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IETF 115
DTN Management Architecture

DTNMA Updates

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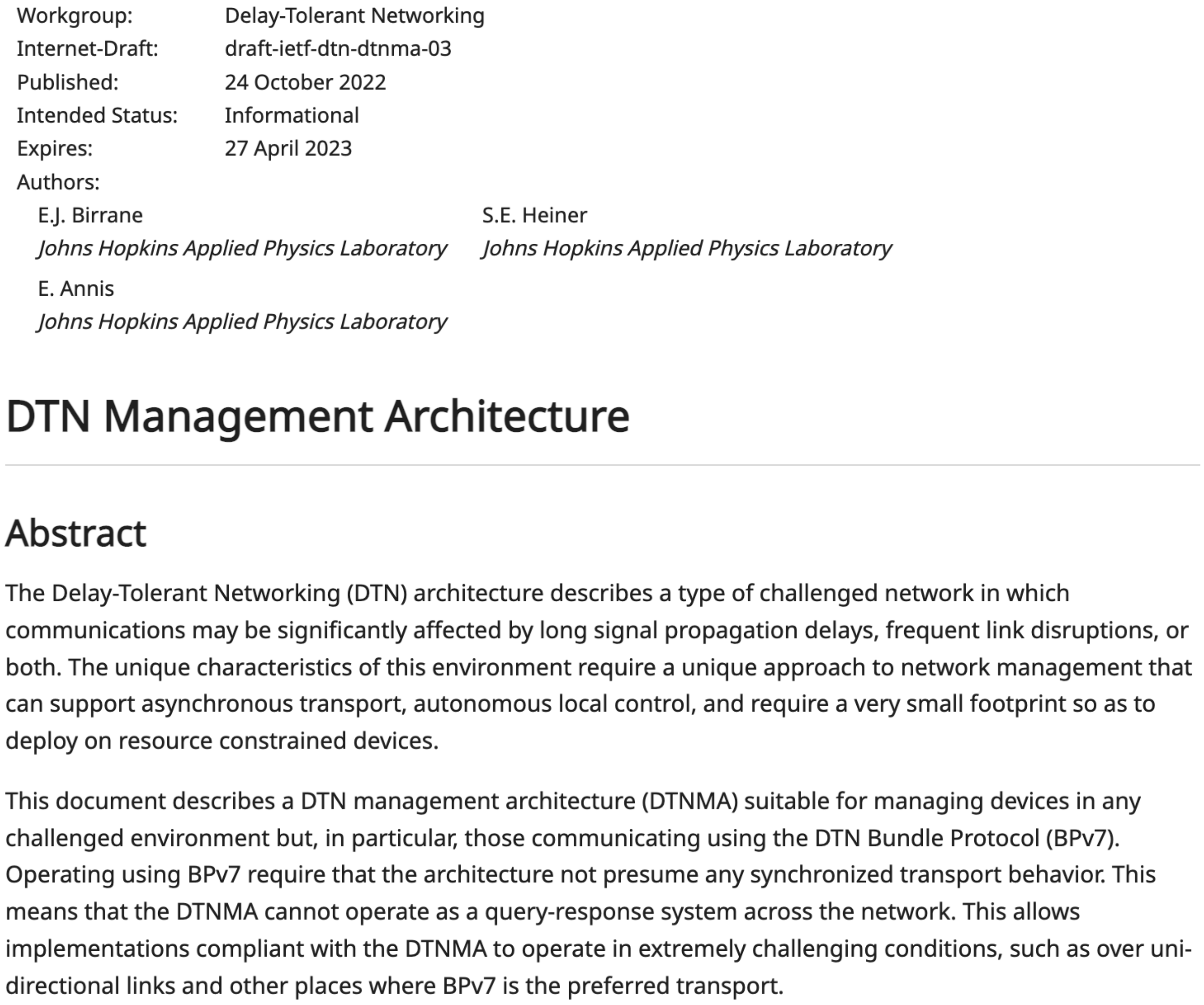
Overview

- DTNMA problem space
- Considerations from existing protocols
- DTNMA Reference Model
- DTNMA Autonomy Model



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DTN Management Architecture

Abstract

The Delay-Tolerant Networking (DTN) architecture describes a type of challenged network in which communications may be significantly affected by long signal propagation delays, frequent link disruptions, or both. The unique characteristics of this environment require a unique approach to network management that can support asynchronous transport, autonomous local control, and require a very small footprint so as to deploy on resource constrained devices.

This document describes a DTN management architecture (DTNMA) suitable for managing devices in any challenged environment but, in particular, those communicating using the DTN Bundle Protocol (BPv7). Operating using BPv7 require that the architecture not presume any synchronized transport behavior. This means that the DTNMA cannot operate as a query-response system across the network. This allows implementations compliant with the DTNMA to operate in extremely challenging conditions, such as over uni-directional links and other places where BPv7 is the preferred transport.

DTNMA Introduction

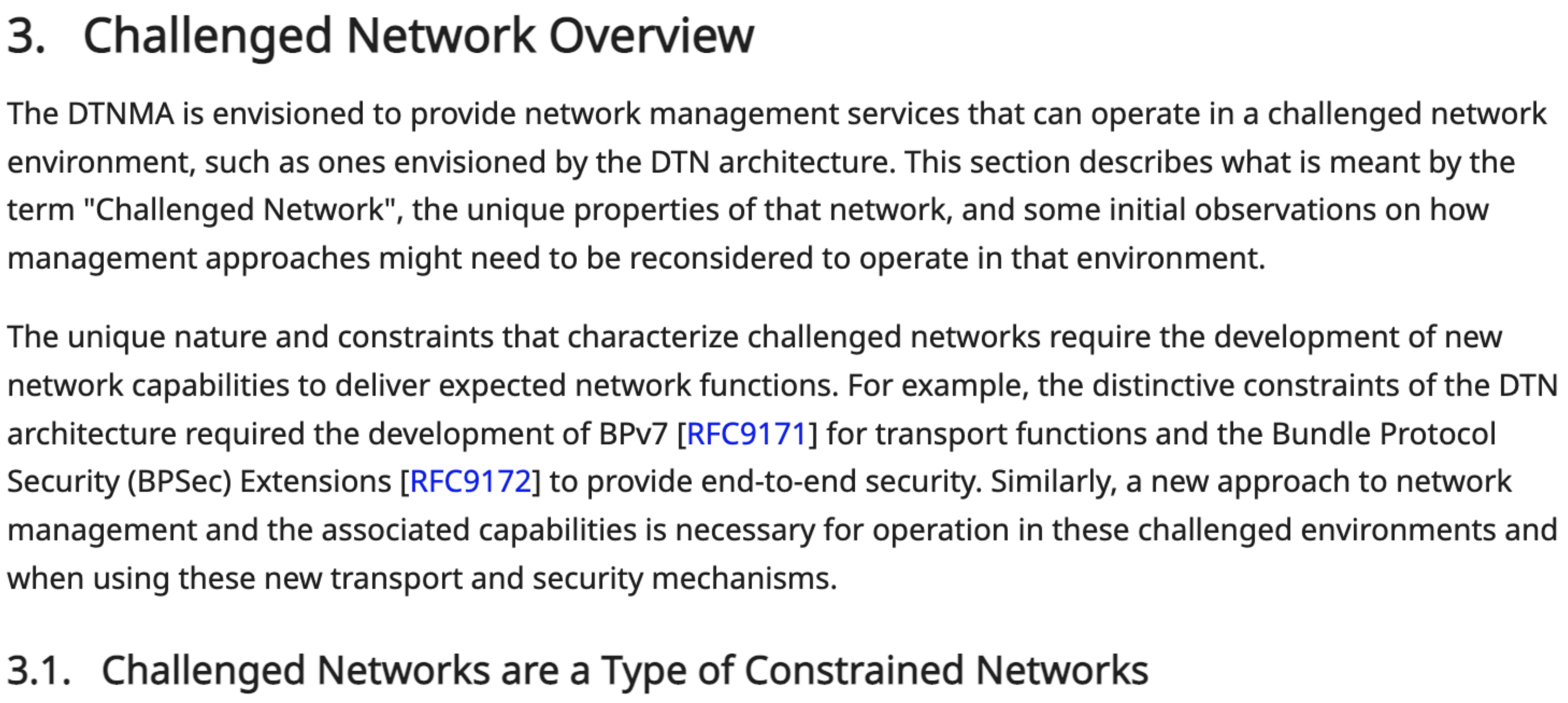
- **AMA -> DTN Network Management Architecture (DTNMA)**
    - Formerly called Asynchronous Management Architecture (AMA).
    - Renamed to capture the proper problem space.

- **DTNMA includes:**
    - A deterministic autonomy model for DTN nodes and self-management.
    - An autonomy engine on local DTN devices.
    - Naming structures that provide very compact encodings.

DTNMA Addresses Challenged Networks

Defining the problem space

- **Differentiate between constrained and challenged networks**
- **A DTN is a challenged network**
- **Must address both constraints and challenges like disruptions and delays**



3. Challenged Network Overview

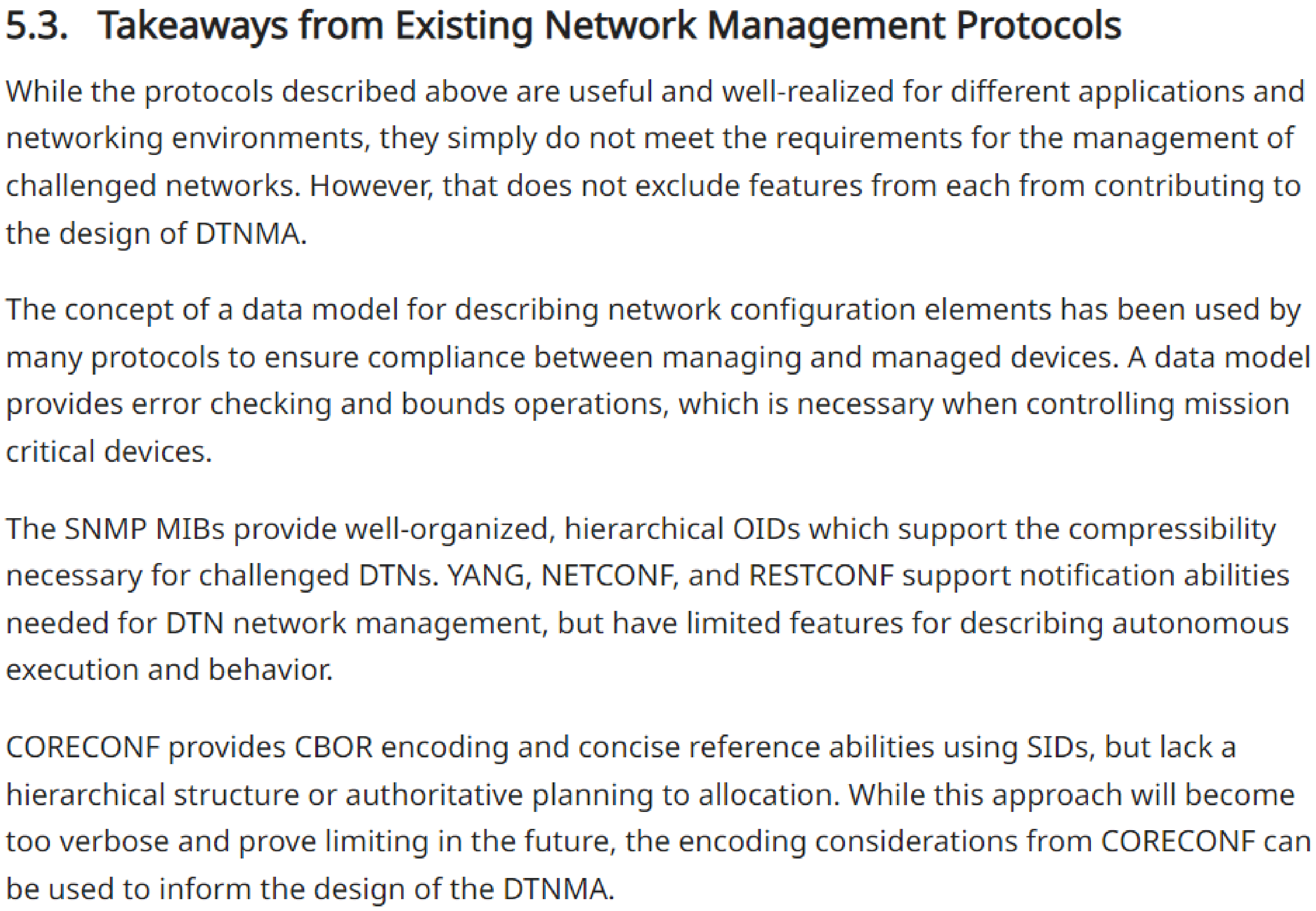
The DTNMA is envisioned to provide network management services that can operate in a challenged network environment, such as ones envisioned by the DTN architecture. This section describes what is meant by the term "Challenged Network", the unique properties of that network, and some initial observations on how management approaches might need to be reconsidered to operate in that environment.

The unique nature and constraints that characterize challenged networks require the development of new network capabilities to deliver expected network functions. For example, the distinctive constraints of the DTN architecture required the development of BPv7 [RFC9171] for transport functions and the Bundle Protocol Security (BPSec) Extensions [RFC9172] to provide end-to-end security. Similarly, a new approach to network management and the associated capabilities is necessary for operation in these challenged environments and when using these new transport and security mechanisms.

3.1. Challenged Networks are a Type of Constrained Networks

DTNMA Informed by Existing Protocols

- Discuss existing approaches and why we need something new
- SNMP and NETCONF
  - Require low latency sessions
- RESTConf
  - Stateless
  - Requires HTTPS and large data transfers
- CORECONF over CoAP
  - More concise encodings
  - YANG schema



5.3. Takeaways from Existing Network Management Protocols

While the protocols described above are useful and well-realized for different applications and networking environments, they simply do not meet the requirements for the management of challenged networks. However, that does not exclude features from each from contributing to the design of DTNMA.

The concept of a data model for describing network configuration elements has been used by many protocols to ensure compliance between managing and managed devices. A data model provides error checking and bounds operations, which is necessary when controlling mission critical devices.

The SNMP MIBs provide well-organized, hierarchical OIDs which support the compressibility necessary for challenged DTNs. YANG, NETCONF, and RESTCONF support notification abilities needed for DTN network management, but have limited features for describing autonomous execution and behavior.

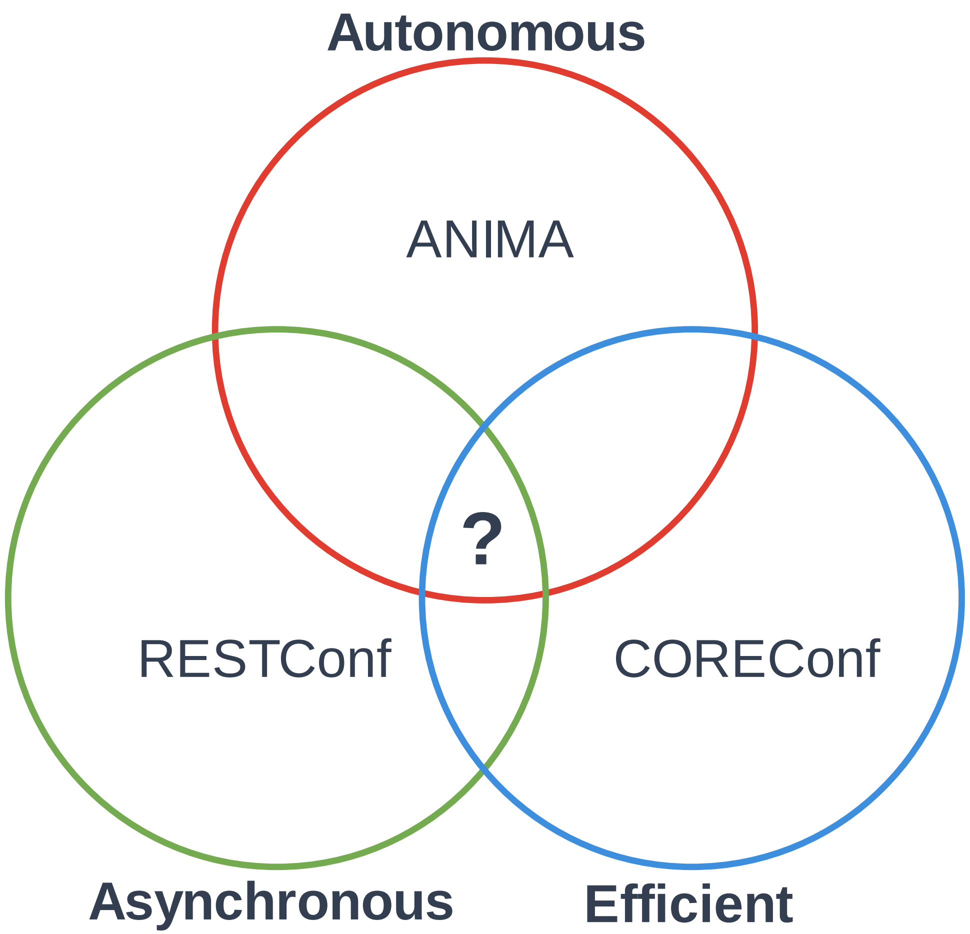
CORECONF provides CBOR encoding and concise reference abilities using SIDs, but lack a hierarchical structure or authoritative planning to allocation. While this approach will become too verbose and prove limiting in the future, the encoding considerations from CORECONF can be used to inform the design of the DTNMA.

DTN-Based Network Management

Approach to address the intersection of three needs

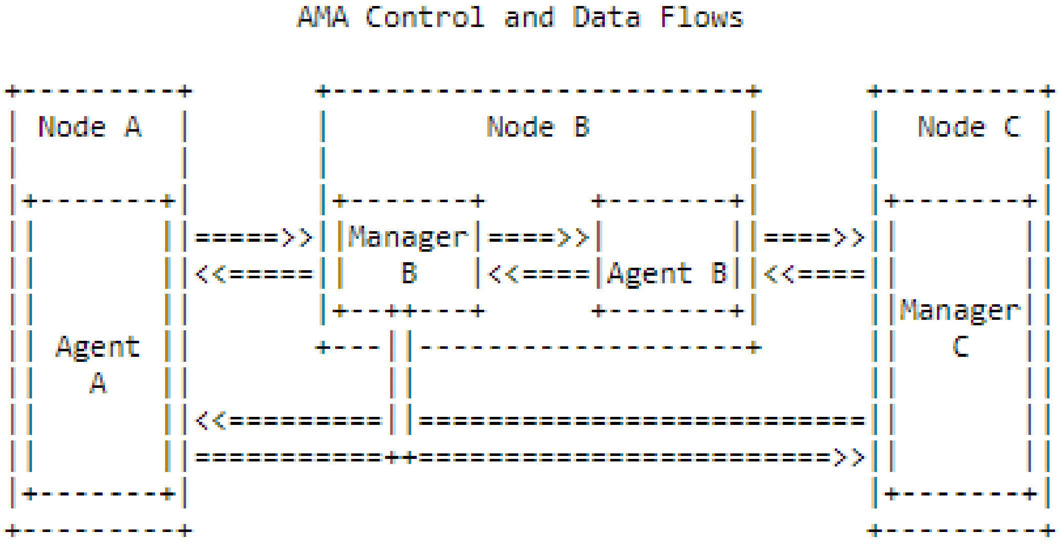
- **Existing work in the areas DTN-based Network Management has to support:**

- **Autonomy**
  - Work being done by the IETF Anima WG: autonomy for distributed calculation of network data for data centers.
  - Not the autonomy needed for DTN NM.
- **Asynchronous Behavior**
  - RESTConf does not require NETCONF sessions.
  - Requires running over HTTPS.
- **Efficient Encodings/Processing**
  - CoAP-based protocols have relatively small encodings.
  - Uses HTTP GET/PUT.
  - No autonomy model.



Updated DTNMA Reference Model

AMA Model (from older document versions)



```
                 AMA Control and Data Flows

+---------+       +------------------------+      +---------+
| Node A  |       |         Node B         |      |  Node C |
|         |       |                        |      |         |
|+-------+|       |+-------+      +-------+|      |+-------+|
||       ||=====>>||Manager|====>>|       ||====>>||       ||
||       ||<<=====||   B   |<<====|Agent B||<<====||       ||
||       ||       |+--++---+      +-------+|      ||Manager||
|| Agent ||       +---||-------------------+      ||   C   ||
||   A   ||           ||                          ||       ||
||       ||<<=========||==========================||       ||
||       ||===========++========================>>||       ||
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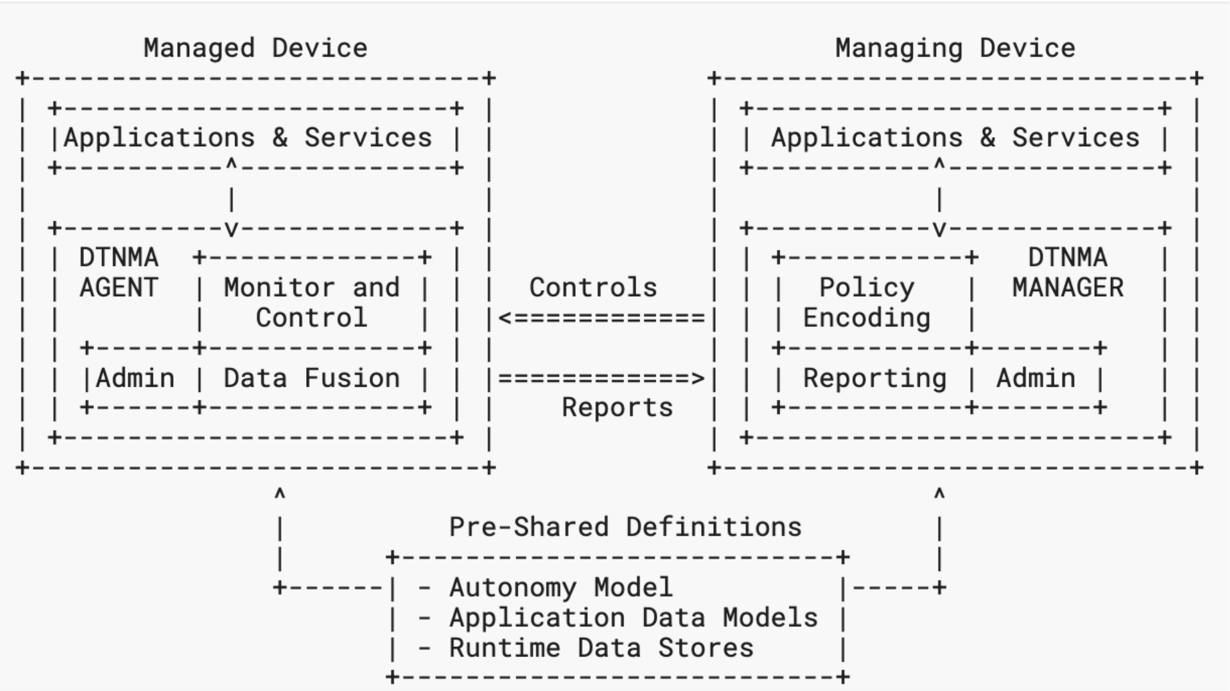
Earlier reviews indicated the AMA was too generic in describing NM autonomy.

Current DTNMA Model



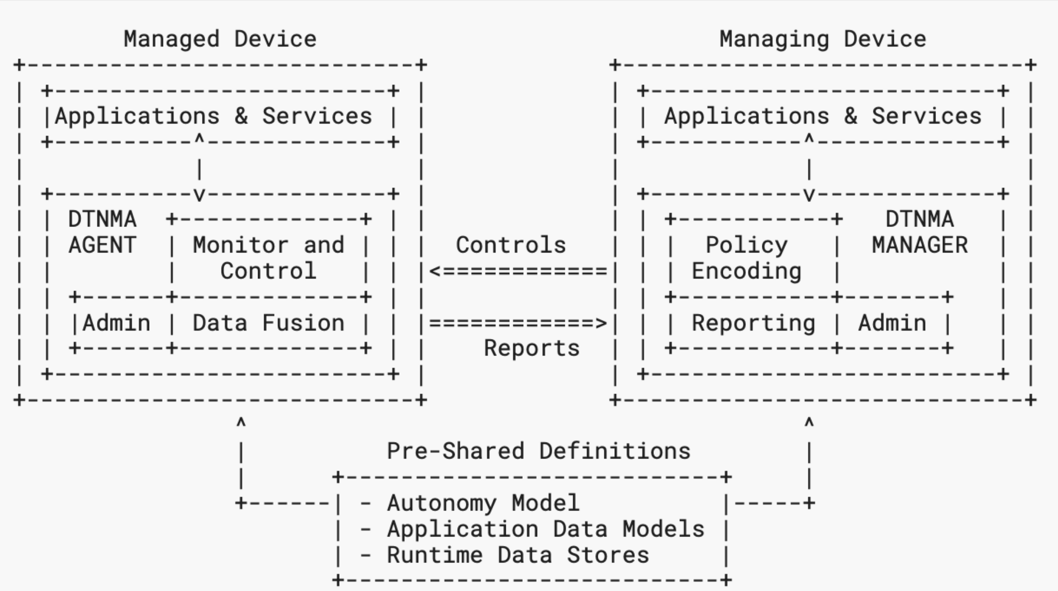
```
        Managed Device                             Managing Device
+----------------------------+             +-----------------------------+
| +------------------------+ |             | +-------------------------+ |
| |Applications & Services | |             | | Applications & Services | |
| +----------^-------------+ |             | +-----------^-------------+ |
|            |               |             |             |               |
| +----------v-------------+ |             | +-----------v-------------+ |
| | DTNMA  +-------------+ | |             | | +-----------+   DTNMA   | |
| | AGENT  | Monitor and | | |  Controls   | | |  Policy   |  MANAGER  | |
| |        |   Control   | | |<============| | | Encoding  |           | |
| | +------+-------------+ | |             | | +-----------+-------+   | |
| | |Admin | Data Fusion | | |============>| | | Reporting | Admin |   | |
| | +------+-------------+ | |    Reports  | | +-----------+-------+   | |
| +------------------------+ |             | +-------------------------+ |
+----------------------------+             +-----------------------------+
                ^                                        ^
                |          Pre-Shared Definitions        |
                |      +---------------------------+     |
                +------| - Autonomy Model          |-----+
                       | - Application Data Models |
                       | - Runtime Data Stores     |
                       +---------------------------+
```

Updated DTNMA clarifies how this NM approach benefits from an autonomy engine and uses policy.

DTNMA Reference Model

Enabling device self-management

- **Pre-Shared Definitions**
  - Pre-shared data and models.
  - Standardize static data definitions wherever possible.
  - Negotiated during brief periods of connectivity.
- **DTNMA Agent Self-Management**
  - Managed device often disconnected.
  - Local autonomy engine enables self-management.
  - Application of pre-shared policies.
- **Command-Based Management**
  - Cannot perform bulk updates with large data stores.
  - Managing devices instead use a command and control interface.
  - Enables updates to the managed device from
    - Remote managers
    - Local autonomy engine



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        Managed Device                             Managing Device
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| | DTNMA  +-------------+ | |             | | +-----------+   DTNMA   | |
| | AGENT  | Monitor and | | |  Controls   | | |  Policy   |  MANAGER  | |
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                |          Pre-Shared Definitions        |
                |      +---------------------------+     |
                +------| - Autonomy Model          |-----+
                       | - Application Data Models |
                       | - Runtime Data Stores     |
                       +---------------------------+
```
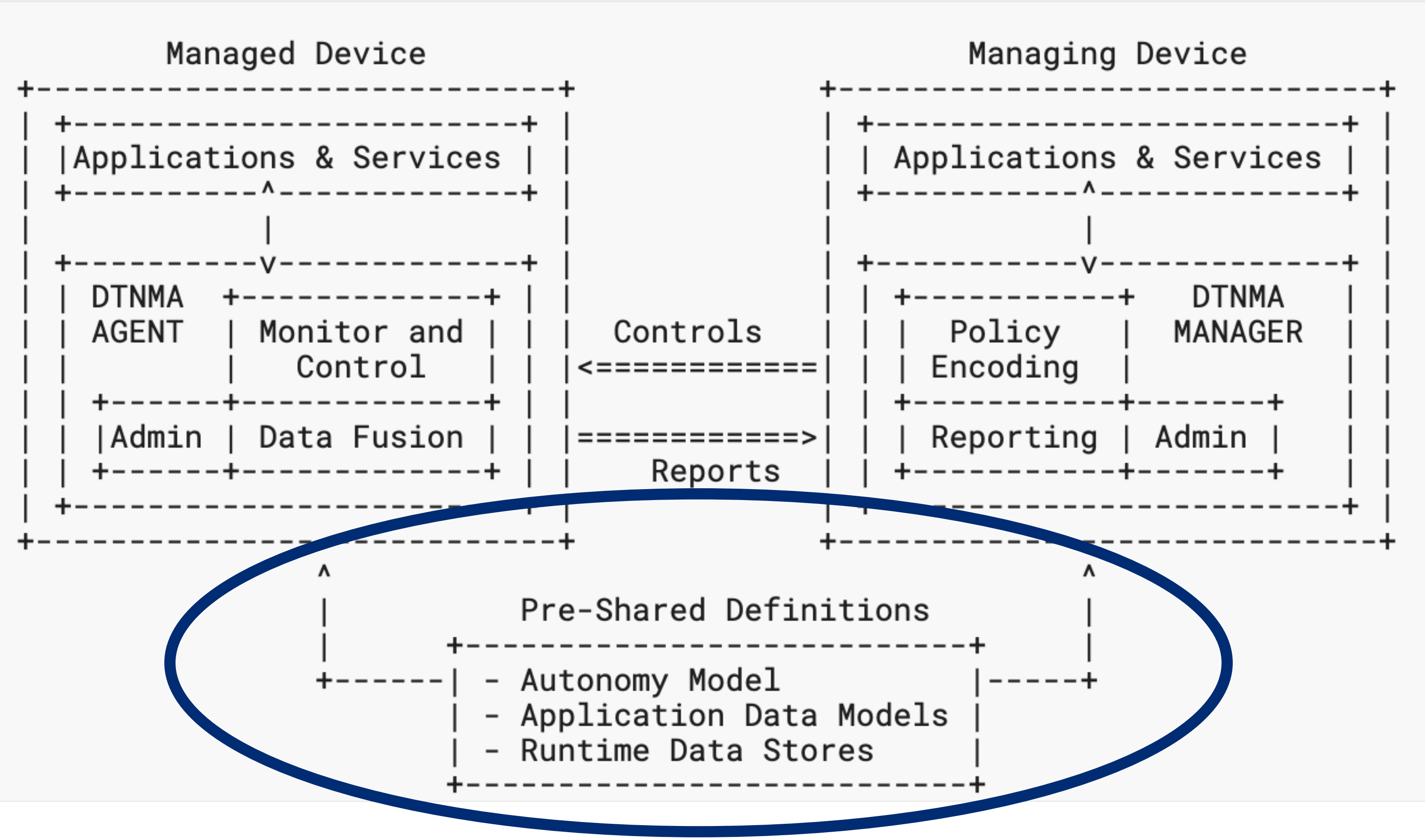

DTNMA Reference Model

Pre-Shared Definitions

- Challenged environment
- Real-time data negotiation not a guarantee
- Pre-shared data includes
  - Autonomy Model
  - ADMs
  - Runtime Data Stores



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        Managed Device                             Managing Device
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| |Applications & Services | |             | | Applications & Services | |
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| | DTNMA  +-------------+ | |             | | +-----------+   DTNMA   | |
| | AGENT  | Monitor and | | |  Controls   | | |  Policy   |  MANAGER  | |
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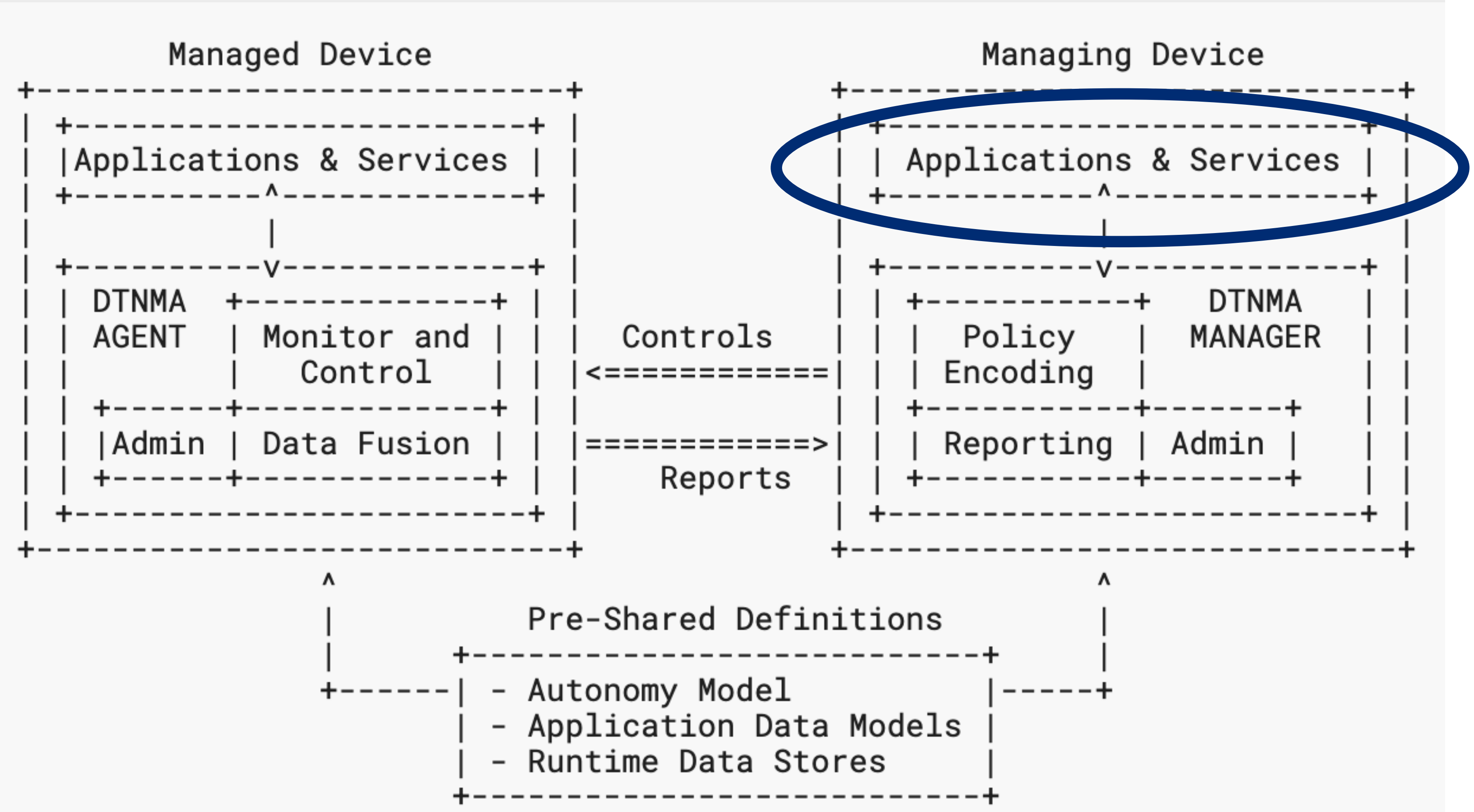
                |          Pre-Shared Definitions        |
                |      +---------------------------+     |
                +------| - Autonomy Model          |-----+
                       | - Application Data Models |
                       | - Runtime Data Stores     |
                       +---------------------------+
```

DTNMA Reference Model

Managing Applications and Services

- Source for policy statements
- Target for DTNMA Agent reporting
- Operate with or without an operator in the loop
- Open-loop control



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            Managed Device                               Managing Device
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| +-------------------------+ |               | +-------------------------+ |
| |Applications & Services  | |               | | Applications & Services | |
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| | DTNMA  +--------------+ | |               | | +----------+   DTNMA    | |
| | AGENT  | Monitor and  | | |   Controls    | | | Policy   |  MANAGER   | |
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                |            Pre-Shared Definitions         |
                |      +---------------------------+        |
                +------| - Autonomy Model          |--------+
                       | - Application Data Models |
                       | - Runtime Data Stores     |
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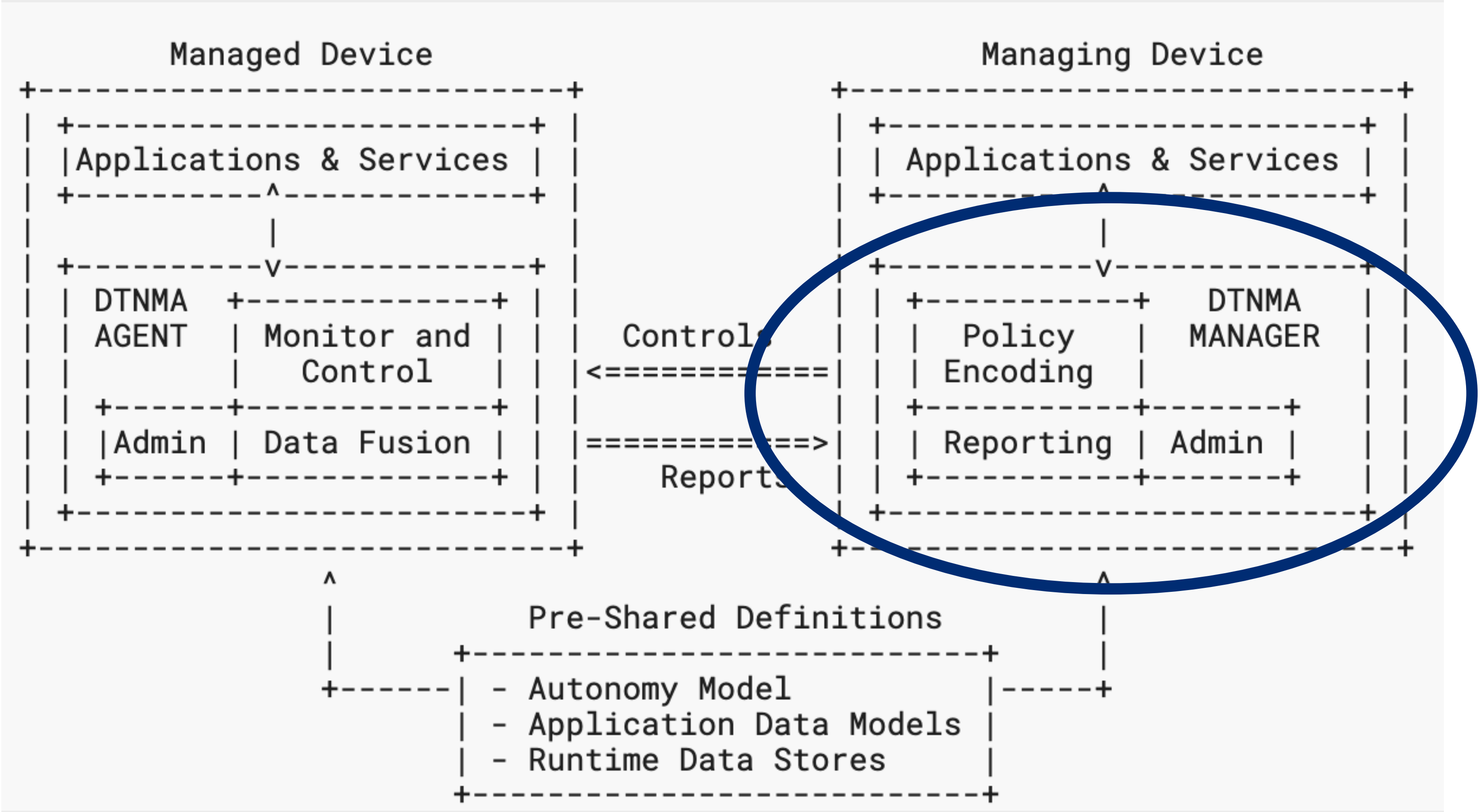
DTNMA Reference Model

DTNMA Manager

- Interface between managing apps and DAs
- Translate policy directives to standard expressions
- Receive reports
- Admin configuration



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          Managed Device                            Managing Device
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| +-------------------------+ |               | +-------------------------+ |
| |Applications & Services | |               | | Applications & Services | |
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| | DTNMA  +-------------+ | |               | | +----------+  DTNMA     | |
| | AGENT  | Monitor and | | |   Controls    | | | Policy   |  MANAGER   | |
| |        |   Control   | | |<==============| | | Encoding |            | |
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| | |Admin | Data Fusion | | |==============>| | | Reporting | Admin |    | |
| | +------+-------------+ | |   Reports     | | +----------+-------+    | |
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              ^                                           ^
              |          Pre-Shared Definitions           |
              |      +----------------------------+       |
              +------| - Autonomy Model           |-------+
                     | - Application Data Models  |
                     | - Runtime Data Stores      |
                     +----------------------------+
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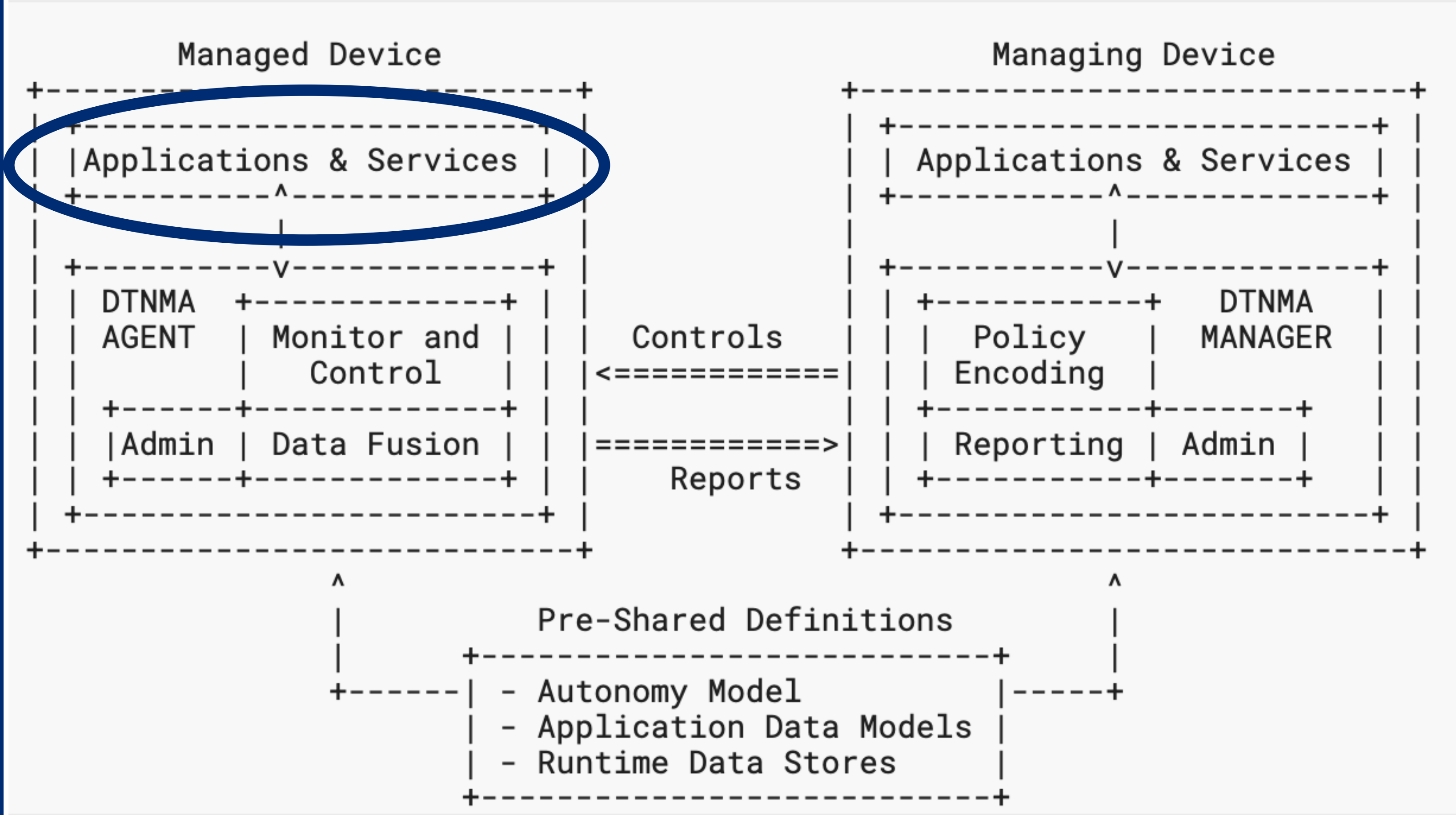
DTNMA Reference Model

Managed Applications and Services

- Periodic monitoring performed by the DA
- DA uses a control interface to:
  - Sample state information
  - Alter configuration
  - Impact behavior



```
        Managed Device                             Managing Device
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| +------------------------+ |             | +-------------------------+ |
| |Applications & Services | |             | | Applications & Services | |
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| | DTNMA  +-------------+ | |             | | +-----------+  DTNMA    | |
| | AGENT  | Monitor and | | |  Controls   | | |  Policy   | MANAGER   | |
| |        |   Control   | | |<============| | | Encoding  |           | |
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| | |Admin | Data Fusion | | |============>| | | Reporting | Admin |   | |
| | +------+-------------+ | |    Reports  | | +-----------+-------+   | |
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                |          Pre-Shared Definitions        |
                |      +---------------------------+     |
                +------| - Autonomy Model          |-----+
                       | - Application Data Models |
                       | - Runtime Data Stores     |
                       +---------------------------+
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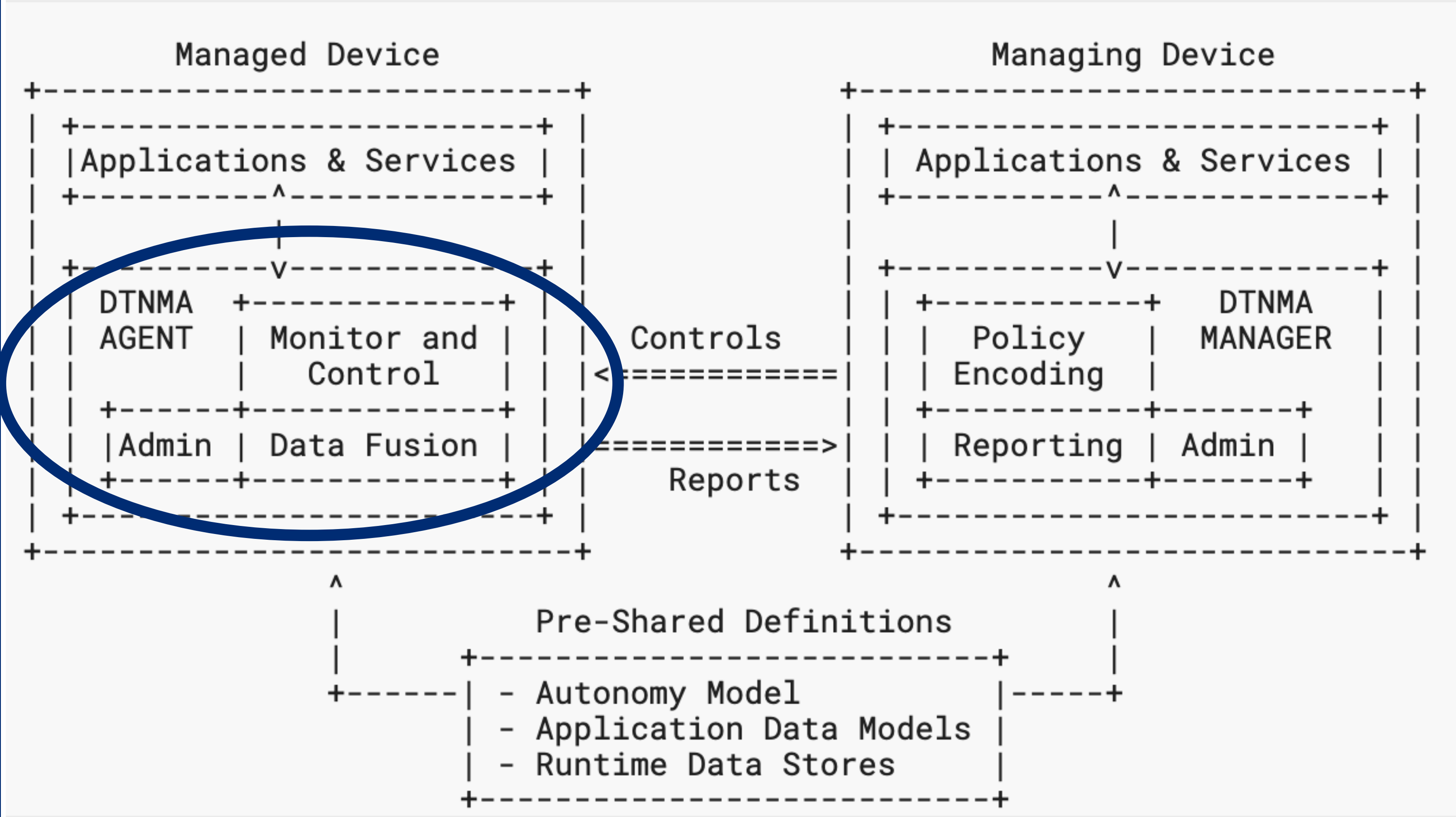
DTNMA Reference Model

DTNMA Agent

- Monitoring and control without regular connection
- Maintenance of rules and autonomy engine
- Data fusion for reporting
- Admin configuration



```
           Managed Device                         Managing Device
+-----------------------------+           +-----------------------------+
| +-------------------------+ |           | +-------------------------+ |
| |Applications & Services  | |           | | Applications & Services | |
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| | DTNMA  +-------------+  | |           | | +-----------+   DTNMA   | |
| | AGENT  | Monitor and |  | | Controls  | | |  Policy   |  MANAGER  | |
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| | |Admin | Data Fusion |  | |==========>| | | Reporting | Admin |   | |
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              |            Pre-Shared Definitions       |
              |      +----------------------------+     |
              +------| - Autonomy Model           |-----+
                     | - Application Data Models  |
                     | - Runtime Data Stores      |
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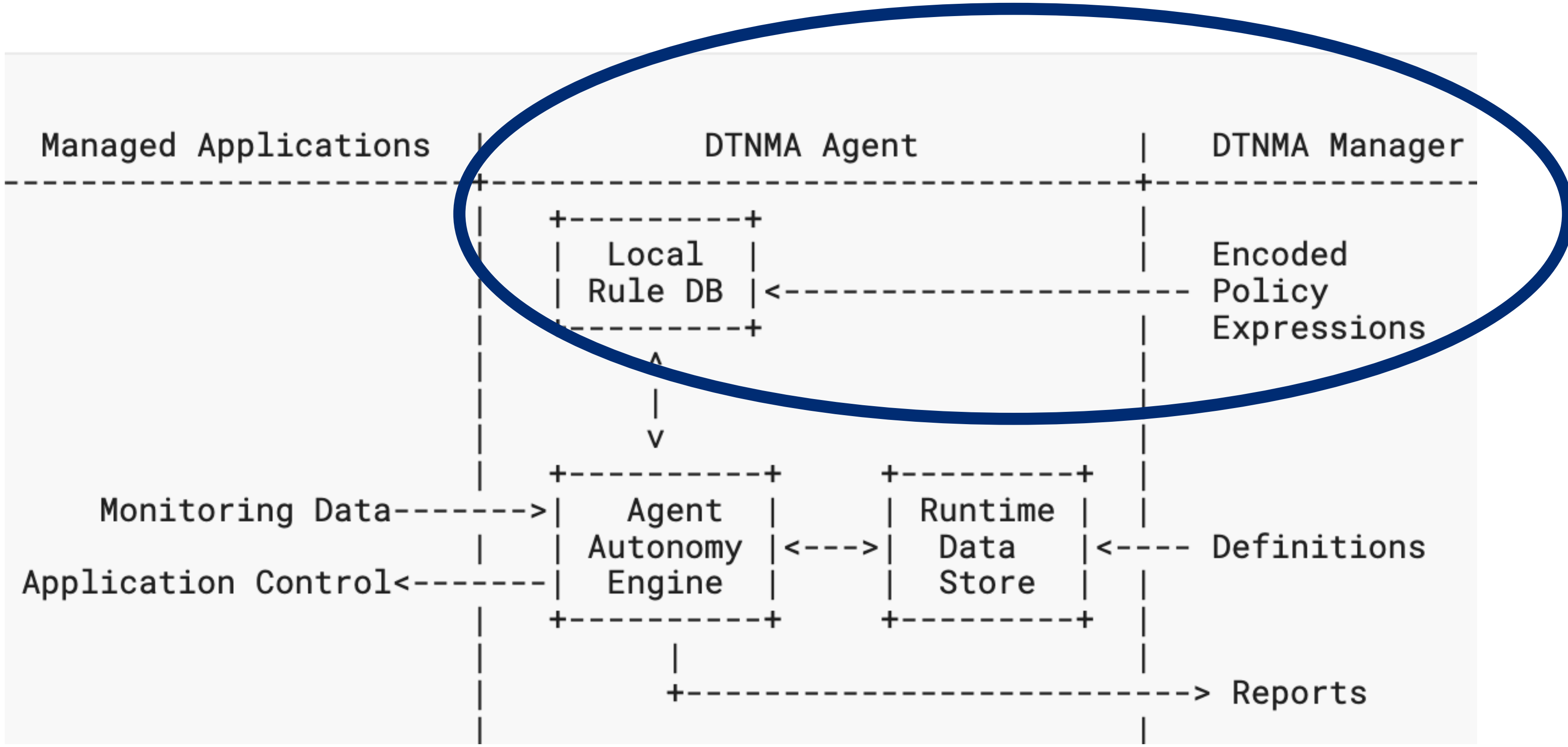
DTNMA Autonomy Model

Predicate Autonomy

- DTNMA Manager provides policy expressions
- IF stimulus THEN response
- Populates the rules known to the DTNMA Agent

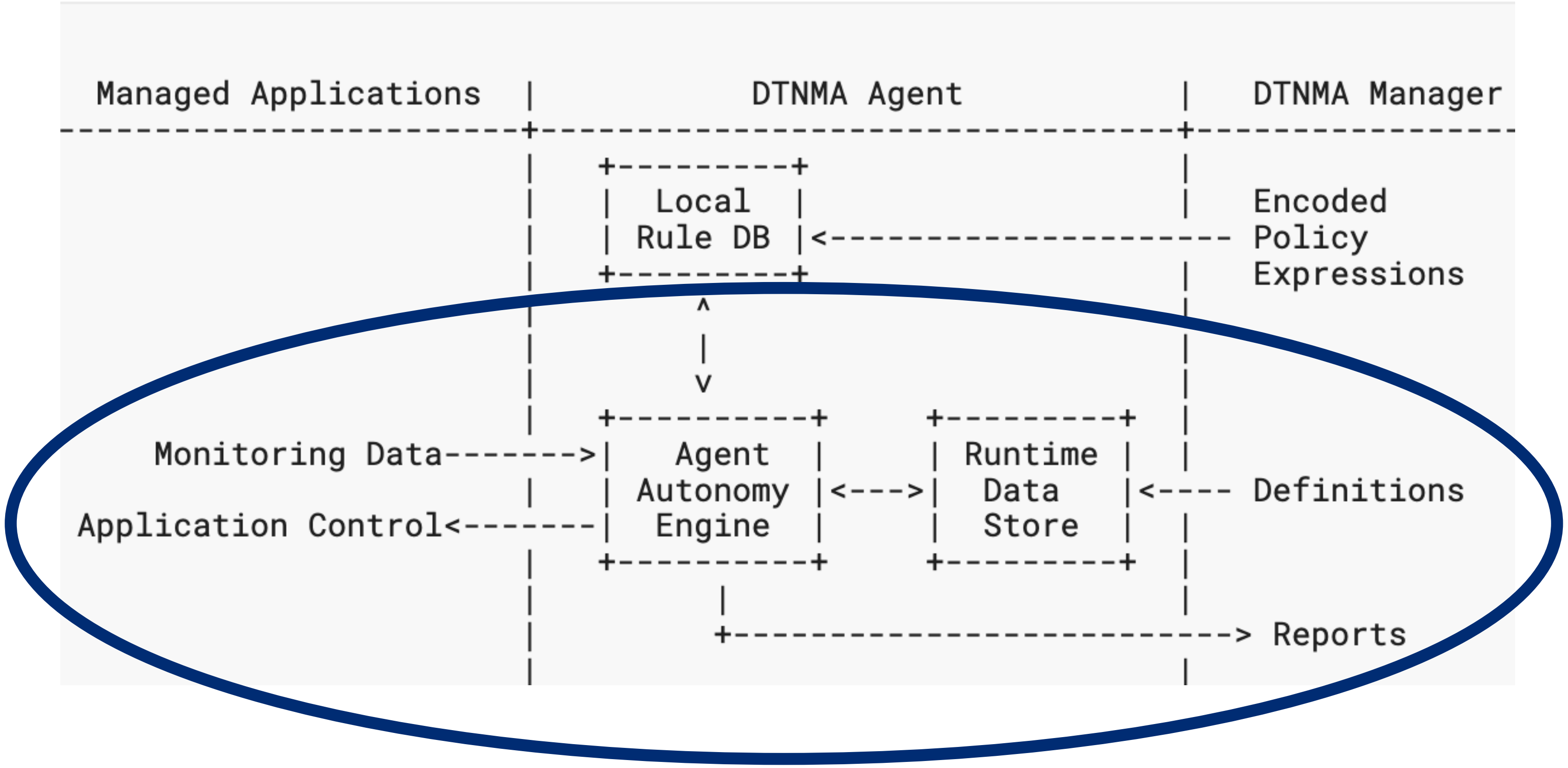


```
  Managed Applications  |           DTNMA Agent           |   DTNMA Manager
------------------------+---------------------------------+------------------
                        |   +---------+                   |
                        |   |  Local  |                   |   Encoded
                        |   | Rule DB |<--------------------- Policy
                        |   +---------+                   |   Expressions
                        |        ^                        |
                        |        |                        |
                        |        v                        |
                        |   +----------+     +---------+  |
     Monitoring Data------->|   Agent  |     | Runtime |  |
                        |   | Autonomy |<--->|  Data   |<---- Definitions
 Application Control<-------|  Engine  |     |  Store  |  |
                        |   +----------+     +---------+  |
                        |         |                       |
                        |         +--------------------------> Reports
                        |                                 |
```

DTNMA Autonomy Model

Acting on Local Rules

- Agent monitors the state of local applications
- Responses:
  - Update rule database
  - Update runtime data store
  - Send control to application
  - Generate reports



```
  Managed Applications  |           DTNMA Agent           |   DTNMA Manager
------------------------+---------------------------------+-----------------
                        |   +---------+                   |
                        |   |  Local  |                   |   Encoded
                        |   | Rule DB |<--------------------- Policy
                        |   +---------+                   |   Expressions
                        |        ^                        |
                        |        |                        |
                        |        v                        |
                        |   +----------+     +---------+  |
     Monitoring Data------->|   Agent  |     | Runtime |  |
                        |   | Autonomy |<--->|  Data   |<---- Definitions
 Application Control<-------|  Engine  |     |  Store  |  |
                        |   +----------+     +---------+  |
                        |         |                       |
                        |         +--------------------------> Reports
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