Using Avahi in Guile Scheme Programs

For Guile-Avahi 0.3

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Edition 0.3
6 March 2008

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# Table of Contents

Using Avahi in Guile Scheme Programs ........ 1

1 Introduction ........................................... 3

2 Conventions ........................................... 5
   2.1 Enumerates and Constants ................................. 5
   2.2 Procedure Names ......................................... 6
   2.3 Explicit Finalization ........................................ 6
   2.4 Error Handling ............................................ 7

3 Examples ................................................ 9
   3.1 Publishing a Service ....................................... 9
   3.2 Browsing Published Services ............................... 10
   3.3 Resolving Services ......................................... 11

4 API Reference ......................................... 13
   4.1 Core Interface ............................................ 13
   4.2 Client Interface ........................................... 16
   4.3 Service Publication ....................................... 16
   4.4 Service Browsing ......................................... 19

Concept Index .......................................... 25

Procedure Index ...................................... 27

Variable Index ....................................... 29
Using Avahi in Guile Scheme Programs

This document describes Guile-Avahi version 0.3. It was last updated in March 2008.
Using Avahi in Guile Scheme Programs
1 Introduction

Guile-Avahi provides GNU Guile bindings to the Avahi library. In other words, it makes it possible to write Scheme programs that use the facilities of Avahi. Avahi itself is a C library that implements the multicast DNS (mDNS) and DNS Service Discovery (DNS-SD) protocols, sometimes erroneously referred to as “Bonjour”. Together, these protocols provide support for fully decentralized host naming and service publication and discovery. They are key components of the so-called Zero-Configuration Networking Stack (Zeroconf).

More precisely, Guile-Avahi provides bindings for the client library of Avahi. The client library allows application to use service discovery by transparently connecting them to the Avahi system-wide daemon using D-Bus. This daemon actually implements the DNS-SD protocol and handles service discovery and publication on behalf of applications running on the same host.

Thus, the functionality of Guile-Avahi could be provided to Guile Scheme applications by writing a D-Bus client to the Avahi daemon in Scheme. Alas, no Scheme-friendly D-Bus implementation was available at the time Guile-Avahi was started, hence the approach taken by Guile-Avahi.

This document describes the Scheme API to Avahi offered by Guile-Avahi. The reader is assumed to have basic knowledge of the protocol and library. Please send bug reports and comments to the Guile-Avahi mailing list.
2 Conventions

This chapter details the conventions used in Guile-Avahi, as well as specificities of the mapping of the C API to Scheme.

2.1 Enumerates and Constants

Lots of enumerates and constants are used in the Avahi C API. For each C enumerate type, a disjoint Scheme type is used—thus, enumerate values and constants are not represented by Scheme symbols nor by integers. This makes it impossible to use an enumerate value of the wrong type on the Scheme side: such errors are automatically detected by type-checking.

The enumerate values are bound to variables exported by the (avahi) and other modules within the avahi hierarchy. These variables are named according to the following convention:

- All variable names are lower-case; the underscore _ character used in the C API is replaced by hyphen -.
- All variable names are prepended by the name of the enumerate type and the slash / character.
- In some cases, the variable name is made more explicit than the one of the C API, e.g., by avoid abbreviations.

Consider for instance this C-side enumerate:

```c
typedef enum
{
    AVAHI_CLIENT_S_REGISTERING,
    AVAHI_CLIENT_S_RUNNING,
    AVAHI_CLIENT_S_COLLISION,
    AVAHI_CLIENT_FAILURE,
    AVAHI_CLIENT_CONNECTING
} AvahiClientState;
```

The corresponding Scheme values are bound to the following variables exported by the (avahi client) module:

- `client-state/s-registering`
- `client-state/s-running`
- `client-state/s-collision`
- `client-state/failure`
- `client-state/connecting`

Hopefully, most variable names can be deduced from this convention.

Scheme-side “enumerate” values can be compared using `eq?` (see section “Equality” in The GNU Guile Reference Manual). Consider the following example:

```scheme
(let ((client (make-client ...)))

    ;;
    ;; ... 
    ;;
```
;; Check the client state.
(if (eq? (client-state client) client-state/failure)
  (format #t "Oh, we failed.")))

In addition, all enumerate values can be converted to a human-readable string, in a type-specific way. For instance, (watch-event->string watch-event/in) yields "in". Note that these strings may not be sufficient for use in a user interface since they are fairly concise and not internationalized.

### 2.2 Procedure Names

Unlike C functions in Avahi, the corresponding Scheme procedures are named in a way that is close to natural English. Abbreviations are also avoided. For instance, the Scheme procedure corresponding to avahi_client_get_version is named client-server-version. The avahi_prefix is always omitted from variable names since a similar effect can be achieved using Guile’s nifty binding renaming facilities, should it be needed (see section “Using Guile Modules” in The GNU Guile Reference Manual).

### 2.3 Explicit Finalization

Except for client objects, all objects created by the Avahi client API are local representative of objects implemented by the system-wide Avahi daemon. For instance, make-service-browser returns a “service browser” object which is actually a proxy to a daemon-implemented service browser (see Section 4.4 [Service Browsing], page 19). In other words, the Avahi daemon allocates resources (objects) on behalf of its clients.

While the Avahi daemon can reclaim resources allocated on behalf of a client program when that program exits, it cannot automatically determine when such resources become unneeded and reclaimable while the program is running. Thus, clients must explicitly tell the daemon when an object is no longer needed.

Consequently, except for client objects, objects manipulated by Guile-Avahi programs must be freed using the appropriate free procedure. For instance, objects created by make-service-browser must eventually be freed by free-service-browser!. Additional procedures are available to determine whether a particular object has already been freed; for instance, freed-service-browser? returns #t when the given service browser has already been freed. Of course, freed objects are no longer usable; procedures that are passed a previously freed object will raise an error/invalid-object exception (see Section 2.4 [Error Handling], page 7).

Note that all such client-side proxy objects are not subject to garbage collection until they have been explicitly freed. Therefore, it is important to free them when they are no longer needed!

As an exception, client objects as returned by make-client are subject to garbage collection and need not be explicitly freed. This is because client programs will usually create only one client object whose lifetime is that of the program itself.
2.4 Error Handling

Avahi errors are implemented as Scheme exceptions (see section “Exceptions” in The GNU Guile Reference Manual). Each time a Avahi function returns an error, an exception with key \texttt{avahi-error} is raised. The additional arguments that are thrown include an error code and the name of the Avahi procedure that raised the exception. The error code is pretty much like an enumerate value: it is one of the \texttt{error/} variables exported by the \texttt{(avahi)} module (see Section 2.1 [Enumerates and Constants], page 5). Exceptions can be turned into error messages using the \texttt{error->string} procedure.

The following examples illustrates how Avahi exceptions can be handled:

\begin{verbatim}
(let ((poll (make-simple-poll)))

  ;;

  ;; ...

  ;;

  (catch 'avahi-error
    (lambda ()
      (run-simple-poll (simple-poll poll)))
    (lambda (key err function . currently-unused)
      (format (current-error-port)
        "an Avahi error was raised by '\textquotedblleft\texttt{~a}'\textquotedblright: \texttt{~a}"
        function (error->string err))))

Again, error values can be compared using \texttt{eq?:}

;; 'avahi-error' handler.

  (lambda (key err function . currently-unused)
    (if (eq? err error/no-daemon)
      (format (current-error-port)
        "\texttt{~a}: the Avahi daemon is not running\textquotedblright"
        function)))

Note that the \texttt{catch} handler is currently passed only 3 arguments but future versions might provide it with additional arguments. Thus, it must be prepared to handle more than 3 arguments, as in this example.
3 Examples

This chapter lists examples that illustrate common use cases.

3.1 Publishing a Service

The following example shows the simplest way to publish a service. There are several stages:

- Create an Avahi client using `make-client`. This will actually connect the application to the Avahi daemon that will eventually perform operations on behalf of the application.
- When the client switches to the running state (i.e., `client-state/s-running`), create an entry group with `make-entry-group` and add a service (or several services, addresses, etc.) to it.
- Commit the entry group using `commit-entry-group`.
- When all entries in the group have been successfully published, the group’s call-back is invoked and passed the `entry-group-state/established` state. The application must keep running so that the service remains published.

Here is the complete example:

```scheme
(use-modules (avahi)
            (avahi client)
            (avahi client publish))

(define (group-callback group state)
  (if (eq? state entry-group-state/established)
      (format #t "service is now published!" %*))
)

(define client-callback
  (let ((group #f))
    (lambda (client state)
      (if (eq? state client-state/s-running)
          (begin
            ;; The client is now running so we can create an entry
            ;; group and publish a service.
            (set! group (make-entry-group client group-callback))
            (add-entry-group-service! group interface/unspecified
                                      protocol/unspecified ()
                                      "my-avahi-service"
                                      ".service-type._tcp"
                                      #f #f ;; any domain and host
                                      1234 ;; the port number

            ;; additional 'txt' properties
            "scheme=yes" "java=no")

            ;; Commit the entry group, i.e., actually publish
            ;; the service.
            (commit-entry-group-group))))
```
Using Avahi in Guile Scheme Programs

3.2 Browsing Published Services

Browsing advertised services requires a number of stages. First, an Avahi daemon client must be created, as usual (see Section 3.1 [Publishing a Service], page 9).

```scheme
(use-modules (avahi)
  (avahi client)
  (avahi client lookup))

(define %service-type
  ;; The type of services we are looking for.
  "._workstation._tcp")

(define (service-browser-callback browser interface protocol event
  service-name service-type
domain flags)
  (if (eq? event browser-event/new)
    (format #t "found service '~a' of type '~a'~%
      service-name service-type))

(define client-callback
  (let ((browser #f))
    (lambda (client state)
      (if (eq? state client-state/s-running)
        ;; Now that the client is up and running, create a service
        ;; browser looking for services of type '%service-type' on
        ;; any network interface and using any protocol.
        (set! browser
          (make-service-browser client
            interface/unspecified
          protocol/unspecified
        %service-type #f '()
          service-browser-callback)))))

(let* ((poll (make-simple-poll))
  (client (make-client (simple-poll poll)
    '() ;; no flags
  client-callback)))

(and (client? client)

;; Run forever.
(run-simple-poll poll)))

Of course, publishing a host address or service subtype works similarly.
In this example, the service type being looked for is "_workstation._tcp". It is used to advertise the presence of computers on a local area network, rather than an actual service.

### 3.3 Resolving Services

The previous example allowed us to find services of a given type, but did not provide us with information such as the IP address of the host providing the service and the port number where the service can be found. To obtain this information, a service resolver must be launched, e.g., by augmenting the service browser call-back as follows:

```scheme
(define (service-browser-callback browser interface protocol event
  service-name service-type
domain flags)
  (define (service-resolver-callback resolver interface protocol event
    service-name service-type domain
    host-name address-type address port
txt flags)
    ;; Handle service resolution events.
    (cond ((eq? event resolver-event/found)
        (format #t "resolved service '~a' at '~a:~a'~%
                service-name host-name port))
        ((eq? event resolver-event/failure)
        (format #t "failed to resolve service '~a'~%
                service-name))))

    (if (eq? event browser-event/new)
      (begin
        (format #t "found service '~a' of type '~a'~%
                service-name service-type)

        ;; Launch a service resolver for the service we just found.
        (make-service-resolver (service-browser-client browser)
          interface protocol
          service-name service-type domain
          protocol/unspecified ()
          service-resolver-callback)))))

Now you know all the important things you need to know to benefit from Avahi!
4 API Reference

This chapter documents Guile-Avahi Scheme procedures. Note that further details can be found in the Avahi C API reference.

4.1 Core Interface

This section lists the Scheme procedures exported by the (avahi) module. These procedures are mainly related to polls, the building block of event loops in Avahi programs. Polls come in three flavors:

- The simple poll provides simple, single-threaded event dispatching. It essentially hangs on select(), processes D-Bus I/O events, and invokes the relevant client call-backs when appropriate.
- The threaded poll processes events similarly but in a separate thread of execution.
- Finally, the guile poll allows you to create customized event loops. This is useful, for instance, in single-threaded programs that process events coming not only from Avahi but also from other sources (e.g., GTK+ events, networking events, etc.).

Creating and manipulating polls is achieved using the procedures below.

unlock-threaded-poll threaded-poll
Unlock the event look object associated with threaded-poll.

lock-threaded-poll threaded-poll
Lock the event loop associated with threaded-poll. Use this if you want to access the event loop object (e.g., creating a new event source) from anything but the event loop helper thread, i.e. not from callbacks.

quit-threaded-poll threaded-poll
Quit the event loop associated with threaded-poll responsible for running the event loop. It must be called from outside said thread (i.e., not from callbacks).

stop-threaded-poll threaded-poll
Stop the helper thread associated with threaded-poll responsible for running the event loop. It must be called from outside said thread (i.e., not from callbacks).

start-threaded-poll threaded-poll
Start the helper thread associated with threaded-poll, which is responsible for running the event loop. Callbacks are called from the helper thread. Thus, synchronization may be required among threads.

threaded-poll threaded-poll
Return the poll object associated with threaded-poll.

make-threaded-poll
Return a threaded-poll object. A threaded poll is essentially an event loop that processes events from the Avahi daemon in its own thread.

run-simple-poll simple-poll
Run the event loop of simple-poll until either an error occurs or a quit request is scheduled. In the former case, an error is raised; in the latter, #f is returned.
iterate-simple-poll simple-poll [sleep-time]  
Handle events registered by simple-poll. If sleep-time is not specified, the function
blocks until an I/O event occurs. If sleep-time is specified, it is the maximum num-
ber of milliseconds of blocking. Return #f is a quit request has been scheduled, #t
otherwise.

simple-poll simple-poll  
Return the poll object associated with simple-poll.

make-simple-poll  
Return a simple-poll object. This is the easiest way to handle I/O of Avahi client
objects and similar.

guile-poll guile-poll  
Return the poll object associated with guile-poll.

make-guile-poll new-watch update-watch! free-watch
new-timeout update-timeout! free-timeout

Return a guile-poll object that can then be used to handle I/O events for Avahi
objects such as clients. All arguments should be procedures:

• new-watch and new-timeout are invoked when the poll-using code requires a new
file descriptor to be watched after, or a new timeout to be honored, respectively.
new-watch is passed a watch object and a list of watch-event values; new-
timeout is passed a timeout object and a number of seconds and nanoseconds
representing the absolute date when the timeout expires, or #f if the newly
created timeout is disabled.

• update-watch! and update-timeout! are called to modify a previously created
watch or timeout. update-watch! is passed the watch object and a new list of
events; update-timeout! is passed a new expiration time or #f.

• Finally, free-watch and free-timeout are called when the poll is asked to no
longer look handle them. For instance, when free-watch is called, the event loop
code may remove the associated file descriptor from the list of descriptors passed
to select.

The Guile-Avahi source code distribution comes with a detailed example.

timeout? obj  
Return true if obj is of type timeout.

watch? obj  
Return true if obj is of type watch.

threaded-poll? obj  
Return true if obj is of type threaded-poll.

guile-poll? obj  
Return true if obj is of type guile-poll.

simple-poll? obj  
Return true if obj is of type simple-poll.
The low-level API for watches, timeouts, and “guile polls”, all of which serve as the basic for the creation of customized event loops (using `make-guile-poll`) is described below. In practice, you should only need it in applications where the Avahi event loop needs to be integrated in some other event loop; in other cases, the “simple poll” or “threaded poll” should be enough.

**poll?** `obj`  
Return true if `obj` is of type `poll`.

**interface->string** `enumval`  
Return a string describing `enumval`, a `interface` value.

**protocol->string** `enumval`  
Return a string describing `enumval`, a `protocol` value.

**watch-event->string** `enumval`  
Return a string describing `enumval`, a `watch-event` value.

**error->string** `enumval`  
Return a string describing `enumval`, a `error` value.

The low-level API for watches, timeouts, and “guile polls”, all of which serve as the basic for the creation of customized event loops (using `make-guile-poll`) is described below. In practice, you should only need it in applications where the Avahi event loop needs to be integrated in some other event loop; in other cases, the “simple poll” or “threaded poll” should be enough.

**set-timeout-user-data!** `timeout data`  
Associated `data` (an arbitrary Scheme object) with `timeout`.

**timeout-user-data** `timeout`  
Return the user-specified data associated with `timeout`.

**timeout-value** `timeout`  
Return the expiration time for `timeout` as two values: the number of seconds and nanoseconds. If `timeout` is disabled, both values are `#f`.

**set-watch-user-data!** `watch data`  
Associated `data` (an arbitrary Scheme object) with `watch`.

**watch-user-data** `watch`  
Return the user-specified data associated with `watch`.

**watch-events** `watch`  
Return the events of interest (a list of `watch-event/` values) for `watch`.

**watch-fd** `watch`  
Return the file descriptor associated with `watch`.

**invoke-timeout** `timeout`  
Invoke the call-back associated with `timeout`. This notifies the interested code that the timeout associated with `timeout` has been reached. The return value is unspecified. An `error/invalid-object` error is raised if `timeout` is disabled or is no longer valid.

**invoke-watch** `watch events`  
Invoke the call-back associated with `watch`. This notifies the interested code that the events listed in `events` (a list of `watch-event/` values) occurred on the file descriptor associated with `watch`. The return value is unspecified. An `error/invalid-object` error is raised if `watch` is no longer valid.
4.2 Client Interface

This section lists the Scheme procedures exported by the (avahi client) module.

**client-state client**
Return the state (a client-state/ value) of client.

**client-host-fqdn client**
Return the fully qualified domain name (FQDN) of the server client is connected to.

**client-host-name client**
Return the host name of the server client is connected to.

**client-server-version client**
Return the version (a string) of the server the client is connected to.

**make-client poll flags callback**
Return a new Avahi client. The client will use poll (a poll object as returned by, e.g., (simple-poll (make-simple-poll))) for I/O management. In addition, when the client state changes, callback (a two-argument procedure) will be invoked and passed the client object and a client-state value. flags must be a list of client flags (i.e., client-flag/ values).

**client? obj**
Return true if obj is of type client.

**client-flag->string enumval**
Return a string describing enumval, a client-flag value.

**client-state->string enumval**
Return a string describing enumval, a client-state value.

The flags argument expected by make-client is a list containing zero or more values among the following:

**client-flag/ignore-user-config**
Don’t read user configuration.

**client-flag/no-fail**
Don’t fail if the daemon is not available when make-client is called; instead enter client-state/connecting state and wait for the daemon to appear.

4.3 Service Publication

The service publication API is provided by the (avahi client publish). To publish services, one must first create a client for the Avahi daemon (see Section 4.2 [Client Interface], page 16).

**alternative-service-name service-name**
Find an alternative name to service-name. If called with an original service name, " #2" is appended. Afterwards the number is incremented on each call (i.e., "foo" becomes "foo #2", which becomes "foo #3", and so on).
alternative-host-name  hostname

Find an alternative name to hostname. If called with an original host name, "2" is appended. Afterwards the number is incremented on each call (i.e., "foo" becomes "foo2", which becomes "foo3", and so on).

add-entry-group-address!  group  interface  protocol  
publish-flags  fqdn  address-protocol  address

Add to group a mapping from fully-qualified domain name fqdn to address address. Depending on address-protocol (a protocol/value), address should be a 32-bit or 128-bit integer (for IPv4 and IPv6, respectively) in host byte order (see section “Network Address Conversion” in The GNU Guile Reference Manual).

update-entry-group-service!  group  interface  protocol  
publish-flags  service-name  service-type  domain  [txt...]

Update the service named service-name in group.

add-entry-group-service-subtype!  group  interface  protocol  
publish-flags  service-name  service-type  domain  subtype

Add subtype as a sub-type of a service already present in group. You may add as many subtypes for a service as you wish.

add-entry-group-service!  group  interface  protocol  
publish-flags  service-name  service-type  domain  host  port  [txt...]

Add a service of type service-type (e.g., "_http._tcp") named service-name to group. port should be an integer telling which port this service is listening on; host can be a string indicating which host it is running on, or #f to let the daemon decide by itself (recommended). Likewise, domain can be #f (recommended) or a string indicating the domain where this service is to be registered. Additionally txt arguments should be string denoting additional txt properties (e.g., "color-printer=yes"). Finally, interface and protocol denote, respectively, the network interface and protocol used to publish the service. interface may be interface/unspecified, in which case the daemon will choose the most appropriate interface, or it can be a string (e.g., "eth0"), or an integer OS-provided integer index; similarly, protocol may be protocol/unspecified, in which case the daemon will choose a protocol, or it can be any other protocol/value.

element-group-client  group

Return the client used by group.

element-group-empty?  group

Return #t if group is empty, #f otherwise.

element-group-state  group

Return the state of group, i.e., an entry-group-state/value.

reset-entry-group!  group

Reset group.

commit-entry-group  group

Commit entry group group, i.e., register its entries on the network. It is an error to commit an empty group.
**make-entry-group** *client callback*  
Return a new entry group using *client* and *callback* as the state-change notification procedure. *callback* should be a two-argument procedure. It will be passed the group object and the group entry’s state (i.e., a group-entry-state/ value).

**publish-flag->string** *enumval*  
Return a string describing *enumval*, a publish-flag value.

**entry-group-state->string** *enumval*  
Return a string describing *enumval*, a entry-group-state value.

**entry-group?** *obj*  
Return true if *obj* is of type entry-group.

**freed-entry-group?** *obj*  
Return #t if *obj* is an object of type entry-group that has already been explicitly freed.

**free-entry-group!** *obj*  
Explicitly free *obj*, an object of type entry-group.

The publish-flags argument expected by add-entry-group-service! and similar procedures is a list containing zero or more values among the following:

**publish-flag/unique**  
For raw records: The RRset is intended to be unique.

**publish-flag/no-probe**  
For raw records: Though the RRset is intended to be unique no probes shall be sent.

**publish-flag/no-announce**  
For raw records: Do not announce this RR to other hosts.

**publish-flag/allow-multiple**  
For raw records: Allow multiple local records of this type, even if they are intended to be unique.

**publish-flag/no-reverse**  
For address records: don’t create a reverse (PTR) entry.

**publish-flag/no-cookie**  
For service records: do not implicitly add the local service cookie to TXT data.

**publish-flag/update**  
Update existing records instead of adding new ones.

**publish-flag/use-wide-area**  
Register the record using wide area DNS (i.e., unicast DNS update).

**publish-flag/use-multicast**  
Register the record using multicast DNS.
4.4 Service Browsing

The service discovery API is provided by the (avahi client lookup) module. Service discovery typically consists of two phases: browsing where one can find, e.g., available services, and resolution where one can, e.g., get detailed information about a discovered service such as its IP address.

All browsers and resolvers support the following lookup flags:

- **lookup-flag/use-wide-area**
  - Force lookup via wide-area DNS.

- **lookup-flag/use-multicast**
  - Force lookup via multicast DNS.

- **lookup-flag/no-txt**
  - When doing service resolving, don’t lookup TXT record.

- **lookup-flag/no-address**
  - When doing service resolving, don’t lookup A/AAAA record.

Procedures to create browsers and resolvers are described below.

**make-address-resolver**

```
client interface protocol address-type
address lookup-flags callback
```

Return a new address resolver using the specified client, interface, etc., that will resolve the host name corresponding to address of type address-type (either protocol/inet for an IPv4 address or protocol/inet6 for an IPv6 address). As usual, address should be the raw IP address in host byte order (see section “Network Address Conversion” in The GNU Guile Reference Manual). Upon resolution, callback is invoked and passed:

- the address resolver object;
- an interface name or number (depending on the OS);
- the protocol (i.e., one of the protocol/ values);
- a resolver event type (i.e., one of the resolver-event/ values);
- the host IP address type (i.e., address-type);
- the host IP address (i.e., address);
- the corresponding host name;
- lookup result flags (i.e., a list of lookup-result-flag/ values).

An exception may be raised on failure.

**make-host-name-resolver**

```
client interface protocol host-name
a-protocol lookup-flags callback
```

Return a new host-name resolver using the specified client, interface, etc., that will resolve host-name, i.e., find the corresponding IP address. Upon resolution, callback is invoked and passed:

- the host-name resolver object;
- an interface name or number (depending on the OS);
• the protocol (i.e., one of the `protocol` values);
• a resolver event type (i.e., one of the `resolver-event` values);
• the host name;
• the host IP address type (i.e., `protocol/inet` for an IPv4 address and `protocol/inet6` for an IPv6 address);
• the host IP address in host byte order (see section “Network Address Conversion” in The GNU Guile Reference Manual);
• lookup result flags (i.e., a list of `lookup-result-flag` values).

An exception may be raised on failure.

**make-service-resolver** client interface protocol service-name

`type domain a-protocol lookup-flags callback`

Return a new service resolver using the specified client, interface, etc., that will resolve the host name, IP address, port and `txt` properties of the service of type `type` named `service-name`. Upon resolution, `callback` is invoked and passed:

• the service type resolver object;
• an interface name or number (depending on the OS);
• the protocol (i.e., one of the `protocol` values);
• a resolver event type (i.e., one of the `resolver-event` values);
• the service name;
• the service type (e.g., "_http._tcp");
• the domain;
• the host name (name of the host the service is running on);
• the host IP address type (i.e., `protocol/inet` for an IPv4 address and `protocol/inet6` for an IPv6 address);
• the host IP address in host byte order (see section “Network Address Conversion” in The GNU Guile Reference Manual);
• a list of `txt` properties (strings);
• lookup result flags (i.e., a list of `lookup-result-flag` values).

An exception may be raised on failure.

**make-service-browser** client interface protocol type domain

`lookup-flags callback`

Return a new service browser using the specified client, interface, etc. Upon browsing events (discovery, removal, etc.) `callback` will be called and passed:

• the service browser object;
• an interface name or number (depending on the OS);
• the protocol (i.e., one of the `protocol` values);
• a browser event type (i.e., one of the `browser-event` values);
• the service name;
• the service type (e.g., "_http._tcp");
• the domain;
• lookup result flags (i.e., a list of lookup-result-flag/ values).

**make-service-type-browser**  
client interface protocol domain  
lookups-flags callback  
[Scheme Procedure]

Return a new service type browser using the specified client, interface, etc. Upon browsing events (discovery, removal, etc.) callback will be called and passed:

• the service type browser object;
• an interface name or number (depending on the OS);
• the protocol (i.e., one of the protocol/ values);
• a browser event type (i.e., one of the browser-event/ values);
• a service type (e.g., "_http._tcp");
• the domain;
• lookup result flags (i.e., a list of lookup-result-flag/ values).

**make-domain-browser**  
client interface protocol domain  
domain-browser-type lookup-flags callback  
[Scheme Procedure]

Return a new domain browser of type domain-browser-type (a domain-browser-type/ value) for domain that uses client. Upon browsing events (discovery, removal, etc.) callback will be called and passed:

• the domain browser object;
• an interface name or number (depending on the OS);
• the protocol (i.e., one of the protocol/ values);
• a browser event type (i.e., one of the browser-event/ values);
• the domain;
• lookup result flags (i.e., a list of lookup-result-flag/ values).

**address-resolver-client**  
address-resolver  
[Scheme Procedure]

Return the client associated with address-resolver.

**host-name-resolver-client**  
host-name-resolver  
[Scheme Procedure]

Return the client associated with host-name-resolver.

**service-resolver-client**  
service-resolver  
[Scheme Procedure]

Return the client associated with service-resolver.

**service-browser-client**  
service-browser  
[Scheme Procedure]

Return the client associated with service-browser.

**service-type-browser-client**  
service-type-browser  
[Scheme Procedure]

Return the client associated with service-type-browser.

**domain-browser-client**  
domain-browser  
[Scheme Procedure]

Return the client associated with domain-browser.

**lookup-result-flag->string**  
enumval  
[Scheme Procedure]

Return a string describing enumval, a lookup-result-flag value.
lookup-flag->string enumval
   Return a string describing enumval, a lookup-flag value.

resolver-event->string enumval
   Return a string describing enumval, a resolver-event value.

browser-event->string enumval
   Return a string describing enumval, a browser-event value.

domain-browser-type->string enumval
   Return a string describing enumval, a domain-browser-type value.

address-resolver? obj
   Return true if obj is of type address-resolver.

freed-address-resolver? obj
   Return #t if obj is an object of type address-resolver that has already been explicitly freed.

free-address-resolver! obj
   Explicitly free obj, an object of type address-resolver.

host-name-resolver? obj
   Return true if obj is of type host-name-resolver.

freed-host-name-resolver? obj
   Return #t if obj is an object of type host-name-resolver that has already been explicitly freed.

free-host-name-resolver! obj
   Explicitly free obj, an object of type host-name-resolver.

service-resolver? obj
   Return true if obj is of type service-resolver.

freed-service-resolver? obj
   Return #t if obj is an object of type service-resolver that has already been explicitly freed.

free-service-resolver! obj
   Explicitly free obj, an object of type service-resolver.

service-type-browser? obj
   Return true if obj is of type service-type-browser.

freed-service-type-browser? obj
   Return #t if obj is an object of type service-type-browser that has already been explicitly freed.

free-service-type-browser! obj
   Explicitly free obj, an object of type service-type-browser.
**service-browser? obj**

[Scheme Procedure]

Return true if obj is of type service-browser.

**freed-service-browser? obj**

[Scheme Procedure]

Return #t if obj is an object of type service-browser that has already been explicitly freed.

**free-service-browser! obj**

[Scheme Procedure]

Explicitly free obj, an object of type service-browser.

**domain-browser? obj**

[Scheme Procedure]

Return true if obj is of type domain-browser.

**freed-domain-browser? obj**

[Scheme Procedure]

Return #t if obj is an object of type domain-browser that has already been explicitly freed.

**free-domain-browser! obj**

[Scheme Procedure]

Explicitly free obj, an object of type domain-browser.

Browser and resolver call-backs are usually passed a browser event or resolver event value, respectively, among the following:

**browser-event/new**

[Scheme Variable]

The object is new on the network.

**browser-event/remove**

[Scheme Variable]

The object has been removed from the network.

**browser-event/cache-exhausted**

[Scheme Variable]

One-time event, to notify the user that all entries from the caches have been sent.

**browser-event/all-for-now**

[Scheme Variable]

One-time event, to notify the user that more records will probably not show up in the near future, i.e., all cache entries have been read and all static servers been queried.

**browser-event/failure**

[Scheme Variable]

Browsing failed.

**resolver-event/found**

[Scheme Variable]

RR found, resolving successful.

**resolver-event/failure**

[Scheme Variable]

Resolving failed.

In addition, browser and resolver call-backs are passed a list lookup result flags which is a list of values among the following:

**lookup-result-flag/cached**

[Scheme Variable]

This response originates from the cache.

**lookup-result-flag/wide-area**

[Scheme Variable]

This response originates from wide area DNS.
**lookup-result-flag/multicast** [Scheme Variable]

This response originates from multicast DNS.

**lookup-result-flag/local** [Scheme Variable]

This record/service resides on and was announced by the local host. Only available in service and record browsers and only on `browser-event/new` events.

**lookup-result-flag/our-own** [Scheme Variable]

This service belongs to the same local client as the browser object. Only available for service browsers and only on `browser-event/new` events.

This is useful for applications that both publish and browse services to distinguish between services published by the application itself and services published from other applications.

**lookup-result-flag/static** [Scheme Variable]

The returned data has been defined statically by some configuration option.
## Concept Index

### A
- avahi-error ................................................. 7

### B
- browsing ................................................. 19
- bug reports ............................................. 3

### C
- constant .................................................. 5

### D
- DNS-SD ..................................................... 3

### E
- enumerate ................................................ 5

### M
- mDNS ....................................................... 3

### P
- poll .......................................................... 13
- publication .............................................. 16

### R
- resolution .................................................. 19

### Z
- Zeroconf .................................................... 3
Using Avahi in Guile Scheme Programs
Procedure Index

A
add-entry-group-address! .................. 17
add-entry-group-service! .................. 17
add-entry-group-service-subtype! ........ 17
address-resolver-client .................. 21
address-resolver? ....................... 22
alternative-host-name ................... 17
alternative-service-name ............... 16

B
browser-event->string ................... 22

C
client-flag->string ..................... 16
client-host-fqdn ......................... 16
client-host-name ....................... 16
client-server-version ................... 16
client-state ........................... 16
client-state->string .................... 16
client? .................................. 16
commit-entry-group ..................... 17

domain-browser-client .................. 21
domain-browser-type->string ........... 22
domain-browser? ........................ 23

E
entry-group-client ...................... 17
entry-group-empty? ..................... 17
entry-group-state ....................... 17
entry-group-state->string .............. 18
entry-group? ........................... 18
error->string ........................... 7,15

F
free-address-resolver! ................. 22
free-domain-browser! .................. 23
free-entry-group! ....................... 18
free-host-name-resolver! .............. 18
free-service-browser! .................. 23
free-service-resolver! ................. 22
free-service-type-browser! ............. 22
free-address-resolver! ................. 22
free-service-type-browser! ............. 22
free-domain-browser? .................. 23
free-entry-group? ...................... 18
free-host-name-resolver? ............... 22
free-service-browser? .................. 23
free-service-resolver? ................ 22

G
guile-poll ............................... 14
guile-poll? ............................. 14

H
host-name-resolver-client ............. 21
host-name-resolver? ................... 22

I
interface->string ....................... 15
invoke-timeout ......................... 15
invoke-watch ......................... 15
iterate-simple-poll .................... 14

L
lock-threaded-poll ...................... 13
lookup-flag->string .................... 22
lookup-result-flag->string .......... 21

M
make-address-resolver .................. 19
make-client ............................ 16
make-domain-browser ................... 21
make-entry-group ...................... 18
make-guile-poll ......................... 14
make-host-name-resolver ............... 19
make-service-browser .................. 20
make-service-resolver ................. 20
make-service-type-browser .......... 21
make-simple-poll ....................... 14
make-threaded-poll .................... 13

P
poll? .................................... 15
protocol->string ....................... 15
publish-flag->string ................... 18

Q
quit-threaded-poll ..................... 13

R
reset-entry-group! ..................... 17
resolver-event->string ................. 22
run-simple-poll.......................... 13

S
service-browser-client.................. 21
service-browser?.......................... 23
service-resolver-client............... 21
service-resolver?....................... 22
service-type-browser-client........ 21
service-type-browser?............. 22
set-timeout-user-data!............ 15
set-watch-user-data!................... 15
simple-poll.............................. 14
simple-poll?.............................. 14
start-threaded-poll............... 13
stop-threaded-poll....................... 13

T
threaded-poll............................. 13
threaded-poll?............................ 14
timeout-user-data....................... 15
timeout-value............................ 15
timeout?................................. 14

U
unlock-threaded-poll.................... 13
update-entry-group-service!........ 17

W
watch-event->string................ 6, 15
watch-events.............................. 15
watch-fd................................ 15
watch-user-data........................ 15
watch?.................................. 14
Variable Index

B
browser-event/all-for-now .................. 23
browser-event/cache-exhausted ............. 23
browser-event/failure ....................... 23
browser-event/new ............................ 23
browser-event/remove ........................ 23

C
client-flag/ignore-user-config ............. 16
client-flag/no-fail ......................... 16
client-state/s-registering .................. 5

E
error/invalid-object ....................... 6
error/no-daemon .............................. 7

L
lookup-flag/no-address ..................... 19
lookup-flag/no-txt .......................... 19
lookup-flag/use-multicast .................. 19
lookup-flag/use-wide-area .................. 19
lookup-result-flag/cached .................. 23
lookup-result-flag/local ................... 24
lookup-result-flag/multicast .............. 24
lookup-result-flag/our-own ................. 24
lookup-result-flag/static .................. 24
lookup-result-flag/wide-area .............. 23

P
publish-flag/allow-multiple ............... 18
publish-flag/no-announce .................. 18
publish-flag/no-cookie ..................... 18
publish-flag/no-probe ...................... 18
publish-flag/no-reverse .................... 18
publish-flag/unique ....................... 18
publish-flag/update ......................... 18
publish-flag/use-multicast ................ 18
publish-flag/use-wide-area ................ 18

R
resolver-event/failure ..................... 23
resolver-event(found) ...................... 23

W
watch-event/in ............................. 6