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Control Plane Protocols and Procedures for Multiple Access Management
Services
draft-zhu-intarea-mams-control-protocol-01

Abstract

Today, a device can be simultaneously connected to multiple communication networks based on different technology implementations and network architectures like WiFi, LTE, DSL. In such multi-connectivity scenario, it is desirable to combine multiple access networks or select the best one to improve quality of experience for a user and improve overall network utilization and efficiency. This document presents the control plane protocols, as well as describes control plane procedures for configuring the user plane in a multi access management services (MAMS) framework that can be used to flexibly select the combination of uplink and downlink access and core network paths, and user plane treatment for improving network efficiency and enhanced application quality of experience.

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1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. Introduction

Multi Access Management Service (MAMS)

[I-D.kanugovi-intarea-mams-protocol] is a framework to select and configure network paths when multiple connections can serve a client device. It allows the path selection and configuration to adapt to dynamic network conditions. It is based on principles of user plane interworking that enables the solution to be deployed as an overlay without impacting the underlying networks.

This document presents the control plane protocols for the MAMS framework. It co-exists and complements user plane protocols (e.g. MPTCP [RFC6824] or MPTCP Proxy [I-D.boucadair-mptcp-plain-mode], [I-D.wei-mptcp-proxy-mechanism]) by providing a way to negotiate and configure them based on client and network capabilities. It allows exchange of network state information and leverages network intelligence to optimize the performance of such protocols.

3. Terminology

"Anchor Connection": Refers to the network path from the N-MADP to the Application Server that corresponds to a specific IP anchor that has assigned an IP address to the client.

"Delivery Connection": Refers to the network path from the N-MADP to the client.

"Network Connection Manager" (NCM), "Client Connection Manager" (CCM), "Network Multi Access Data Proxy" (N-MADP), and "Client Multi Access Data Proxy" (C-MADP) in this document are to be interpreted as described in [I-D.kanugovi-intarea-mams-protocol].

4. MAMS Control-Plane Protocol

4.1. Overview

The MAMS architecture [I-D.kanugovi-intarea-mams-protocol] introduces the following functional elements,

- o Network Connection Manager (NCM) and Client Connection Manager (CCM) in the control plane, and

- o Network Multi Access Data Proxy (N-MADP) and Client Multi Access Data Proxy (C-MADP) handling the user plane.

Figure 1 shows the default MAMS control plane protocol stack. HTTPS is used for transporting management and control messages between NCM and CCM.

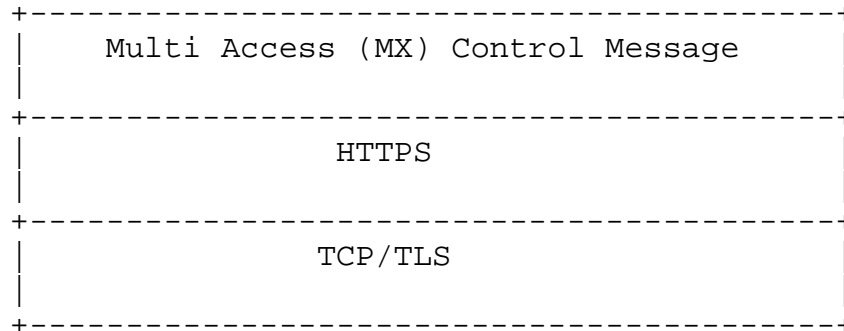


Figure 1: TCP-based MAMS Control Plane Protocol Stack

5. MAMS User Plane Protocol

Figure 2 shows the MAMS user plane protocol stack.

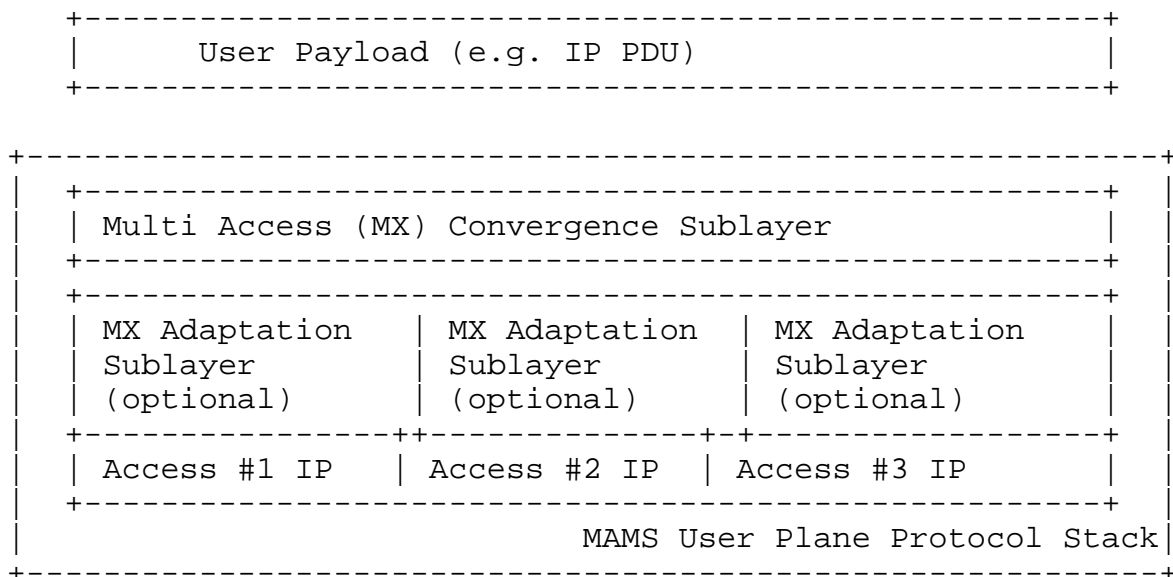


Figure 2: MAMS User Plane Protocol Stack

It consists of the following two Sublayers:

- o Multi-Access (MX) Convergence Sublayer: This layer performs multi-access specific tasks, e.g. access (path) selection, multi-link (path) aggregation, splitting/reordering, lossless switching, fragmentation, concatenation, etc. For example, MX Convergence layer can be implemented using existing user plane protocols like MPTCP or by adapting encapsulating header/trailer schemes (e.g. Trailer Based MX Convergence as specified in [I-D.zhu-intarea-mams-user-protocol]).
- o Multi-Access (MX) Adaptation Sublayer: This layer performs functions to handle tunnelling, network layer security, and NAT. For example, MX Adaptation can be implemented using IPsec, DTLS or Client NAT (Source NAT at Client with inverse mapping at N-MADP [I-D.zhu-intarea-mams-user-protocol]). The MX Adaptation Layer is optional and can be independently configured for each of the Access Links, e.g. in a deployment with LTE (assumed secure) and Wi-Fi (assumed not secure), the MX Adaptation Sublayer can be omitted for the LTE link but MX Adaptation Sublayer is configured as IPsec for the Wi-Fi link.

6. MAMS Control Plane Procedures

6.1. Overview

CCM and NCM exchange signaling messages to configure the user plane functions, C-MADP and N-MADP, at the client and network respectively. The means for CCM to obtain the NCM credentials (FQDN or IP Address) for sending the initial discovery messages are outside of the scope of MAMS document, e.g. using methods like provisioning, DNS. Once the discovery process is successful, the (initial) NCM can update and assign additional NCM addresses for sending subsequent control plane messages.

CCM discovers and exchanges capabilities with the NCM. NCM provides the credentials of the N-MADP end-point and negotiates the parameters for user plane with the CCM. CCM configures C-MADP to setup the user plane path (e.g. MPTCP/UDP Proxy Connection) with the N-MADP based on the credentials (e.g. (MPTCP/UDP) Proxy IP address and port, Associated Core Network Path), and the parameters exchanged with the NCM. The key procedures are described in details in the following sub-sections.

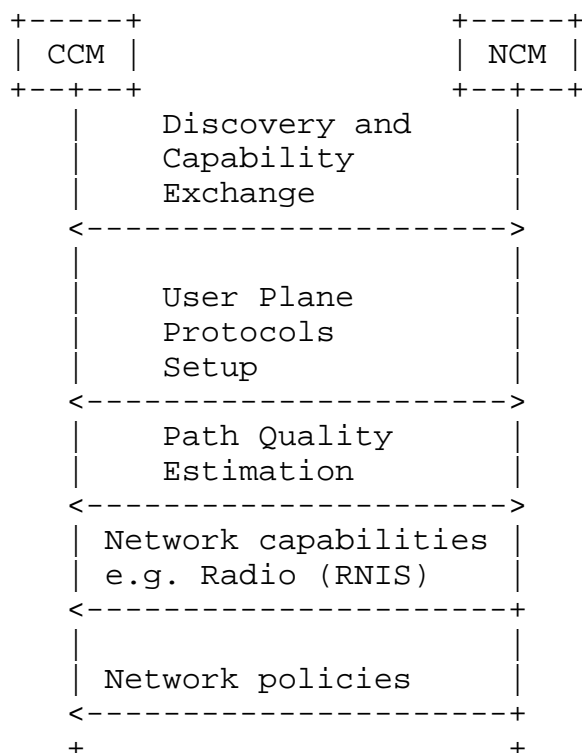


Figure 3: MAMS Control Plane Procedures

6.2. Common fields in MAMS Control Messages

Each MAMS control message consists of the following common fields:

- o Version: indicates the version of MAMS control protocol.
- o Message Type: indicates the type of the message, e.g. MX Discovery, MX Capability REQ/RSP etc.
- o Sequence Number: auto-incremented integer to uniquely identify a transaction of message exchange, e.g. MX Capability REQ/RSP.

6.3. Discovery & Capability Exchange

Figure 4 shows the MAMS discovery and capability exchange procedure consisting of the following key steps:

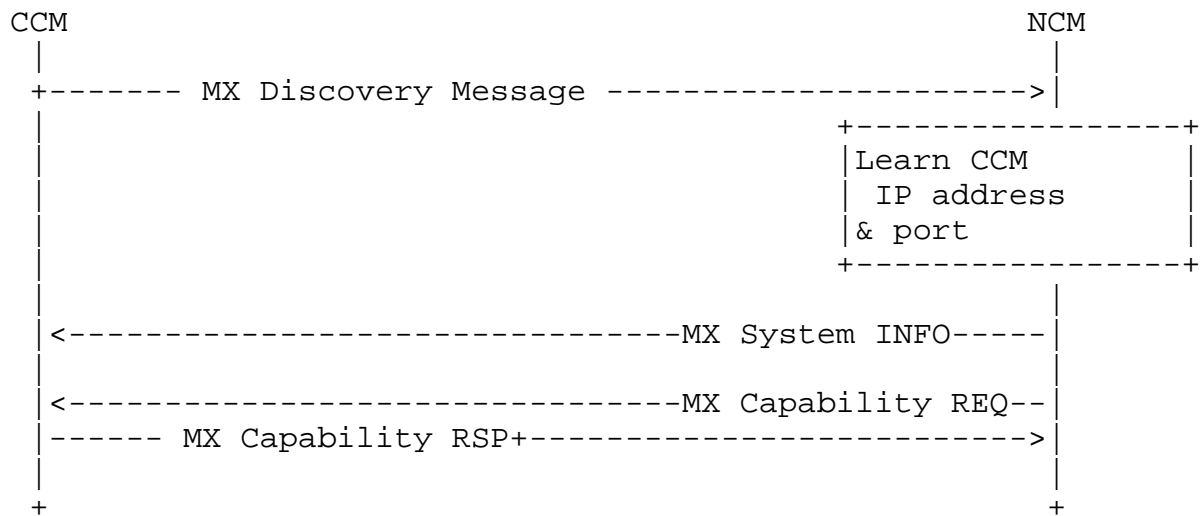


Figure 4: MAMS Control Procedure for Discovery & Capability Exchange

Step 1 (Discovery): CCM periodically sends out the MX Discovery Message to a pre-defined (NCM) IP Address/ port until receives an MX System INFO message in acknowledgement.

MX Discovery Message includes the following information:

- o MAMS Version

MX System INFO includes the following information:

- o Number of Anchor Connections

For each Anchor Connection, it includes the following parameters:

- * Connection ID: Unique identifier for the Anchor Connection
- * Connection Type (e.g., 0: Wi-Fi; 1: 5G NR; 2: Multi-Fire; 3: LTE)
- * NCM Endpoint Address (For Control Plane Messages over this connection)
 - + IP Address or FQDN (Fully Qualified Domain Name)
 - + Port Number

Step 2 (Capability Exchange): once receiving a MX discovery message, NCM learns the IP address and port number to communicate with CCM, and sends out the MX Capability REQ message, including the following Parameters:

- o MX Feature Activation List: Indicates if the corresponding feature is enabled or not, e.g. lossless switching, fragmentation, concatenation, Uplink aggregation, Downlink aggregation, Measurement, etc.
- o Number of Anchor Connections (Core Networks)

For each Anchor Connection, it includes the following parameters:

- * Connection ID
- * Connection Type (e.g., 0: Wi-Fi; 1: 5G NR; 2: Multi-Fire; 3: LTE)
- o Number of Delivery Connections (Access Links)

For each Delivery Connection, it includes the following parameters:

- * Connection ID
- * Connection Type (e.g., 0: Wi-Fi; 1: 5G NR; 2: Multi-Fire; 3: LTE)
- o MX Convergence Method Support List

- * Trailer-based MX Convergence;
- * MPTCP Proxy;

- o MX Adaptation Method Support List

- * UDP Tunnel without DTLS;
- * UDP Tunnel with DTLS;
- * IPsec Tunnel[RFC3948];
- * Client NAT;

In response, CCM sends out the MX Capability RSP message, including the following information:

- o MX Feature Activation List: Indicates if the corresponding feature is enabled or not, e.g. lossless switching, fragmentation, concatenation, Uplink aggregation, Downlink aggregation, Measurement, etc.
- o Number of Anchor Connections (Core Networks)

For each Anchor Connection, it includes the following parameters:

- * Connection ID
- * Connection Type (e.g., 0: Wi-Fi; 1: 5G NR; 2: Multi-Fire; 3: LTE)
- o Number of Delivery Connections (Access Links)

For each Delivery Connection, it includes the following parameters:

- * Connection ID
- * Connection Type (e.g., 0: Wi-Fi; 1: 5G NR; 2: Multi-Fire; 3: LTE)
- o MX Convergence Method Support List
 - * Trailer-based MX Convergence;
 - * MPTCP Proxy;
- o MX Adaptation Method Support List
 - * UDP Tunnel without DTLS;
 - * UDP Tunnel with DTLS;
 - * IPsec Tunnel[RFC3948];
 - * Client NAT;

6.4. User Plane Configuration

Figure 5 shows the user plane configuration procedure consisting of the following key steps:

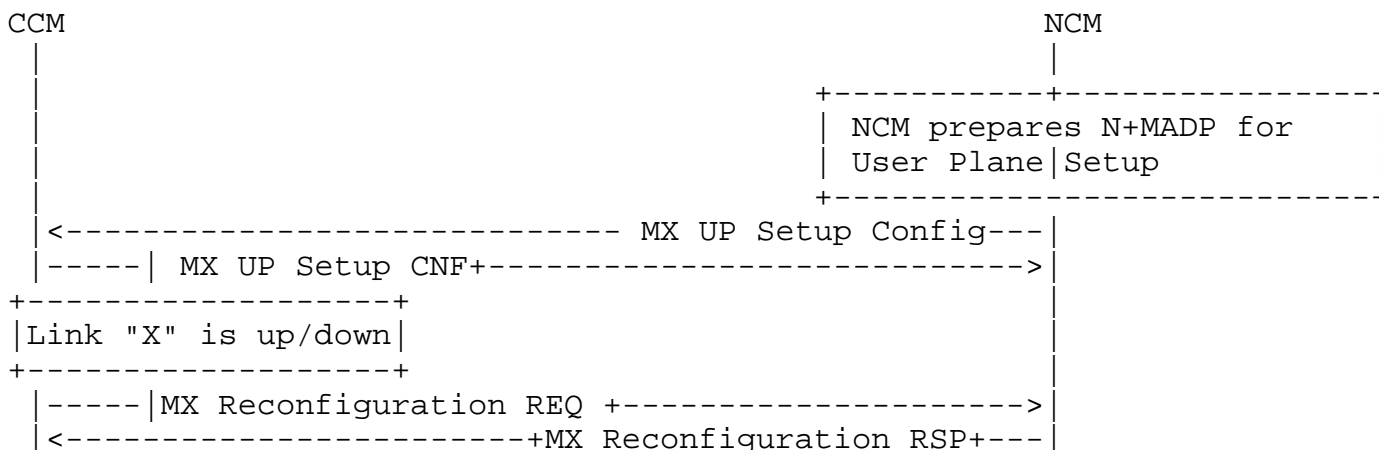


Figure 5: MAMS Control Procedure for User Plane Configuration

User Plane Protocols Setup: Based on the negotiated capabilities, NCM sets up the user plane (Adaptation Layer and Convergence Layer) protocols at the N-MADP, and informs the CCM of the user plane protocols to setup at the client (C-MADP) and the parameters for C-MADP to connect to N-MADP.

Each MADP instance is responsible for one anchor connection. The MX UP Setup Config consists of the following parameters:

- o Number of Anchor Connections (Core Networks)

For Each Anchor Connection, it includes the following parameters

- * Anchor Connection ID
- * Connection Type (e.g., 0: Wi-Fi; 1: 5G NGC; 2: Multi-Fire; 3: LTE)
- * MX Convergence Method
 - + Trailer-based MX Convergence;
 - + MPTCP Proxy;
- * MX Convergence Method Parameters
 - + Convergence Proxy IP Address
 - + Convergence Proxy Port
- * Number of Delivery Connections

For each Delivery Connection, include the following:

- + Delivery Connection ID
- + Connection Type (e.g., 0: Wi-Fi; 1: 5G NGC; 2: Multi-Fire; 3: LTE)
- + MX Adaptation Method
 - UDP Tunnel without DTLS;
 - UDP Tunnel with DTLS;
 - IPsec Tunnel;
 - Client NAT;
- + MX Adaptation Method Parameters
 - Tunnel Endpoint IP Address
 - Tunnel Endpoint Port
 - Shared Secret

e.g. When LTE and Wi-Fi are the two user plane accesses, NCM conveys to CCM that IPsec needs to be setup as the MX Adaptation Layer over the Wi-Fi Access, using the following parameters - IPsec end-point IP address, Pre-Shared Key., No Adaptation Layer is needed over the LTE Access as it is considered secure with no NAT. The MX Convergence Method is configured as MPTCP Proxy along with parameters for connection to the MPTCP Proxy, namely IP Address and Port of the MPTCP Proxy for TCP Applications.

Once the user plane protocols are configured, CCM informs the NCM of the status via the MX UP Setup CNF message

Reconfiguration: when the client detects that the link is up/down or the IP address changes (e.g. via APIs provided by the client OS), CCM

sends out a MX Reconfiguration REQ Message to setup / release /update the connection, and the message SHOULD include the following information

- o Reconfiguration Action: indicate the reconfiguration action (0: release; 1: setup; 2: update)
- o Connection ID: identify the connection for reconfiguration

If (Reconfiguration Action is setup or update), then include the following parameters

- o IP address of the connection
- o MTU (Maximum Transmission Unit) size of the connection

6.5. MAMS Path Quality Estimation

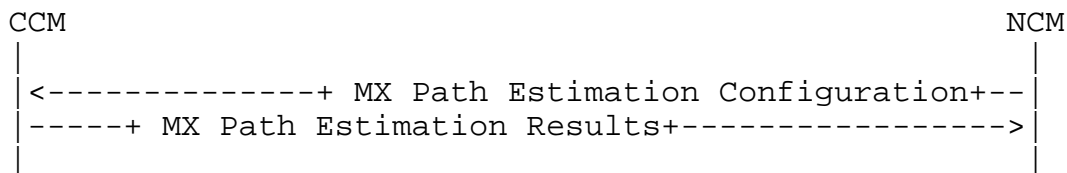


Figure 6: MAMS Control Plane Procedure for Path Quality Estimation

NCM sends following the configuration parameters in the MX Path Estimation Configuration message to the CCM

- o Connection ID (of Delivery Connection whose path quality needs to be estimated)
- o Init Probe Test Duration (ms)
- o Init Probe Test Rate (Mbps)
- o Init Probe Size (Bytes)
- o Init Probe Ack Required (0 -> No/1 -> Yes)
- o Active Probe Frequency (ms)
- o Active Probe Size (Bytes)
- o Active Probe Ack Required (0 -> No/1 -> Yes)

CCM configures the C-MADP for probe reception based on these parameters and for collection of the statistics according to the following configuration.

- o Init Probe Results Configuration

- * Lost Probes (%)
- * Probe Delay
- * Probe Rate
- o Active Probe Results Configuration
 - * Average Throughput in the last Probe Duration

The user plane probing is divided into two phases - Initialization phase and Active phase.

- o Initialization phase: A network path that is not included by N-MADP for transmission of user data is deemed to be in the Initialization phase. The user data may be transmitted over other available network paths.
- o Active phase: A network path that is included by N-MADP for transmission of user data is deemed to be in Active phase.

In Initialization phase, NCM configures N-MADP to send an MX Idle Probe REQ message. CCM collects the Idle probe statistics from C-MADP and sends the MX Path Estimation Results Message to NCM per the Initialization Probe Results configuration.

In Active phase, NCM configures N-MADP to send an MX Active Probe REQ message.. C-MADP calculates the metrics as specified by the Active Probe Results Configuration. CCM collects the Active probe statistics from C-MADP and sends the MX Path Estimation Results Message to NCM per the Active Probe Results configuration.

6.6. MAMS Traffic Steering

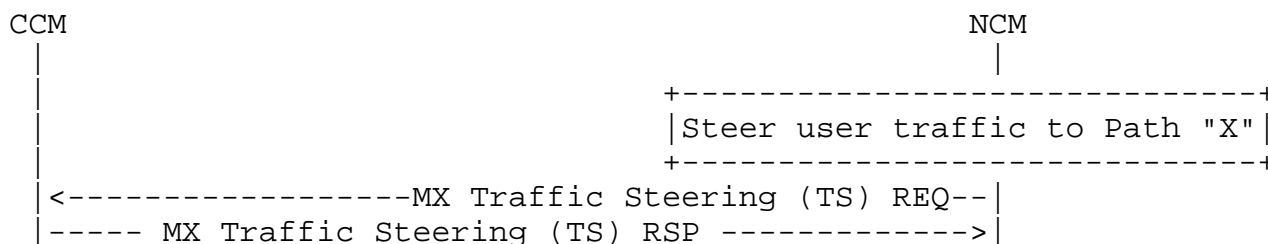


Figure 7: MAMS Traffic Steering Procedure

NCM sends out a MX Traffic Steering (TS) REQ message to steer data traffic. It is also possible to send data traffic over multiple connections simultaneously, i.e. aggregation. The message includes the following information:

- o Connection ID of the Anchor Connection

- o Connection ID List of Delivery Connections for DL traffic
- o Connection ID List of Delivery connections for UL traffic
- o MX Feature Activation List: each parameter indicates if the corresponding feature is enabled or not: lossless switching, fragmentation, concatenation, Uplink aggregation, Downlink aggregation, Measurement

In response, CCM sends out a MX Traffic Steering (TS) RSP message, including the following information:

- o MX Feature Activation List: each parameter indicates if the corresponding feature is enabled or not: lossless switching, fragmentation, concatenation, Uplink aggregation, Downlink aggregation

7. Applying MAMS Control Procedures with MPTCP Proxy as User Plane

If NCM determines that N-MADP is to be instantiated with MPTCP as the MX Convergence Protocol, it exchanges the MPTCP capability support in discovery and capability exchange procedures. NCM then exchanges the credentials of the N-MADP instance, setup as MPTCP Proxy, along with related parameters to the CCM. CCM configures C-MADP with these parameters to connect with the N-MADP (MPTCP proxy [I-D.wei-mptcp-proxy-mechanism], [I-D.boucadair-mptcp-plain-mode]) instance, on the available network path (Access).

Figure 8 shows the MAMS assisted MPTCP Proxy control procedure.

- o For securing the TCP subflow data over links that cannot be assumed to be secure, NCM configures MX Adaptation Layer. E.g. NCM can inform CCM to use IPsec as the MX Adaptation Layer over the link "X" (e.g. Wi-Fi). CCM informs C-MADP to set up IPsec (transport mode) with N-MADP using the MPTCP-Proxy IP address to protect the TCP subflow over Link "X".
- o NCM informs the CCM that N-MADP is configured as the MPTCP proxy and provides the parameters like MPTCP Proxy IP address/Port. C-MADP obtains the IP address & port of MPTCP-Proxy for Link "X" locally from CCM. This is useful if N-MADP is reachable via different IP address or/and port, from different access networks. The current MPTCP signaling can't identify or differentiate the MPTCP proxy IP address & port among multiple access networks.

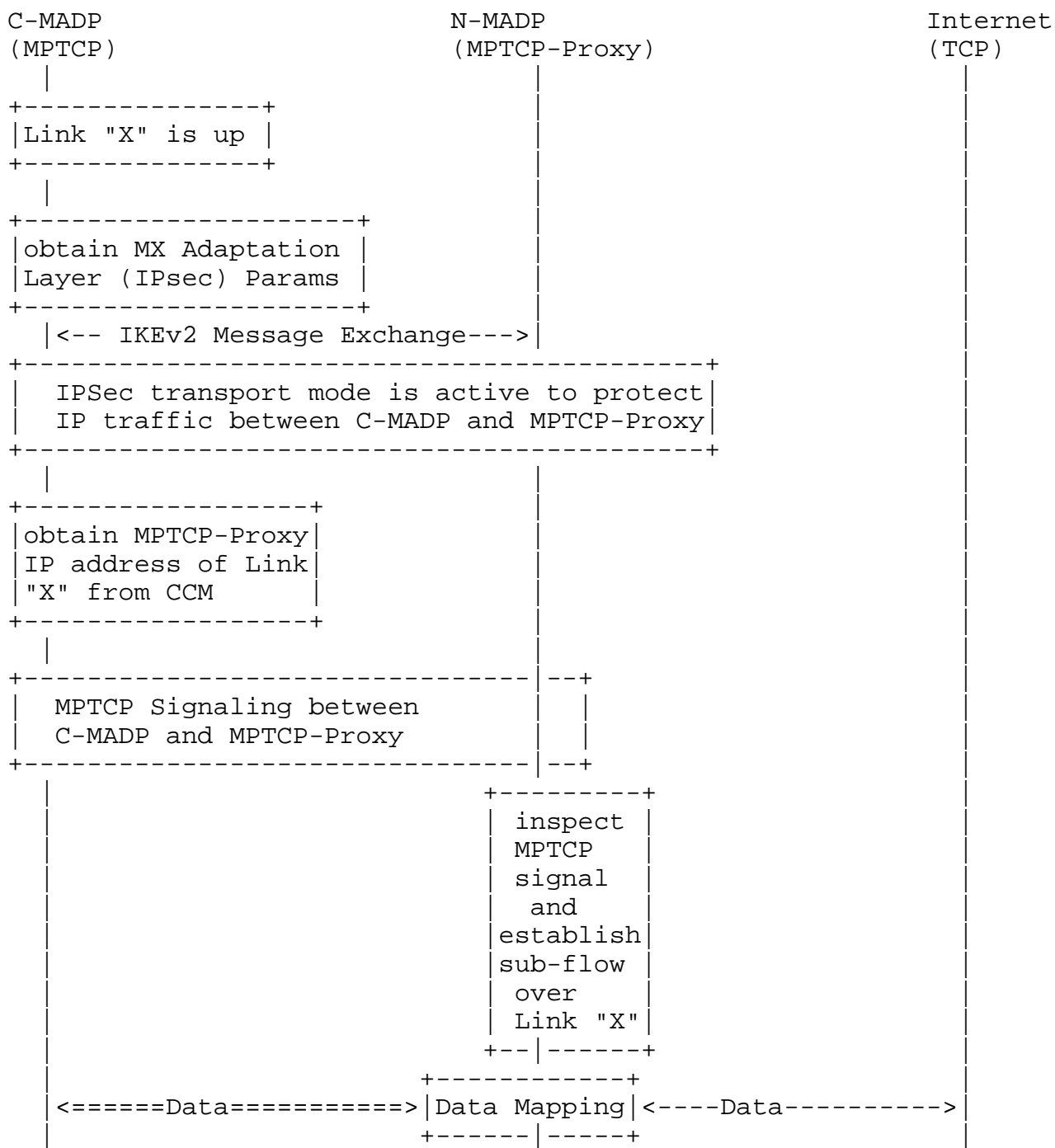


Figure 8: MAMS-assisted MPTCP Proxy as User Plane

8. Co-existence of MX Adaptation and MX Convergence Layers

MAMS u-plane protocols support multiple combinations and instances of user plane protocols to be used in the MX Adaptation and the Convergence layer.

For example, one instance of the MX Convergence Layer can be MPTCP Proxy and another instance can be Trailer based. The MX Adaptation for each can be either UDP tunnel or IPsec. IPsec may be set up when network path needs to be secured, e.g. to protect the TCP subflow traversing the network path between the client and MPTCP proxy.

Each of the instances of MAMS user plane, i.e. combination of MX Convergence and MX Adaptation layer protocols, can coexist simultaneously and independently handle different traffic types.

9. Security Considerations

9.1. MAMS Control plane security

For deployment scenarios, where the client is configured (e.g. by the network operator) to use a specific network for exchanging control plane messages and assume the network path to be secure, MAMS control messages will rely on security provided by the underlying transport network.

For deployment scenarios where the security of the network path cannot be assumed, NCM and CCM implementations MUST support the "https" URI scheme [RFC2818] and Transport Layer Security (TLS) [RFC5246] to secure control plane message exchange between the NCM and CCM.

For deployment scenarios where client authentication is desired, HTTP Digest Authentication MUST be supported. TLS Client Authentication is the preferred mechanism if it is available.

9.2. MAMS User plane security

User data in MAMS framework relies on the security of the underlying network transport paths. When this cannot be assumed, NCM configures use of protocols, like IPsec [RFC4301] [RFC3948] in the MX Adaptation Layer, for security.

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Appendix A. MAMS Control Plane Optimization over Secure Connections

If the connection between CCM and NCM over which the MAMS control plane messages are transported is assumed to be secure, UDP is used as the transport for management & control messages between NCM and UCM (see Figure 9).

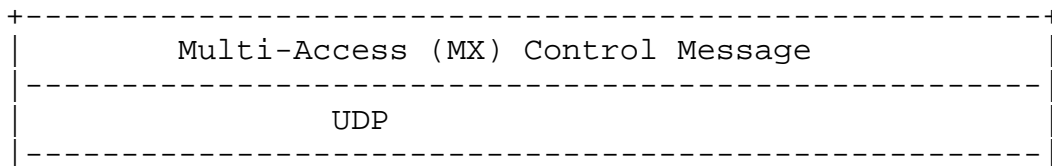


Figure 9: UDP-based MAMS Control plane Protocol Stack

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