

**net2**  
Technical Specification

Eric Griffis  
dedbox@gmail.com

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## **Abstract**

This is a technical specification for **net2**, a networking abstraction for URL-addressable agents communicating via byte streams. Its purpose is to drive the engineering design process.

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# Chapter 1

## Introduction

This report defines an abstract model for `net2`.

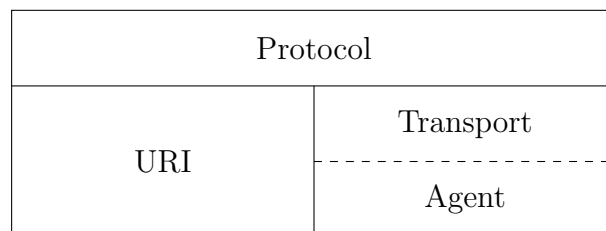


Figure 1.1: The `net2` API stack

# Chapter 2

## URI

- Explain how URIs work in `net2`.

“A URI has several parts. The authority defines *who* you are talking to. The scheme defines *how* you talk to them. The path and query define *what resource* you’re talking to them about.”

- We roll our own URI sub-system.

$\mathcal{S}$  = schemes

$\mathcal{A}$  = authorities

$\mathcal{P}$  = paths

$\mathcal{Q}$  = queries

scheme :  $\mathcal{U} \rightarrow \mathcal{S}$

authority :  $\mathcal{U} \rightarrow \mathcal{A}$

path :  $\mathcal{U} \rightarrow \mathcal{P}$

query :  $\mathcal{U} \rightarrow \mathcal{Q}$

# Chapter 3

## Transport

A *byte stream* is a one-way communications channel. A *connection* is a pair of opposing byte streams.

### 3.1 Primitive types

#### References

$$\mathcal{L} = \text{listeners} \qquad \mathcal{T} = \text{transports} \qquad \mathcal{R} = \mathcal{L} \cup \mathcal{T}$$

A *reference* is an opaque token that represents a portion of run-time state. A listener represents a connection request queue. A transport represents a connection.

#### Ports

$$\mathcal{I} = \text{input ports} \qquad \mathcal{O} = \text{output ports}$$

A *port* is a host platform object that represents one end of a byte stream. Ports come in pairs—an input port and an output port. An output port sends bytes to the byte stream. An input port receives bytes from the byte stream.

#### Literals

$$\mathcal{B} = \text{byte arrays} \qquad \emptyset = \text{void}$$

A *literal* is a fixed unit of data. A byte array is a unit of data exchange. The void literal is returned by operations with a side effect and no useful result.

$[k \mapsto v]D$	associate $k$ with $v$ in $D$ .
$D \setminus \{k \mapsto \cdot\}$	remove from $D$ the association keyed by $k$ .
$D(k)$	lookup $k$ in $D$ .

Figure 3.1: Dictionary notation

## 3.2 Dictionaries

$$\mathcal{D} = \{\mathcal{R} \rightarrow *\}$$

A *dictionary* is an associative array. Dictionaries associate references to some underlying data. Associations can be added, removed, or looked up.

## 3.3 The run-time state

$$L : \mathcal{L} \rightarrow \mathcal{A} \qquad T : \mathcal{T} \rightarrow \mathcal{A} \times \mathcal{A} \times \mathcal{I} \times \mathcal{O}$$

The run-time state is a set of dictionaries. All side effects occur during operations on dictionaries in the run-time state.

$L$  records the addresses of listeners. Given listener  $\ell$  and local authority authority  $a_L$ , the host platform queues requests to connect to  $a_L$  under  $\ell$  for as long as  $L(\ell) = a_L$ .

$T$  records the addresses and ports of established connections. Given transport  $\tau$ , addresses  $a_L, a_R$ , and ports  $p_I, p_O$ , the host platform establishes a connection between local authority  $a_L$  and remote authority  $a_R$  for as long as  $T(\tau) = (a_L, a_R, p_I, p_O)$ . Updating  $p_I$  or  $p_O$  will exchange bytes over the connection.

## 3.4 The Agent API

A registered name driver implements the operations defined in this section.

$$\text{listener} : \mathcal{A} \rightarrow \mathcal{L} \qquad \text{listener}(a_L) = \ell$$

Creates a reference  $\ell$  to a connection request queue associated with local authority  $a_L$ .

$$\text{accepter} : \mathcal{L} \rightarrow \mathcal{T} \times \mathcal{A} \times \mathcal{I} \times \mathcal{O} \qquad \text{accepter}(\ell) = \langle \tau, a_R, p_I, p_O \rangle$$

Creates a reference  $\tau$  to a connection request from remote authority  $a_R$  queued under listener  $\ell$ . Opens ports  $p_I, p_O$  for exchanging bytes over the connection.



$t ::= \text{listen}(t)$	bind authority	$v ::= a$	authority
$\text{accept}(t)$	accept connection	$b$	byte array
$\text{connect}(t)$	connect to authority	$\ell$	listener
$\text{release}(t)$	disconnect	$\tau$	transport
$\text{send}(t, t)$	send bytes	$u$	URI
$\text{receive}(t)$	receive bytes	$\emptyset$	void

Figure 3.2: Transport syntax

$$\text{connector} : \mathcal{A} \rightarrow \mathcal{T} \times \mathcal{A} \times \mathcal{I} \times \mathcal{O} \quad \text{connector}(a_R) = \langle \tau, a_L, p_I, p_O \rangle$$

Creates a reference  $\tau$  to a connection from local authority  $a_L$  to remote authority  $a_R$ . Opens ports  $p_I, p_O$  for exchanging bytes over the connection.

$$\text{sender} : \mathcal{B} \times \mathcal{O} \rightarrow \mathcal{O} \quad \text{sender}(b, p_O) = p'_O$$

Creates a port update  $p'_O$  that writes byte array  $b$  to port  $p_O$ .

$$\text{receiver} : \mathcal{I} \rightarrow \mathcal{B} \times \mathcal{I} \quad \text{receiver}(p_I) = \langle b, p'_I \rangle$$

Creates a port update  $p'_I$  that reads byte array  $b$  from port  $p_I$ .

### 3.5 Creating and destroying connections

$$\text{listen} : \mathcal{A} \rightarrow \mathcal{L} \quad \text{listen}(a_L) = \ell \quad \frac{\text{listener}(a_L) = \ell}{\text{L} \vdash \text{listen}(a_L) \rightsquigarrow [\ell \mapsto a_L] \text{L} \vdash \ell} \text{LSN}$$

Creates a listener  $\ell$  on local authority  $a_L$ .

$$\text{accept} : \mathcal{L} \rightarrow \mathcal{T} \quad \text{accept}(\ell) = \tau \quad \frac{\text{L}(\ell) = u_L \quad \text{accepter}(\ell) = \langle \tau, a_R, p_I, p_O \rangle}{\text{T} \vdash \text{accept}(\ell) \rightsquigarrow [\tau \mapsto \langle a_L, a_R, p_I, p_O \rangle] \text{T} \vdash \tau} \text{ACC}$$

Accepts a transport  $\tau$  from listener  $\ell$ .

$$\text{connect} : \mathcal{A} \rightarrow \mathcal{T} \quad \text{connect}(a) = \tau \quad \frac{\text{connector}(a_R) = \langle \tau, a_L, p_I, p_O \rangle}{\text{T} \vdash \text{connect}(a_R) \rightsquigarrow [\tau \mapsto \langle a_L, a_R, p_I, p_O \rangle] \text{T} \vdash \tau} \text{CON}$$

Connects a transport  $\tau$  from local authority  $a_L$  to remote authority  $a_R$ .

$$\text{release} : \mathcal{R} \rightarrow \emptyset \quad \text{release}(r) = \emptyset \quad \frac{}{\text{L} \vdash \text{release}(r) \rightsquigarrow \text{L} \setminus \{r \mapsto \cdot\} \vdash \emptyset} \text{RLS}$$

Stops listening when  $r$  is a listener. Closes the connection when  $r$  is a transport.

### 3.6 Exchanging bytes

$$\text{send} : \mathcal{B} \times \mathcal{T} \rightarrow \emptyset \quad \text{send}(b, \tau) = \emptyset \quad \frac{\text{T}(\tau) = \langle a_L, a_R, p_I, p_O \rangle \quad \text{sender}(b, p_O) = p'_O}{\text{T} \vdash \text{send}(b, \tau) \rightsquigarrow [\tau \mapsto \langle a_L, a_R, p_I, p'_O \rangle] \text{T} \vdash \emptyset} \text{SND}$$

Sends byte array  $b$  over transport  $\tau$ .

$$\text{receive} : \mathcal{T} \rightarrow \mathcal{B} \quad \text{receive}(\tau) = b \quad \frac{\text{T}(\tau) = \langle a_L, a_R, p_I, p_O \rangle \quad \text{receiver}(p_I) = \langle b, p'_I \rangle}{\text{T} \vdash \text{receive}(\tau) \rightsquigarrow [\tau \mapsto \langle a_L, a_R, p'_I, p_O \rangle] \text{T} \vdash b} \text{RCV}$$

Receives byte array  $b$  over transport  $\tau$ .

# Chapter 4

## Protocol

### 4.1 Codecs

### 4.2 Messengers

### 4.3 Clients and servers

# Glossary

**agent** A URL-addressable process capable of exchanging bytes.

**authority** The authority component of a URI. This could be an IP address and port number, or other kinds of extensible registered names [BLFM14].

**byte array** A finite sequence of bytes.

**byte stream** A one-way communications channel.

**connection** A two-way communications channel.

**connector** A means of requesting a connection to another agent.

**dictionary** A binary relation between references and run-time state.

**host platform** The programming platform implementing `net2`.

**input port** A port that receives bytes.

**listener** A means of accepting connection requests from other agents.

**output port** A port that sends bytes.

**port** One end of a byte stream.

**reference** An opaque token that identifies a set of related objects.

**scheme** The scheme component of a URI.

**transport** A reliable, buffered, and ordered means of exchanging bytes with other agents.

**URL** A URI, as defined in RFC 3986 [BLFM14], that locates an agent.

# References

- [BLFM14] Tim Berners-Lee, Roy Fielding, and Larry Masinter. Rfc 3986, uniform resource identifier (uri): Generic syntax, 2005. *URL: [http://www. faqs. org/rfcs/rfc3986. html](http://www.faqs.org/rfcs/rfc3986.html)*, 2014.

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