← |

| DXQP-1.0 OK ← |
|---------------|
| Msg-From: http://metasearch.isn-oldenburg.de/dxq-xqd/  ← |
| Msg-To: http://physnet.isn-oldenburg.de/dxq-xdp/  ← |

| DXQP-1.0 UNREGISTER ← |
|-----------------------|
| Msg-From: http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/  ← |
| Msg-To: http://metasearch.isn-oldenburg.de/dxq-xqd/  ← |

| DXQP-1.0 OK ← |
|---------------|
| Msg-From: http://metasearch.isn-oldenburg.de/dxq-xqd/  ← |
| Msg-To: http://physnet-mirror.isn-oldenburg.de:8080/dxq-xdp/  ← |