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DTN Management Architecture

DTNMA Updates

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Overview

- Current version 05
- Reference Model
- Autonomy Model
- Design Decisions
- Use Cases

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 supports asynchronous transport, autonomous local control, and a small footprint (in both resources and dependencies) so as to deploy on 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 (BP). Operating over BP requires an architecture that neither presumes synchronized transport behavior nor relies on query-response mechanisms. Implementations compliant with this DTNMA should expect to successfully operate in extremely challenging conditions, such as over uni-directional links and other places where BP is the preferred transport.
DTNMA Key Features

Building autonomous management for challenged networking environments

1. Open Loop Control
   • Cannot guarantee timely, round-trip communications.
   • Move away from request-response architecture.

2. Standard Autonomy Model
   • Standard policy expressions.
   • Guarantee deterministic behavior across devices and vendor implementations.

3. Compressible Model Structure
   • Data model for shared data definitions.
   • Use common data schema elements: hierarchical structure, compression.
   • Enable compact encodings with model design.

New capabilities provided by existing mechanisms:

• Message Data Exchange
  - BPv7
• Data Representations
  - CBOR
• Data Modeling Languages
  - YANG
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
DTNMA Autonomy Model

Predicate Autonomy

- DM configures the DA autonomy engine
- DA monitors the state of local applications
- DA Responses:
  - Update rule database
  - Update runtime data store
  - Send control to application
  - Generate reports
DTNMA Desirable Design Properties
The DTNMA is designed for operation in challenged environments

1. Dynamic Architectures
2. Hierarchically Modeled Information
   - Concise data representation
3. Adaptive Push of Information
4. Efficient Data Encoding
5. Universal, Unique Data Identification
   - Avoid round-trip lookups and synchronization of state information
6. Runtime Data Definition
   - Compact reporting preserves link capacity and processing time
7. Autonomous Operation
   - Stand-alone operation
   - Deterministic, engine-based behavior
**Dynamic Architectures**

**Design Property 1**

- Accommodate dynamic network topologies
  - Anticipate operation in partitioned environments
  - Topology will change over time
  - Avoid assumptions that create a fragile solution/brittle management framework and limit performance

- Agnostic of:
  - Physical topology
  - Network supporting infrastructure
  - Underlying transport protocols
  - Security solutions

- Avoid prescribed association between DTNMA Managers and Agents

DTNMA is designed to run in every environment BP may be used, but there is no underlying transport protocol requirement.
Hierarchically Modeled Information

Design Property 2

- Models provide syntactic and semantic contracts for data exchange
  - Validation
  - Pre-defined data representation
- Cohesive models
  - Manage a single application/protocol
  - Ex: BPv7, BPSec ADMs
- Hierarchically related models
  - Inclusion mechanisms to inherit model contents
  - Avoid repetition, allow re-use of data models
- Supports DA autonomy engines: parameterization, filtering, and event driven behaviors
- Enables interoperable report parsing on DMs

Provides:
- Compressible data identification
- Concise encoding
- Pattern matching
- Parameterization
- DA autonomy functions
- DM report parsing
Adaptive Push of Information
Design Property 3

- DAs push information to DMs
  - DA evaluation of local state
  - Leverage local autonomy engine

- Adaptive push leverages local autonomy engine
  - DA decides what data to push, and when
  - Based on changes in internal state
  - Event-based reporting
  - Pushed data may be queued depending on connectivity

- Best choice for a challenged network
  - Pull mechanisms can increase overall traffic
  - May prevent autonomy at managed devices

Local autonomy at the managed device (DA) determines what information is sent to the managing device (DM) and when.

Time and State-Based Rules (TBR and SBR).
Efficient Data Encoding

Design Property 4

• Priority: efficient on-the-wire encoding
• Prefer additional node processing to larger message size
  - Consider the asynchronous nature of challenged networks
• Minimal message size benefits:
  - Requires smaller windows of connectivity
  - Associated with less retransmission cost
  - Consume less resources when messages are stored en-route

Compact encodings result from data models designed for compression.

The proposed hierarchical data model for the DTNMA addresses this priority.
Universal, Unique Data Identification

Design Property 5

• Manipulation of individual data elements requires:
  - Unique identification
  - Absolute, universal identification

• The identifier for a data element should be the same regardless of:
  - Role
  - Implementation
  - Network instance

• Avoids approaches designed for reliable, round-trip communications:
  - Associative lookups
    • Impacted by delays and potential configuration changes
  - Synchronizing on state information
    • Prevented by disruptions to connectivity

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Extract from BPv7 BPA ADM

```json

// Excerpt from BPv7 BPA ADM

"Mdat": [{
  "name": "name",
  "type": "STR",
  "value": "bp_agent",
  "description": "The human-readable name of the ADM."
},

{ "name": "namespace",
  "type": "STR",
  "value": "Dtn/bp_agent",
  "description": "The namespace of the ADM."
},

{ "name": "version",
  "type": "STR",
  "value": "v0.1",
  "description": "The version of the ADM"
},

{ "name": "organization",
  "type": "STR",
  "value": "JHUAPL",
  "description": "The name of the issuing organization of the ADM."
}

"Edd": [{
  "name": "bp_node_id",
  "type": "STR",
  "description": "The node administration endpoint"
},

{ "name": "bp_node_version",
  "type": "STR",
  "description": "The latest version of the BP supported by this node"
}

```
Runtime Data Definition
Design Property 6

- Support custom data definitions
  - May be applicable to a particular device, network, scenario, etc.

- New data defined from existing data
  - Data fusion
  - Sampling
  - Averaging

- Supports more efficient reporting by DAs
  - Local data fusion
  - Definition of new reporting templates
Autonomous Operation

Design Property 7

- Stand-Alone Operation
  - DA self-management
  - Enabled by pre-configuration

- Deterministic Behavior
  - DM can predict DA state when disconnected

- Engine-Based Behavior
  - Move away from mobile code solutions
  - Configurable autonomy engine

- Authentication, Authorization, and Accounting
  - Standard approach as an underlying protocol stack is not specified
  - Support multiple, concurrently active DMs
Use Cases
DTNMA applied to challenged network scenarios

- Serialized Management
- Intermittent Connectivity
- Open-Loop Reporting
- Multiple Administrative Domains
- Cascading Management

Open-Loop Reporting, Data Fusion

Single Node, DM and DA Roles
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