`net2`
Technical Specification

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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 and to support future work.

Contents

Chapter 1

Formalism

This chapter defines an abstract model for the primary constructs of `net2`. The model exposes six primary operations and five primitive data types.

1.1 URIs

- Explain how URIs work in `net2`.
- So far, all operations restrict URIs to URL authorities.

1.2 Primitive data

All primitive data is opaque for now...

References

$\mathcal{L}$ = listeners $\qquad\qquad$ $\mathcal{T}$ = transports

A *reference* is an opaque token that identifies a portion of run-time state. A listener identifies a bound URL authority and a host platform hook for accept connection requests. A transport identifies the URLs of its endpoints and a pair of ports.

Ports

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

A *port* is a host platform object that represents one side of a byte stream. An input port receives bytes. An output port send bytes.

Structures

$$\mathcal{U} = \text{URLs} \qquad \mathcal{B} = \text{byte arrays} \qquad \varnothing = \text{void}$$

A *structure* is a host platform data structure. A URL addresses an agent. A byte array is a unit of data exchange. The void constant $\varnothing$ is returned by operations with a side-effect and no useful result.

1.3 The `net2` API

The API exposes six primary operations. Four create or destroy connections. Two exchange bytes over ports.

Connections

$$\mathsf{listen} : \mathcal{U} \to \mathcal{L} \qquad \mathsf{accept} : \mathcal{L} \to \mathcal{T} \qquad \mathsf{connect} : \mathcal{U} \to \mathcal{T} \qquad \mathsf{release} : \mathcal{L} \cup \mathcal{T} \to \varnothing$$

listen$(u) = \ell$ Starts accepting connections to URL authority u. Binds accepted connections to listener ℓ.

accept$(\ell) = \tau$ Claims a connection bound to listener ℓ. Blocks until an unclaimed connection is available. Binds a pair of ports to transport τ.

connect$(u) = \tau$ Requests a connection to URL authority u over transport τ. Blocks until the host system resolves the request. Binds a pair of ports to transport τ.

release$(\ell) = \varnothing$ Stops accepting connections to the URL authority bound to listener ℓ. Unbinds ℓ.

release$(\tau) = \varnothing$ Closes the ports bound to τ. Unbinds τ.

Ports

$$\mathsf{send} : \mathcal{T} \times \mathcal{B} \to \varnothing \qquad \mathsf{receive} : \mathcal{T} \to \mathcal{B}$$

send$(\tau, b) = \varnothing$ Sends byte array b over transport τ.

receive$(\tau) = b$ Receives byte array b over transport τ.

1.4 Host platform support

$$\text{listener} : \mathcal{U} \to \mathcal{L} \qquad \text{accepter} : \mathcal{L} \to \mathcal{T} \times \mathcal{U} \times \mathcal{I} \times \mathcal{O}$$

$$\text{connector} : \mathcal{U} \to \mathcal{T} \times \mathcal{U} \times \mathcal{I} \times \mathcal{O}$$

$$\text{sender} : \mathcal{B} \times \mathcal{O} \to \mathcal{O} \qquad \text{receiver} : \mathcal{I} \to \mathcal{B} \times \mathcal{I}$$

1.5 Formal syntax and semantics

$t ::=$	$\mathsf{listen}(t)$	bind to URL	$v ::= b$	byte array
$\mid$	$\mathsf{accept}(t)$	accept connection	$\mid \ell$	listener
$\mid$	$\mathsf{connect}(t)$	connect to URL	$\mid \tau$	transport
$\mid$	$\mathsf{release}(t)$	disconnect	$\mid u$	URL
$\mid$	$\mathsf{send}(t, t)$	bytes out	$\mid \varnothing$	void
$\mid$	$\mathsf{receive}(t)$	bytes in		

The run-time environment

$$\Lambda : \mathcal{L} \to \mathcal{U} \qquad \Gamma : \mathcal{T} \to \mathcal{U} \times \mathcal{U} \qquad \Pi : \mathcal{T} \to \mathcal{I} \times \mathcal{O}$$

The run-time state consists of three maps, each representing a distinct realm of effect. When a binding exists, its effects are visible. Adding a binding to a map tells the run-time to perform a computation with visible effects until the binding is removed. In Λ, $\cdot \mapsto u_L$ listens for connections on u_L. In Γ, $\cdot \mapsto (u_L, u_R)$ establishes a connection between u_L and u_R. In Π, $\cdot \mapsto (p_I, p_O)$ opens ports p_I and p_O for reading and writing. When $\Pi(t) = (p_I, p_O)$, re-binding $t \mapsto (p'_I, p_O)$ or $t \mapsto (p_I, p'_O)$ tells the run-time to read or write bytes from or to the port.

$$\frac{\ell = \text{listener}(u)}{\Lambda \vdash \mathsf{listen}(u) \rightsquigarrow [\ell \mapsto u]\Lambda \vdash \ell}\ \textsc{Lsn}$$

$$\frac{\Lambda(\ell) = u_L \qquad \text{accepter}(\ell) = (\tau, u_R, p_I, p_O)}{\Lambda, \Gamma, \Pi \vdash \mathsf{accept}(\ell) \rightsquigarrow \Lambda, [\tau \mapsto (u_L, u_R)]\Gamma, [\tau \mapsto (p_I, p_O)]\Pi \vdash \tau} \textsc{Acc}$$

$$\frac{\text{connector}(u_R) = (\tau, u_L, p_I, p_O)}{\Lambda, \Gamma, \Pi \vdash \mathsf{connect}(u_R) \rightsquigarrow \Lambda, [\tau \mapsto (u_L, u_R)]\Gamma, [\tau \mapsto (p_I, p_O)]\Pi \vdash \tau} \textsc{Con}$$

$$\frac{}{\Lambda, \Gamma, \Pi \vdash \mathsf{release}(\ell) \rightsquigarrow \Lambda \setminus \{\ell \mapsto \cdot\}, \Gamma, \Pi \vdash \varnothing} \textsc{RlsL}$$

$$\frac{}{\Lambda, \Gamma, \Pi \vdash \mathsf{release}(\tau) \rightsquigarrow \Lambda, \Gamma \setminus \{\tau \mapsto \cdot\}, \Pi \setminus \{\tau \mapsto \cdot\} \vdash \varnothing} \textsc{RlsT}$$

$$\frac{\Pi(\tau) = (p_I, p_O) \qquad \text{sender}(b, p_O) = p'_O}{\Lambda, \Gamma, \Pi \vdash \mathsf{send}(\tau, b) \rightsquigarrow \Lambda, \Gamma, [\tau \mapsto (p_I, p'_O)]\Pi \vdash \varnothing} \textsc{Snd}$$

$$\frac{\Pi(\tau) = (p_I, p_O) \qquad \text{receiver}(p_I) = (b, p'_I)}{\Lambda, \Gamma, \Pi \vdash \mathsf{receive}(\tau) \rightsquigarrow \Lambda, \Gamma, [\tau \mapsto (p'_I, p_O)]\Pi \vdash b} \textsc{Rcv}$$

Lsn says $\mathsf{listen}(u_L)$ produces a listener ℓ on URL authority u_L. Acc says $\mathsf{accept}(\ell)$ produces a transport τ that, when URL authority u_R connects to u_L, represents the connection between u_L and u_R. Con says $\mathsf{connect}(u_R)$ produces a transport τ that, when u_R accepts the connection from a "chosen" URL authority u_L, represents the connection between u_L and u_R. Snd says $\mathsf{send}(\tau, b)$ writes the bytes in b to the output port bound to τ. Rcv says $\mathsf{receive}(\tau)$ produces all available bytes b from the input port bound to τ.

Glossary

agent A URL-addressable process capable of exchanging bytes over the network.

byte array A finite sequence of bytes.

byte stream A one-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.

structure A host platform data structure.

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

URL authority A URL, as defined in RFC 3986 [BLFM14], that addresses an agent.

Bibliography

[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*, 2014.

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