**Remote Access to Embedded Devices**

Status of this Memo

Abstract

   The aim of this document is to standardize remote access options to
   parameters of embedded devices with limited resources.  Typically
   such devices are based on 8-bit or 16-bit microcontrollers with
   limited memory (64K or less) and a low operating frequency (20 MHz or
   less).  The protocol described in this document uses existing markup
   formats to specify modifiable parameters of embedded devices and
   existing protocols to transfer these parameters between clients and
   servers.

Conventions used in this document

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED",  "MAY", and "OPTIONAL" in this
   document are to be interpreted as described in RFC-2119 [2].

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## 1. Introduction

Remote access to embedded devices in our homes, factories, and
vehicles or to personal mobile electronic appliances becomes reality.
The RFC2324 [3] published on April 1st, 1998 was a humorous approach:
getting a coffee machine online and needing a Hyper Text Coffee Pot
Control Protocol (HTCPCP/1.0) seemed to be funny at that time.

Today RFC2324 does not sound as funny anymore - it is closer to
reality today than it was on its publishing date.  There is a clear
drive in the industry to Internet-enable embedded device like climate
control units and appliances - and coffee machines.

There are attempts by several companies to Internet-enable their
products û with some companies inventing their own proprietary
protocols and methods on how to allow remote access via the Internet.

Unfortunately this approach is not user-friendly.  Users have to get
acquainted with different methods and tools on how to access their
devices via email, web or other services û and none of them are
compatible with each other.

The goal of this document is to find a common ground for remote
access functionality û from the client viewpoint.  No matter what
kind of embedded system is connected to the Internet the client
should be able to expect some standardized methods for the remote
access using common services like email, regular web browsers or
minimized web browsers for PDAs or mobile phones,.

This document does not invent any new Internet technologies - it just
RECOMMENDS how existing protocols and methods should be used to offer
users standardized methods for remote access.

For the scope of this document it does not matter how an embedded
device is connected to the Internet.  Connection can be directly or
via a specialized gateway for embedded devices that might use a
simple serial link or other lower cost network or fieldbus to
exchange information with the embedded devices.  However, this
document assumes that there is at least one Internet node that
manages one or more embedded device(s) and that offers the
standardized protocols and methods described in this document to
allow remote access to the embedded device(s).  We distinguish
between three types of devices:

1) Remote Access Client (RAC): the system that attempts to access an
   embedded device over the Internet.
2) Remote Access Server (RAS): the system that manages the internet
   access to one or multiple embedded device and
3) Remote Access Device (RAD): the device that is to be accessed
   through the Internet.

In some implementations, the RAS might be implemented directly with
one RAD. In others, one RAS will be able to handle multiple RADs.


## 1.1 Terminology and Abbreviations

RAD û Remote Access Device
The embedded device(s) that can be accessed via the Internet.

RAS û Remote Access Server
This is the access point for the Remote Access Client.  The RAS
manages one or multiple Remote Access Devices and provides the
Internet connectivity.  The RAS can be part of an embedded device or
part of a gateway connecting several Remote Access Devices to the
Internet.

RAC û Remote Access Client
A software or hardware client used to provide remote access to a
Remote Access Server.  This can be a web browser, email client, PDA
or any other internet connected device.

RAPDF û Remote Access Parameter Description Format
A format that describes all Remote Access Devices and their
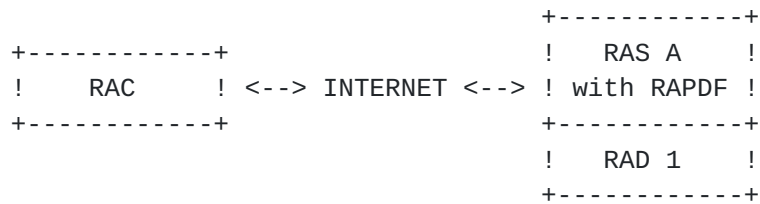configurable parameters connected to a single Remote Access Server.

```
                                     +------------+
      +------------+                 !   RAS A    !
      !    RAC     ! <--> INTERNET <--> ! with RAPDF !
      +------------+                 +------------+
                                     !   RAD 1    !
                                     +------------+
```

FIGURE 1 û Remote Access to a RAS/RAD combination device

Figure 1 shows a Remote Access Device (RAD 1) that directly
implements a Remote Access Server (RAS A).  The RAS A can directly
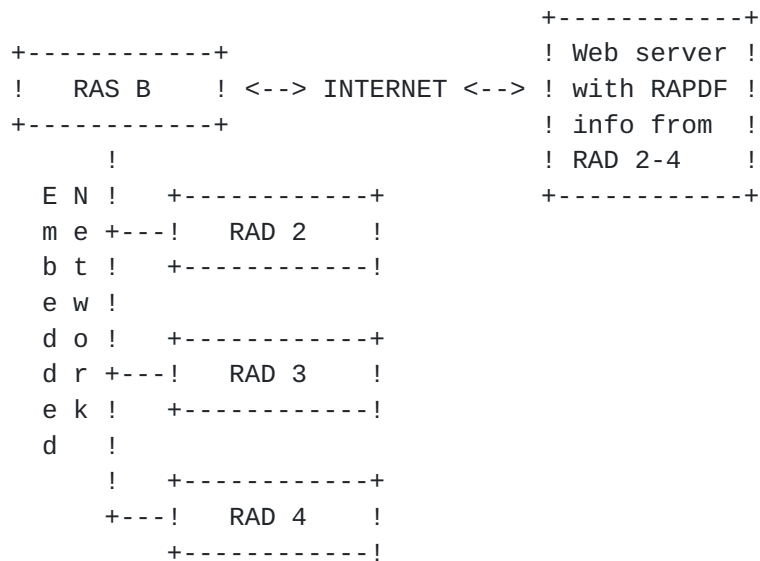serve RAPDF information to a Remote Access Client (RAC).


```
                                     +------------+
      +------------+                 ! Web server !
      !   RAS B    ! <--> INTERNET <--> ! with RAPDF !
      +------------+                 ! info from  !
          !                          ! RAD 2-4    !
     E N !   +------------+          +------------+
     m e +---!   RAD 2    !
     b t !   +------------!
     e w !
     d o !   +------------+
     d r +---!   RAD 3    !
     e k !   +------------!
     d   !
         !   +------------+
       +---!   RAD 4    !
           +------------!
```

FIGURE 2 û Remote Access to devices on a local, embedded network

Figure 2 shows how one Remote Access Server (RAS B) can handle
multiple Remote Access Devices (RAD 2-4).  The RADs can be connected
to the RAS via a local, low-cost serial network or fieldbus.
Depending on resources available to RAS and RAD, the RAS MAY retrieve
the RAPDF information from a web server instead from the RAD itself,
after the appropriate URL was reported to the RAS by each RAD.

**[2](#). Remote Access Parameter Description Format (RAPDF)**

Every remote access devices has certain parameters/variables that we
want to be able to read or write through an Internet connection.

All accessible parameters (both, read and write) of a certain device
MUST be defined using the Remote Access Parameter Description Format
(RAPDF).

**[2.1](#) RAPDF Outline**

RAPDF is based on HTML 4.0 [4] and obeys the following rules:

1.)    The header section MUST include the META tag

```
<META name=ötypeö content=öRAPDF 1.0ö>
```

2.)    The body section MUST include AT LEAST ONE HTML FORM. The name
of the form and the action identifies exactly one RAD (Remote Access
Device). For example:

```
<FORM name=öRemote Access to MyHomeDeviceö
action="mailto:remote@mail.com?subject=RAPDF" method="post">
...
</FORM>
```

Additionally, it is RECOMMENDED to use the <LABEL> tag to ensure
proper display of the formsÆ name:

```
<LABEL for=öra_my_formö>MyHomeDevice</LABEL>
<FORM name=öRemote Access to MyHomeDeviceö
action="mailto:remote@mail.com?subject=RAPDF" method="post"
id=öra_my_formö>
...
</FORM>
```

3.)    For every parameter of the embedded device the form contains a
dedicated field The tags LABEL and ID MUST be used to associate a
name with the corresponding parameter:

```
<LABEL for="ra_temp_lr">Living Room Temperature</LABEL>
<INPUT name="temp_living_room" type="text" id="ra_temp_lr">

<INPUT name="light_living" type="checkbox" value="Living Room"
id="ra_light_lr">
<LABEL for="ra_light_lr">Living Room Lights</LABEL>
```

```
<LABEL for="ra_safety">Select the device to shut off</LABEL>
<SELECT name="safety_shutoff" id="ra_safety">
   <OPTION>None</OPTION>
   <OPTION>Water Heater</OPTION>
   <OPTION>Furnace</OPTION>
   <OPTION>Stove</OPTION>
</SELECT>
```

4.)   The usage of formatting tags such as paragraphs, tables, inline
graphics or tables has no effect on the automatic interpretation of
an RAPDF.  Devices or processing tools that work automatically on a
RAPDF MAY ignore all formatting tags (especially if implemented on
medium to low performance systems).

5.)   It is recommended to use FIELDSET and LEGEND where appropriate.
See the Appendix for examples.

6.)   The ôreadonlyö tag is supported for inputs and marks parameters
of the embedded device that cannot be changed. Example:

```
<LABEL for="ra_temp">Current Temperature</LABEL>
<INPUT name="temp" type="text" id="ra_temp_lr" readonly>
```

Note that there is no particular language specified for an RAPDF.
The description in the <LABEL> section can be provided in any
language.

The primary identifier to match a parameter to the RAPDF is the
ônameö of each <FORM>, <INPUT> or <SELECT> element.  These variable
names MUST remain the same in any language, as these would be most
likely hard-coded into the firmware of the RAD.

Also note that any other HTML tags for formatting or links may be
used outside or within a FORM. However, each FORM MUST be associated
with a RAD.

## 2.2 Storing the RAPDF

Manufacturers of Remote Access Devices MUST provide the RAPDF
information along with their devices.

As code and data space in many embedded devices is limited, it is
recommended to provide the RAPDF information on HTTP servers [5] on
the Internet.  This way an embedded device does not need to store the

entire RAPDF information locally.  Storing the URL indicating where
to find the RAPDF is sufficient for such cases.

If the embedded device integrates a Remote Access Server (RAS)
directly and its CPU performance and disk storage capacity is
sufficient in size, the RAPDF MAY be stored and made available by the
device itself.


**3**. **Protocols and Formats Used**

Which protocols are used to exchange the RAPDF information between
the RAD, RAS and RAC is not specified in this document.  Depending on
the application a variation of existing email or web protocols MAY be
used.  Also depending on the application additional security
protocols should be used to prohibit unauthorized access.

The information flow and formats used are:

Information sent from the RAS to the RAC MUST be in RAPDF.  This
ensures support of a wide variety of existing and future clients.

Information sent from the RAC to the RAS MUST be the regular POST
reply used for HTML forms (see [4] and [5]).

Information flow between RAD and RAS is application and manufacturer
specific.  Either the RAD provides the RAS with the entire RAPDF or
it provides the RAS with information where to get the RAPDF (for
example by giving it a URL to the RAPDF info)


**4**. **General RAPDF Usage Example**

To illustrate how Remote Access MAY be implemented in accordance to
this document, here is an example:

In an automated home, one RAS provides access to several RAD, such as
thermostats, light controls, etc.  The RAS is configured to recognize
a list of authorized users.

Using a RAC, an authorized user requests the RAPDF from the RAS.  The
RAS assembles the RAPDF information by either getting the data from
the RAD themselves û or if they are minimal implementations,
retrieves the RAPDF information from the manufacturerÆs web page
(using a URL reported by the RAD).

Once the RAPDF is assembled and the current data values / settings
inserted, the RAS transmits the RAPDF to the RAC who requested it.

If the user requests changes to the data values / settings, the new
values are transmitted back to the RAS who is in charge of applying
them.

Security Considerations

This document does not address the security issue, as it focuses on
the data format exchanged between the RAC and RAS, not on the
protocols used to exchange the data. Depending on the security level
required by the application, an appropriate secure transmission
protocol SHOULD be used.

References

1  Bradner, S., "The Internet Standards Process -- Revision 3", BCP
   9, RFC 2026, October 1996.

2  Bradner, S., "Key words for use in RFCs to Indicate Requirement
   Levels", BCP 14, RFC 2119, March 1997.

3  L. Masinter, ôHyper Text Coffee Pot Control Protocol
   (HTCPCP/1.0)ö, RFC2324, April 1998.

4  Dave Ragget, Arnaud Le Hors, Ian Jacobs, ôHTML 4.01ö,
   www.w3.org/TR/html4, December 1999.

5  R. Fielding, J. Gettys, J. Mogul, H. Frystyk, L. Masinter, P.
   Leach, T. Berners-Lee, ôHypertext Transfer Protocol -- HTTP/1.1ô,
   RFC2616, June 1999.

Appendix A û RAPDF Examples

    NOTE: Additional examples are available at:
    http://www.embeddedinternetworking.com/remoteaccess/


    A.1 RAPDF Example with minimal formatting

    <HTML>

    <HEAD>
    <meta http-equiv="Content-Type" content="text/html; charset=windows-
    1252">
    <META name=ötypeö content=öRAPDF 1.0ö>
    <TITLE>Remote Access to Home Control Center</TITLE>
    </HEAD>

    <BODY>

    <LABEL for="ra_form_name">Remote Access to Home Control
    Center</LABEL>
    <FORM name=öRemote Access to MyDeviceö
    action="remote@mail.com?subject=RAPDF%20Command%20Set" method="post"
    id="ra_form_name">
    <P>
      <LABEL for="ra_temp_lr">Living Room Temperature</LABEL>
      <INPUT name="temp_living_room" type="text" id="ra_temp_lr"><br>
      <LABEL for="ra_temp_mb">Master Bedroom Temperature</LABEL>
      <INPUT name="temp_master_bedroom" type="text" id="ra_temp_mb"><br>
      <LABEL for="ra_temp_gr">Guest Room Temperature</LABEL>
      <INPUT name="temp_guest_bedroom" type="text" id="ra_temp_gr"><br>
    </P>
    <P>
      <INPUT name="light_living" type="checkbox" value="Living Room"
    id="ra_light_lr">
      <LABEL for="ra_light_lr">Living Room Lights</LABEL><br>
      <INPUT name="light_kitchen" type="checkbox" value="Kitchen"
    id="ra_light_ki">
      <LABEL for="ra_light_ki">Kitchen Lights</LABEL><br>
      <INPUT name="light_bath" type="checkbox" value="Bathroom"
    id="ra_light_ba">
      <LABEL for="ra_light_ba">Bathroom Lights</LABEL><br>
    </P>
    <P>
      <LABEL for="ra_safety">Safety Shut-off</LABEL><br>
      <SELECT name="safety_shutoff" id="ra_safety">
       <OPTION>None</OPTION>
       <OPTION>Water Heater</OPTION>

```
     <OPTION>Furnace</OPTION>
```

```
   <OPTION>Stove</OPTION>
  </SELECT>
</P>
<P>
  <INPUT name="time_method" type="radio" value="Once">
  <LABEL for="ra_time_now">Activate settings now</LABEL><br>
  <INPUT name="time_method" type="radio" value="Daily">
  <LABEL for="ra_time_daily">Activate settings every 24
hours</LABEL><br>
  <INPUT name="time_method" type="radio" value="Weekly">
  <LABEL for="ra_time_weekly">Activate settings every 7
days</LABEL><br>
</P>
<P>
 <INPUT type="submit" value="Send Settings"> <INPUT type="reset"
value="Reset Values">
</P>
</FORM>

</BODY>

</HTML>
```

A.2 RAPDF Example with FIELDSET and LEGEND

```
<HTML>

<HEAD>
<META http-equiv="Content-Type" content="text/html; charset=windows-
1252">
<META name=ötypeö content=öRAPDF 1.0ö>
<TITLE>Remote Access to Home Control Center</TITLE>
</HEAD>

<BODY>

<LABEL for="ra_form_name">Remote Access to Home Control
Center</LABEL>
<FORM name=öRemote Access to MyDeviceö
action="mailto:ra@mail.com?subject=RAPDF%20Command%20Set"
method="post" id="ra_form_name">

 <FIELDSET>
  <LEGEND>Climate Control Settings</LEGEND>
  <LABEL for="ra_temp_lr">Living Room Temperature</LABEL>
  <INPUT name="temp_living_room" type="text" id="ra_temp_lr"><br>
  <LABEL for="ra_temp_mb">Master Bedroom Temperature</LABEL>
  <INPUT name="temp_master_bedroom" type="text" id="ra_temp_mb"><br>
```

```
  <LABEL for="ra_temp_gr">Guest Room Temperature</LABEL>
  <INPUT name="temp_guest_bedroom" type="text" id="ra_temp_gr"><br>
 </FIELDSET>

 <FIELDSET>
  <LEGEND>Light Controls</LEGEND>
  <INPUT name="light_living" type="checkbox" value="Living Room"
id="ra_light_lr">
  <LABEL for="ra_light_lr">Living Room Lights</LABEL><br>
  <INPUT name="light_kitchen" type="checkbox" value="Kitchen"
id="ra_light_ki">
  <LABEL for="ra_light_ki">Kitchen Lights</LABEL><br>
  <INPUT name="light_bath" type="checkbox" value="Bathroom"
id="ra_light_ba">
  <LABEL for="ra_light_ba">Bathroom Lights</LABEL><br>
 </FIELDSET>

 <FIELDSET>
  <LEGEND>Safety Shut Off</LEGEND>
  <LABEL for="ra_safety">Select the device to shut off</LABEL><br>
  <SELECT name="safety_shutoff" id="ra_safety">
   <OPTION>None</OPTION>
   <OPTION>Water Heater</OPTION>
   <OPTION>Furnace</OPTION>
   <OPTION>Stove</OPTION>
  </SELECT>
 </FIELDSET>

 <FIELDSET>
  <LEGEND>Timing Information</LEGEND>
  <INPUT name="time_method" type="radio" value="Once">
  <LABEL for="ra_time_now">Activate settings now</LABEL><br>
  <INPUT name="time_method" type="radio" value="Daily">
  <LABEL for="ra_time_daily">Activate settings every 24
hours</LABEL><br>
  <INPUT name="time_method" type="radio" value="Weekly">
  <LABEL for="ra_time_weekly">Activate settings every 7
days</LABEL><br>
 </FIELDSET>

 <INPUT type="submit" value="Send Settings"> <INPUT type="reset"
value="Reset Values">

</FORM>

</BODY>

</HTML>
```

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