

# APRX Software Requirement Specification

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## 5 **1 APRX Software Requirement Specification**

6 This is *Requirement Specification* for a software serving in Amateur Radio APRS service.

7 Reader is assumed to be proficient with used terminology, and they are not usually  
8 explained here.

### 9 **1.1 Purpose:**

10 This describes algorithmic, IO-, and environmental requirements for a software doing any  
11 combination of following four tasks related to APRS service:

- 12 1. Listen on messages with a radio, and pass them to APRSIS network service
- 13 2. Listen on messages with a radio, and selectively re-send them on radio
- 14 3. Listen on messages with a radio, and selectively re-send them on radios on other  
15 frequencies
- 16 4. Receive messages from APRSIS network, and after selective filtering, send some of  
17 them on radio

18

19 Existing *aprx* software implements Receive-Only (Rx) IGate functionality, and the purpose  
20 of this paper is to map new things that it will need for extending functionality further.

21

22

## 23 1.2 Usage Environments:

24 The *aprx* software can be used in several kinds of environments to handle multiple tasks  
25 associated with local APRS network infrastructure tasks.

26 On following one should remember that amateur radio transmitters need a licensed  
27 owner/operator/license themselves, but receivers do not:

- 28 1. License-free Receive-Only (RX) IGate, to add more “ears” to hear packets, and to  
29 pipe them to APRSIS
- 30 2. Licensed bidirectional IGate, selectively passing messages from radio channels to  
31 APRSIS, and from APRSIS to radio channels, but not repeating packets heard on a  
32 radio channel back to a radio channel.
- 33 3. Licensed bidirectional IGate plus selectively re-sending of packets heard on radio  
34 channels back to radio channels
- 35 4. Licensed system for selectively re-sending of packets heard on radio channels back  
36 to other radio channels, and this without bidirectional IGate service.
- 37 5. Licensed system for selectively re-sending of packets heard on radio channels back  
38 to radio channels, and doing with with “receive only” IGate, so passing information  
39 heard on radio channel to APRSIS, and not the other way at all.

40

41 In more common case, there is single radio and single TNC attached to digipeating (re-  
42 sending), in more challenging cases there are multiple receivers all around, and very few  
43 transmitters. Truly challenging systems operate on multiple radio channels. As single-  
44 TNC and single-radio systems are just simple special cases of these complex systems,  
45 and for the purpose of this software requirements we consider the complex ones:

- 46 1. 3 different frequencies in use, traffic is being relayed in between them, and the  
47 APRSIS network.
- 48 2. On each frequency there are multiple receivers, and one well placed transmitter.
- 49 3. Relaying from one frequency to other frequency may end up having different rules,  
50 than when re-sending on same frequency: Incoming packet retains traced paths,  
51 and gets WIDEn-N/TRACEn-N requests replaced with whatever sysop wants.

52

53

## 54 2 Treatment rules:

55 Generally: All receivers report what they hear straight to APRSIS, after small amount of  
56 filtering of junk messages, and things which explicitly state that they should not be sent to  
57 APRSIS.

### 58 2.1 Basic IGate rules:

59 General rules for these receiving filters are described here:

60 <http://www.aprs-is.net/IGateDetails.aspx>  
61

62 Gate all packets heard on RF to the Internet (Rx-IGate) EXCEPT

- 63 1. 3<sup>rd</sup> party packets (data type '}' ) should have all before and including the data  
64 type stripped and then the packet should be processed again starting with  
65 step 1 again. There are cases like D-STAR gateway to APRS of D-STAR  
66 associated operator (radio) positions.
- 67 2. generic queries (data type '?' ).
- 68 3. packets with TCPIP, TCPXX, NOGATE, or RFONLY in the header, especially  
69 in those opened up from a 3<sup>rd</sup> party packets.

70  
71 Gate message packets and associated posits to RF (Tx-IGate) if

- 72 1. the receiving station has been heard within range within a predefined time  
73 period (range defined as digi hops, distance, or both).
- 74 2. the sending station has not been heard via RF within a predefined time  
75 period (packets gated from the Internet by other stations are excluded from  
76 this test).
- 77 3. the sending station does not have TCPXX, NOGATE, or RFONLY in the  
78 header.
- 79 4. the receiving station has not been heard via the Internet within a predefined  
80 time period.

81 A station is said to be heard via the Internet if packets from the station contain  
82 TCPIP\* or TCPXX\* in the header or if gated (3<sup>rd</sup> party) packets are seen on RF  
83 gated by the station and containing TCPIP or TCPXX in the 3<sup>rd</sup> party header (in  
84 other words, the station is seen on RF as being an IGate).

85 Gate all packets to RF based on criteria set by the sysop (such as call sign, object  
86 name, etc.).

87

88 Rx-IGate to APRSIS can use duplicate detection, and refuse to repeat same packet over  
89 and over again to APRSIS network.

90 With more advanced looking inside frames to be relayed, both the digipeater and Tx-IGate  
91 can use filtering rules, like “packet reports a position that is within my service area.”

92

93

94 From multiple receivers + single (or fewer) transmitter(s) follows, than when a more usual  
95 system does not hear what it sent out itself, this one will hear, and its receivers must have  
96 a way to ignore a frame it sent out itself a moment ago.

97 Without explicit “ignore what I just sent” filtering, an APRS packet will get reported twice to  
98 APRSIS:

99 rx  $\Rightarrow$  igate-to-aprsis + digi  $\Rightarrow$  tx  $\Rightarrow$  rx  $\Rightarrow$  igate-to-aprsis + digi (dupe filter stops)

100 Digipeating will use common packet duplication testing to sent similar frame out only once  
101 per given time interval (normally 30 seconds.)

102

## 103 2.2 Low-Level Transmission Rules:

104 These rules control repeated transmissions of data that was sent a moment ago, and other  
105 basic transmitter control issues, like persistence. In particular the persistence is fine  
106 example of how to efficiently use radio channel, by sending multiple small frames in quick  
107 succession with same preamble and then be silent for longer time.

108 1. Duplication detector per transmitter: Digipeater and Tx-IGate will ignore packets  
109 finding a hit in this subsystem.

110 2. A candidate packet is then subjected to a number of filters, and if approved for it,  
111 the packet will be put on duplicate packet detection database (one for each  
112 transmitter.) See Digipeater Rules, below.

113 3. Because the system will hear the packets it sends out itself, there must be a global  
114 expiring storage for recently sent packets, which the receivers can then compare  
115 against. (Around 100 packets of 80-120 bytes each.) This storage gets a full copy  
116 of packet being sent out – a full AX.25 frame.

117 Also, transmitters should be kept in limited leash: Transmission queue is less than T  
118 seconds ( < 5 ? ), which needs some smart scheduling coding, when link from computer to  
119 TNC is considerably faster.

120 Original KISS interface is defined as “best effort”: if TNC is busy while host sends a frame,  
121 the frame may be discarded, and “upper layers” will resend. In APRS Digipeating, the  
122 upper layer sends the packet once, and then declares circa 30 second moratorium on  
123 packets with same payload.

124

## 125 2.3 Low-Level Receiving Rules:

- 126 1. Received AX.25 packet is compared against “my freshly sent packets” storage, and  
127 matched ones are dropped. (Case of one/few transmitters, and multiple receivers  
128 hearing them.)
  - 129 2. Received packet is validated against AX.25 basic structure, invalid ones are  
130 dropped.
  - 131 3. Received packet is validated against Rx-IGate rules, forbidden ones are dropped  
132 (like when a VIA-field contains invalid data.)
  - 133 4. Packet may be rejected for Rx-IGate, but it may still be valid for digipeating!  
134 For example a 3<sup>rd</sup> party frame is OK to digipeat, but not to Rx-IGate to APRSIS!  
135 Also some D-STAR to APRS gateways output 3<sup>rd</sup> party frames, while the original  
136 frame is quite close to an APRS frame.
- 137 Divide packet rejection filters to common, and destination specific ones.

## 138 2.4 Additional Tx-IGate rules:

139 The Tx-IGate can have additional rules for control:

- 140 1. Multiple filters look inside the message, and can enforce a rule of “repeat only  
141 packets within my service area,” or to “limit passing message responses only to  
142 destinations within my service area”. Filter input syntax per javAPRSSrvr's adjunct  
143 filters with negation extension.
- 144 2. Basic gate filtering rules:
  - 145 1. the receiving station has been heard within range within a predefined time  
146 period (range defined as digi hops, distance, or both).
  - 147 2. the sending station has not been heard via RF within a predefined time period  
148 (packets gated from the Internet by other stations are excluded from this test).
  - 149 3. the sending station does not have TCPXX, NOGATE, or RFONLY in the header.
  - 150 4. the receiving station has not been heard via the Internet within a predefined time  
151 period.

152 A station is said to be heard via the Internet if packets from the station contain  
153 TCPIP\* or TCPXX\* in the header or if gated (3rd-party) packets are seen on RF  
154 gated by the station and containing TCPIP or TCPXX in the 3rd-party header (in  
155 other words, the station is seen on RF as being an IGate).
- 156 3. Optionally wait a few seconds (like a random number of seconds in range of 1 to 5  
157 seconds) before letting received packet out. This permits other systems to be faster  
158 than the Tx-IGate system, and thus to get their voice.

159

160

## 161 2.5 Digipeater Rules:

162 Digipeater will do following for each transmitter:

- 163 1. Compare candidate packet against duplicate filter, if found, then drop it. (Low-level  
164 transmission rules, number 1)
- 165 2. Count number of hops the message has so far done, and...
- 166 3. Figure out the number of hops the message has been requested to do  
167 (e.g. "OH2XYZ-1>APRS,OH2RDU\*,WIDE7-5: ..." will report that there was request  
168 of 7 hops, so far 2 have been executed – one is shown on trace path.)
- 169 4. If either of previous ones are over any of configured limits, the packet is dropped.
- 170 5. FIXME: WIDEn-N/TRACEn-N treatment rules: By default treat both as TRACE,  
171 have an option to disable "WIDE-is-TRACE" mode. Possibly additional keywords  
172 for cross-band digipeating? (E.g. Bruninga said '6MTRSn-N' would be 'WIDEn-N'  
173 on 50 MHz APRS, and only there.)
- 174 6. Multiple filters look inside the message, and can enforce a rule of "repeat only  
175 packets within my service area."
- 176 7. FIXME: Cross frequency digipeating? Treat much like Tx-IGate?  
177 Relaying from one frequency to other frequency may end up having different rules,  
178 than when re-sending on same frequency: Incoming packet retains traced paths,  
179 and gets WIDEn-N/TRACEn-N requests replaced with whatever sysop wants.
- 180 8. Cross band relaying may need to add both an indication of "received on 2m", and  
181 transmitter identifier: "sent on 6m":  
182 "OH2XYZ-1>APRS,RX2M\*,OH2RDK-6\*,WIDE3-2: ..."
- 183 This "source indication token" may not have anything to do with real receiver  
184 identifier, which is always shown on packets passed to APRSIS.  
185

186 The MIC-e has a weird way to define same thing as normal packets do with  
187 SRCCALL-n>DEST,WIDE2-2: ...

188 The MIC-e way (on specification, practically nobody implements it) is:  
189 SRCCALL-n>DEST-2: ...

190

191

## 2.6 Duplicate Detector

Normal digipeater duplicate packet detection compares message source (with SSID), destination (without SSID!), and payload data against other packets in self-expiring storage called “duplicate detector”. Lifetime of this storage is commonly considered to be 30 seconds.

Practically the packet being compared at Duplicate Detector will be terminated at first CR or LF in the packet, and if there is a space character preceding the line end, also that is ignored when calculating duplication match. **However: The Space Characters are sent, if any are received, also when at the end of the packet!** (Some TNC:s have added one or two extra space characters on packets they digipeat...)

The “destination without SSID” rule comes from MIC-e specification, where a destination WIDEn uses SSID to denote number of distribution hops.

## 2.7 Radio Interface Statistics Telemetry

Current *aprx* software offers telemetry data on radio interfaces. It consists of following four things. Telemetry is reported to APRS-IS every 10 minutes:

1. Channel occupancy average in Erlangs over 1 minute interval, and presented as busiest 1 minute within the report interval. Where real measure of carrier presence on radio channel is not available, the value is derived from number of received AX.25 frame bytes plus a fixed Stetson-Harrison constant added per each packet for overheads. That is then divided by presumed channel modulation speed, and thus derived a figure somewhere in between 0.0 and 1.0.
2. Channel occupancy average in Erlangs over 10 minute interval. Same data source as above.
3. Count of received packets over 10 minutes.
4. Count of packets dropped for some reason during that 10 minute period.

Additional telemetry data points could be:

1. Number of transmitted packets over 10 minute interval
2. Number of packets IGate:d from APRSIS over 10 minute interval
3. Number of packets digipeated for this radio interface over 10 minute interval
4. Erlang calculations could include both Rx and Tx, but could also be separate.



## 225    **2.8 Individual Call-Signs for Each Receiver, or Not?**

226    Opinions are mixed on the question of having separate call-signs for each receiver (and  
227    transmitter), or not. Even the idea to use all 16 available SSIDs for a call-sign for  
228    something does get some opposition.

- 229        • There is no license fee in most countries for receivers, and there is no need to limit  
230        used call signs only on those used for the site transmitters.
- 231        • There is apparently some format rule on APRSIS about what a “call-sign” can be,  
232        but it is rather lax: 6 alphanumerics + optional tail of: “-” (minus sign) and one or two  
233        alphanumerics. For example OH2XYZ-R1 style call-sign can have 36 different  
234        values before running out of variations on last character alone (A to Z, 0 to 9.)
- 235        • Transmitter call-signs are important, and there valid AX.25 format call-signs are  
236        mandatory.

237

238    Transmitters should have positional beacons for them sent on correct position, and  
239    auxiliary elements like receivers could have their positions either real (when elsewhere), or  
240    actually placed near the primary Tx location so that they are separate on close enough  
241    zoomed map plot.

242    Using individual receiver identities (and associated net-beaconed positions near the real  
243    location) can give an idea of where the packet was heard, and possibly on which band. At  
244    least the *aprs.fi* is able to show the path along which the position was heard.

245

## 2.9 Beacons

Smallest time interval available to position viewing at aprs.fi site is 15 minutes. A beacon interval longer than that will at times disappear from that view. Default view interval is 60 minutes.

Beacon transmission time **must not** be manually configured to fixed exact minute. There are large peaks in APRSIS traffic because of people are beaconing out every 5 minutes, and every 10 minutes, at exact 5/10 minutes. (Common happening with e.g. *digi\_ned*.)

Beaconing system must be able to spread the requests over the entire cycle time (10 to 30 minutes) evenly. Even altering the total cycle time by up to 10% at random at the start of each cycle should be considered (and associated re-scheduling of all beacon events at every cycle start). All this to avoid multiple non-coordinated systems running at same rhythm. System that uses floating point mathematics to determine spherical distance in between two positions can simplify the distribution process by using float mathematics. Also all-integer algorithms exist (e.g. Bresenham's line plotting algorithm.)

```
float dt = (float)cycle_in_seconds;
for (int i = 0; i < number_of_beacons;++i) {
    beacon[i].tx_time = now + (i+1) * dt;
}
```

With only one beacon, it will go out at the end of the beacon cycle.

Receiver location beacons need only to be on APRSIS with additional TCPXX token, transmitter locations could be also on radio.

### 2.9.1 Radio Beacons

“Tactical situation awareness” beaconing frequency could be 5-10 minutes, WB4APR does suggest at most 10 minutes interval. Actively moving systems will send positions more often. Transmit time spread algorithm must be used.

Minimum interval of beacon transmissions to radio should be 60 seconds. If more beacons need to be sent in this time period, use of Persistence parameter on TNCs (and KISS) should help: Send the beacons one after the other (up to 3?) during same transmitter activation, and without prolonged buffer times in between them. That is especially suitable for beacons *without* any sort of distribution lists.

**Minimize the number of radio beacons!**

### 2.9.2 Network beaconing

Network beaconing cycle time can be up to 30 minutes.

Network beaconing can also transmit positions and objects at much higher rate, than radio beaconing. Transmit time spread algorithm must be used.

Net-beacons could also be bursting similar to radio beacon Persistence – within a reason.

### 283 3 Configuration Language

284 System configuration language has several semi-conflicting requirements:

- 285 1. Easy to use
- 286 2. Minimal setup necessary for start
- 287 3. Sensible defaults
- 288 4. Self-documenting
- 289 5. Efficient self-diagnostics
- 290 6. Powerful – as ability to define complicated things

291

292 Examples of powerful, yet miserably complicated rule writing can be seen on *digi\_ned*, and  
293 *aprsd*. Both have proven over and over again that a correct configuration is hard to make.

294 On Embedded front, things like UIDIGI have tens of parameters to set, many of which can  
295 be configured so that the network behaviour is degraded, if not downright broken.

296 UIView32 has poor documentation on what to put on destination address, and therefore  
297 many users put there “WIDE” instead of “APRS,WIDE”, and thus create broken beacons.

298

299 Current *aprx* configuration follows “minimal setup” and “easy to use” rules, it is even “self-  
300 documenting” and “self-diagnosing”, but its lack of power becomes apparent.

301 Some examples:

- 302 1. radio serial /dev/ttyUSB0 19200 8n1 KISS callsign N0CALL-14
- 303 2. netbeacon for N0CALL-13 dest "APRS" via "NOGATE" symbol "R&"  
304 lat "6016.30N" lon "02506.36E" comment "aprx - an Rx-only iGate"

305 The “radio serial” definition lacks handling of multiple TNCs using KISS device IDs, and  
306 there is no easy way to define subid/callsign pairs.

307 The “netbeacon” format can do only basic “!”-type location fix packets. Extending it to  
308 objects would probably cover 99% of wanted use cases.

309 Both have extremely long input lines, no input line folding is supported!

310

### 3.1 APRSIS Interface Definition

There can be multiple APRSIS connections defined, although only one is used at any time. Parameter sets controlling this functionality is non-trivial.

```

314 <aprsis>                                # Alternate A, single server, defaults
315     login  = OH2XYZ-R1
316     server = finland.aprs2.net:14580
317     filter = ....
318     heartbeat-timeout = 2 minutes
319 </aprsis>
320 <aprsis>                                # Alternate B, multiple alternate servers
321     login  = OH2XYZ-R1
322     <server finland.aprs2.net:14580>
323         heartbeat-timeout = 2 minutes
324         filter = ....
325     </server>
326     <server rotate.aprs.net:14580>
327         heartbeat-timeout = 120 seconds
328         filter = ....
329         # Alt Login ?
330     </server>
331 </aprsis>

```

### 3.2 Radio Interface Definitions

Interfaces are of multitude, some are just plain serial ports, some can be accessed via Linux internal AX.25 network.

```

335 <interface>
336     serial-device = /dev/ttyUSB1 19200 8n1 KISS
337     tx-ok         = false           # receive only (default)
338     callsign      = OH2XYZ-R2      # KISS subif 0
339 </interface>
340 <interface>
341     serial-device = /dev/ttyUSB2 19200 8n1 KISS
342     <kiss-subif 0>
343         callsign = OH2XYZ-2
344         tx-ok    = true             # This is our transmitter
345     </kiss-subif>
346     <kiss-subif 1>
347         callsign = OH2XYZ-R3      # This is receiver
348         tx-ok    = false          # receive only (default)
349     </kiss-subif>
350 </interface>
351 <interface>
352     ax25-device = OH2XYZ-6
353     tx-ok       = true             # This is also transmitter
354 </interface>

```

### 3.3 Digipeating Definitions

The powerfulness is necessary for controlled digipeating, where traffic from multiple sources gets transmuted to multiple destinations, with different rules for each of them.

1. Destination device definition (refer to “serial radio” entry, or AX.25 network interface), must find a “tx-ok” feature flag on the interface definition.
2. Possible Tx-rate-limit parameters
3. Groups of:
  1. Source device references (of “serial radio” or ax25-rxport call-signs, or “APRSIS” keyword)
  2. Filter rules, if none are defined, source will not pass anything in. Can have also subtractive filters – “everything but not that”. Multiple filter entries are processed in sequence.
  3. Digipeat limits – max requests, max executed hops.
  4. Control of treat WIDEn-N as TRACEn-N or not. (Default: treat as TRACE)
  5. Alternate keywords that are controlled as alias of “WIDEn-N”
  6. Alternate keywords that are controlled as alias of “TRACEn-N”
  7. Additional rate-limit parameters

Possible way to construct these groups is to have similar style of tag structure as Apache HTTPD does:

```
<digipeater>
  transmit = OH2XYZ-2 # to interface with callsign OH2XYZ-2
  ratelimit = 20      # 20 posts per minute
  <source>
    source = OH2XYZ-2      # Repeat what we hear on TX TNC
    filters = ....
  </source>
  <source>
    source = OH2XYZ-R2     # include auxiliary RX TNC data
    filters = ....
  </source>
  <source>
    source = APRSIS        # Tx-IGate some data too!
    filters = ....
    ratelimit = 10        # only 10 IGated msgs per minute
  </source>
</digipeater>
```

394 **3.4 Beacon definitions**

395 Netbeacons are sent only to APRSIS, and rfbeacons to radio transmitters.

396

397 <netbeacon>

398

399 </netbeacon>

400