

APRS-IS Servers on The BEAM*



* ... Or how to prototype APRS-IS software on Erlang and Elixir quickly under a tight deadline

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Topics

- Amateur Radio
- APRS and APRS-IS
- apresse: a simple mapping system
- Implementing apresse
- Summary

Automatic Packet Reporting System (APRS)¹

- Amateur radio
- Short messaging (max 256 bytes)
- Broadcast on AX.25 UI frames
- Positioning reporting and messaging

¹ APRS is a registered trademark of Bob Bruninga, WB4APR

Amateur radio

amateur service: A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.

– ITU Radio Regulations, Number 1.56

Amateur radio, in plain English

- Solely for technical experiments
- No business communication
- No cryptography, no privacy
- You need a license
- Pre-allocated radio spectrum only
- Third-party traffic handling is prohibited (expect for where allowed, and in case of emergency)

Amateur radio privacy in the USA

- Anyone can intercept anything in the amateur radio bands (18 USC §2511(2)(g))
- Anyone can make a backup and disclosure of the information transmitted in amateur radio bands (18 USC chapter 121)
- ... therefore NO PRIVACY²

² Radio regulation details may differ in the country, region, or economy where the radio station operates.

Then WHY amateur radio?

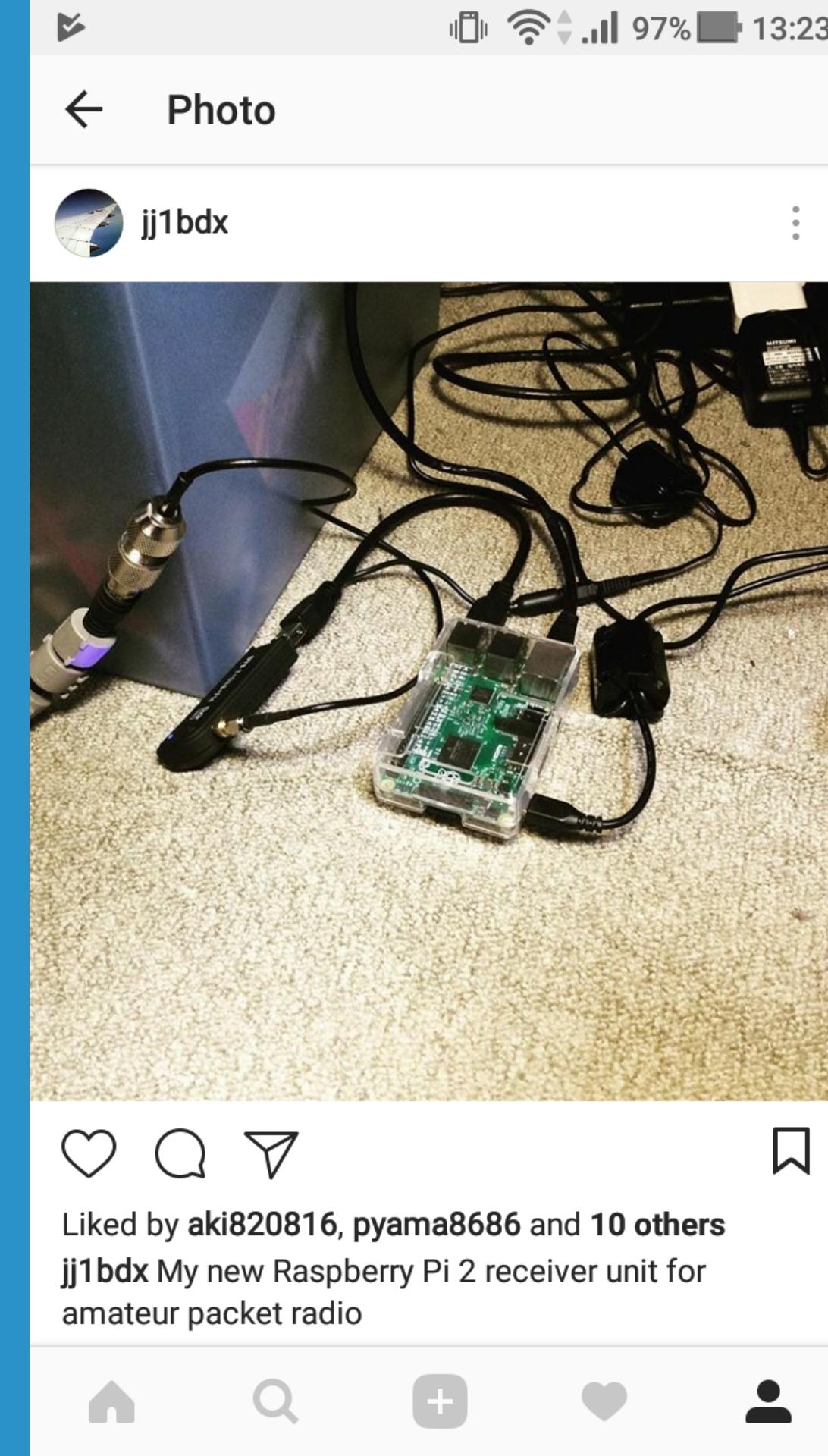
- You can *experiment* your ideas using radio transmitters and antennas
- It is an origin of all the internet cultures emerged after 1980s: sharing, helping each others, and the global friendship without borders
- ... and it's fun

Me enjoying amateur packet radio, December 1986



Messaging on amateur radio

- AX.25 protocol since 1980s
- 1200bps Bell202 + audio FM transceivers
- 9600bps GMSK + specific transceivers
- Modern gears: Raspberry Pi + SDR dongle for receiver



So what is APRS anyway?

- Global network of amateur radio stations
- Broadcasting/receiving information like Twitter
- Aggregated information site: aprs.fi
- Stations connected via APRS Internet Service (APRS-IS)

A YouTube example of 1200bps AX.25/APRS sound³

73448 63N/12139.25W-188/019/A-0000839/The Beamer on the Moon
00000000-RF-S226_X61XR-3_W6CD-5_WIDE2-1 <UI>
0222247-3630 69N/11940.88W_004/005-0071072r000p0000P000b10124h3.
00000000-RF-S226_X61XR-3_W6CX-3_WIDE2-1 <UI>
0222247-3630 69N/11940.88W_004/005-0071072r000p0000P000b10124h3.
00000000-RF125N_X61UD-3_WIDE2-1 <<UI>>
0222248,3751 53N/12012.83W_158/001p0061061r000p001P001h570PRS/0
201

WIDE2-1: <<UI>>
JUN 1 1974

REF ID: A6145815X K6100-3 REBA WIDE2-1 <<UI>>
AM 1 4/17/60

KI-0010-90-RF0121.W86TMS-5.WIDE1-KC01-1- <01>
I have a mile of Caution tape and a line of men went
KI-0010-90-RF0121.W86TMS-5.WIDE1-KC01-5- <01>
I have a mile of Caution tape and a line of men went

³ by radionerd1, <https://www.youtube.com/watch?v=32yuWezqjrk>

Google Maps APRS

https://aprs.fi/#addr=Stockholm

Map Overlays

59°19.24' N 18°3.31' E, JO99AH

aprs.fi · Login

Found: Stockholm, Sweden

Track callsign: Clear Search ?

Address, city or Locator: Clear Stockholm Search ?

Show last: 1 hour Show all

Track tail length: 1 hour

Wx: 6.9°C 86% 1028 mbar 0.0 m/s N

Other views:

- Station info
- Raw packets
- Status packets - Beacon packets
- APRS/CWOP weather - Telemetry
- Messages - Bulletin board
- Prefix browsing
- Google Earth KML ?
- Data export tool
- Preferences - My account

Information:

Stations currently moving · FAQ · Blog · Discussion group · Linking to aprs.fi · AIS sites · Service status · Database statistics · Advertising on aprs.fi · Technical details · API · Change log · Planned changes · Credits and thanks · Terms Of Service · iPhone/iPad APRS

idle

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Map data ©2018 Google 200 m Terms of Use Report a map error

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Google Maps APRS

https://aprs.fi/#addr=Toyonaka

34°47.04' N 135°26.22' E, PM74RS

Map Overlays

apr.sfi · Login

Found: Toyonaka, Osaka Prefecture, Japan

Track callsign: Clear

Address, city or Locator: Clear

Toyonaka Search ?

Show last: 1 hour Show all

Track tail length: 1 hour

Wx: 26.6°C 42% 1006 mbar 0.0 m/s W

Other views:

- Station info
- Raw packets
- Status packets - Beacon packets
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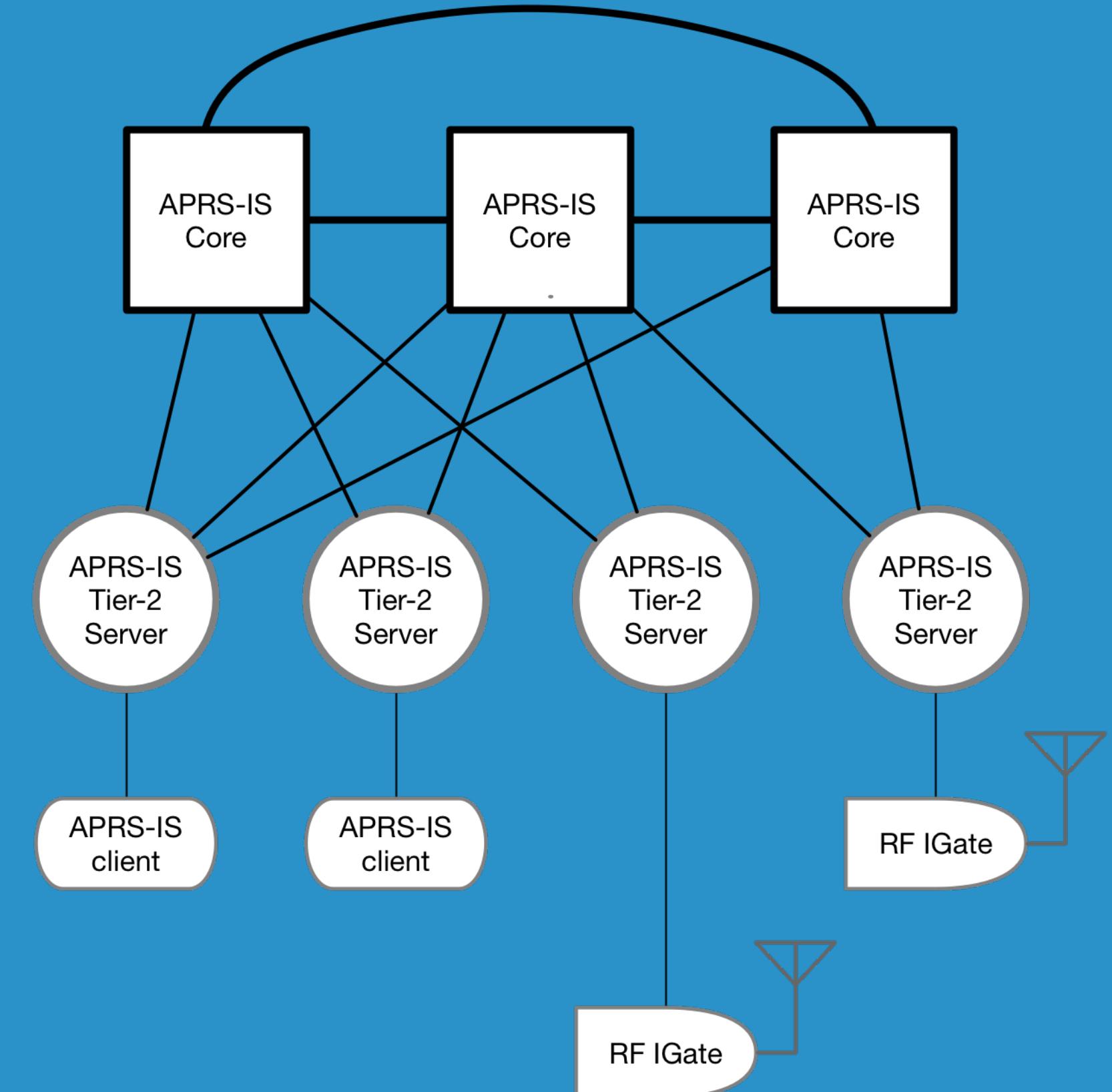
idle: points updated 2, deleted 0

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APRS-IS systems⁴

- Very much like old USENET or modern messaging systems
- IGate systems are clients for the radio systems
- All contents are supposed to be on the amateur radio
- A text messaging system with the specific format



⁴ quoted from <http://www.aprs-is.net/Specification.aspx>, by Peter Loveall, AE5PL

APRS-IS messages

AK4VF>APRX28,TCPIP*,qAC,T2INDIANA:!3735.58N@07730.15W&↔
Raspberry Pi iGate
OE1W-11>APLWS2,qAU,OE1W-2:;N3620455 *140549h4821.65N/0↔
1621.32E@0302/008/A=011516!wvl!clb=-3.3m/s 403.50MHz ↔
Type=RS41 BK=Off
KB1EJH-13>APN391,TCPIP*,qAS,KB1EJH:@111405z3849.75N/07↔
519.50W_287/002g008t075r000p000P000h58b10151.DsVP
BA1GM-6>APLM2C,TCPIP*,qAS,BA1GM-6:=3952.10N/11631.65E>↔
272/049/A=000039http://www.aprs.cn 10X_12S_4.12V

APRS-IS message formats

- Position reports (also timestamps, messages)
- Broadcast messages/bulletins and queries
- Objects and items
- Weather reports
- Telemetry data
- ... and many others

apresse: a simple mapping system of APRS-IS

- Erlang part: retrieving information from APRS-IS and cache the position info in the ETS
- Elixir part: picking up the info from the ETS and show it to the Web browser when requested
- Browser: running mapping framework LeafLet with Google Maps

What Erlang part of apresse does

- Connect to an APRS-IS (Tier-2) server
- Pull the messages and decode them
- Pick up the position data and store into ETS

APRS-IS client code in Erlang

```
connect_dump() ->
{ok, Socket} = gen_tcp:connect("sweden.aprs2.net", 10152,
[binary, {active, false}, {packet, line},
{nodelay, true}, {keepalive, true}
]),
{ok, _Prompt} = gen_tcp:recv(Socket, 0, 5000),
ok = gen_tcp:send(Socket,
"user NOCALL pass -1 vers apresse 0.01\n"),
_C = connect_dump_receive_loop(Socket, 0,
aprs_is_decode:init_cp(), true),
ok = gen_tcp:close(Socket).
```

gen_tcp:connect/3 options

```
connect_dump() ->
{ok, Socket} = gen_tcp:connect("sweden.aprs2.net", 10152,
[binary, {active, false}, {packet, line},
{nodelay, true}, {keepalive, true}
]),
{ok, _Prompt} = gen_tcp:recv(Socket, 0, 5000),
ok = gen_tcp:send(Socket,
"user NOCALL pass -1 vers apresse 0.01\n"),
_C = connect_dump_receive_loop(Socket, 0,
aprs_is_decode:init_cp(), true),
ok = gen_tcp:close(Socket).
```

APRS-IS message header decoder in Erlang

```
init_cp() -> {binary:compile_pattern(<<$>>>),
                binary:compile_pattern(<<$:>>),
                binary:compile_pattern(<<$,>>)}.

decode_header(D, {CPS, CPI, CPR}) ->
    [Header, InfoCRLF] = binary:split(D, CPI),
    [Source, Destrelay] = binary:split(Header, CPS),
    [Destination|Relay] = binary:split(
        Destrelay, CPR, [global]),
    Info = binary:part(InfoCRLF, 0,
                       erlang:byte_size(InfoCRLF) - 2),
    {Source, Destination, Relay, Info}.
```

APRS-IS message content decoder in Erlang

```
info_dispatch(Info) ->
<<Type:8, Rest/binary>> = Info,
info_dispatch_type(Type, Rest).

info_dispatch_type(_, <<>>) -> {undefined, nofield};
info_dispatch_type($!, Field) ->
    position_nomsg(binary:first(Field), Field);
info_dispatch_type($=, Field) ->
    position_msg(binary:first(Field), Field);
%%% and the pattern matching continues...
```

Decoded APRS-IS message example

F4BSX>APFD09,WIDE3-3,qAR,F1ZXR-3:=4313.61N/00134.33E↔
-PHG52NaN04/Dep:09 {UIV32}

Source: F4BSX

Destination: APFD09

Relay: [<<"WIDE3-3">>, <<"qAR">>, <<"F1ZXR-3">>]

Info: =4313.61N/00134.33E-PHG52NaN04/Dep:09 {UIV32}

Decoded: {position,no_message,{uncompressed,
{{longlat,43.22683333333333,1.5721666666666665},{symid,47},
<"-PHG52NaN04/Dep:09 {UIV32}">>}}}

Storing positions in the ETS with Erlang

```
ets_init() ->
    ets:new(aprs_positions, [set, protected, named_table]).
put_ets({Source, _Dest, _Relay, Info}) ->
    Time = erlang:monotonic_time(millisecond),
    put_ets(Time, Source,
            parse_message(aprs_is_decode:info_dispatch(Info))).
put_ets(Time, Source, {Lat, Long}) ->
    % io:format("~p~n", [{Time, Source, Lat, Long}]),
    ets:insert(aprs_positions, {Time, Source, Lat, Long}).
```

How ETS data are stored

```
6> ets:tab2list(aprs_positions).  
[{-576459299045,<<"SR3NOW">>,51.6595,17.7965},  
 {-576459323341,<<"HS3LIQ-2">>,  
  14.9745,102.070333333333334},  
 {-576459367284,<<"K3HQI-1">>,  
  39.96216666666667,-76.801},  
 {-576459335460,<<"LSBRG">>,38.580333333333336,  
 -94.61716666666666},|...]
```

Use ets:tab2list/1 to dump the ETS table

```
6> ets:tab2list(aprs_positions).  
[{-576459299045,<<"SR3NOW">>,51.6595,17.7965},  
 {-576459323341,<<"HS3LIQ-2">>,  
  14.9745,102.07033333333334},  
 {-576459367284,<<"K3HQI-1">>,  
  39.96216666666667,-76.801},  
 {-576459335460,<<"LSBRG">>,38.58033333333336,  
 -94.61716666666666},|...]
```

Purging older ETS data

```
-include_lib("stdlib/include/ms_transform.hrl").  
  
ets_cleanup() ->  
    T = erlang:monotonic_time(millisecond) - 180000,  
    ets:select_delete(  
        aprs_positions,  
        ets:fun2ms(fun({Time, _, _, _}) -> Time < T end)).
```

What Elixir part of apresse does

- Start the Erlang part and Web server
- When requested, create the position data for LeafLet
- Respond with all the headers and scripts of LeafLet as HTML

ApresseWeb.Endpoint: web server in Plug

```
defmodule ApresseWeb.Endpoint do
  use Plug.Builder
  plug Plug.Static,
    at: "/static", from: :apresse_web
  % default processing
  plug ApresseWeb.APRSMap
  plug :not_found
  plug :halt # and the code continues...
```

Generating LeafLet markers by EEx template

```
<%
  popup = :io_lib.format(
    "Source: ~s<br>Lat: ~.4f<br>Long: ~.4f",
    [source, lat, long])
%>

var marker =
  L.marker([<%= lat %>, <%= long %>])
  .addTo(mymap).bindPopup('<%= popup %>');
```

An excerpt from the result HTML

```
<script>
  function showmap() {
    var mymap = L.map('mapid').setView([0.0, 0.0], 1);
    L.gridLayer.googleMutant({type: 'roadmap'}).addTo(mymap);
// Generated part
    var marker = L.marker([-34.4095, 19.307166666666667])
      .addTo(mymap).bindPopup('Source: ZR1TX<br>
Lat: -34.4095<br>Long: 19.3072');
// ... and the HTML continues
```

Automatically generated by the EEX template

```
<script>
  function showmap() {
    var mymap = L.map('mapid').setView([0.0, 0.0], 1);
    L.gridLayer.googleMutant({type: 'roadmap'}).addTo(mymap);
// Generated part
    var marker = L.marker([-34.4095, 19.307166666666667])
      .addTo(mymap).bindPopup('Source: ZR1TX<br>
Lat: -34.4095<br>Long: 19.3072');
// ... and the HTML continues
```

LeafLet



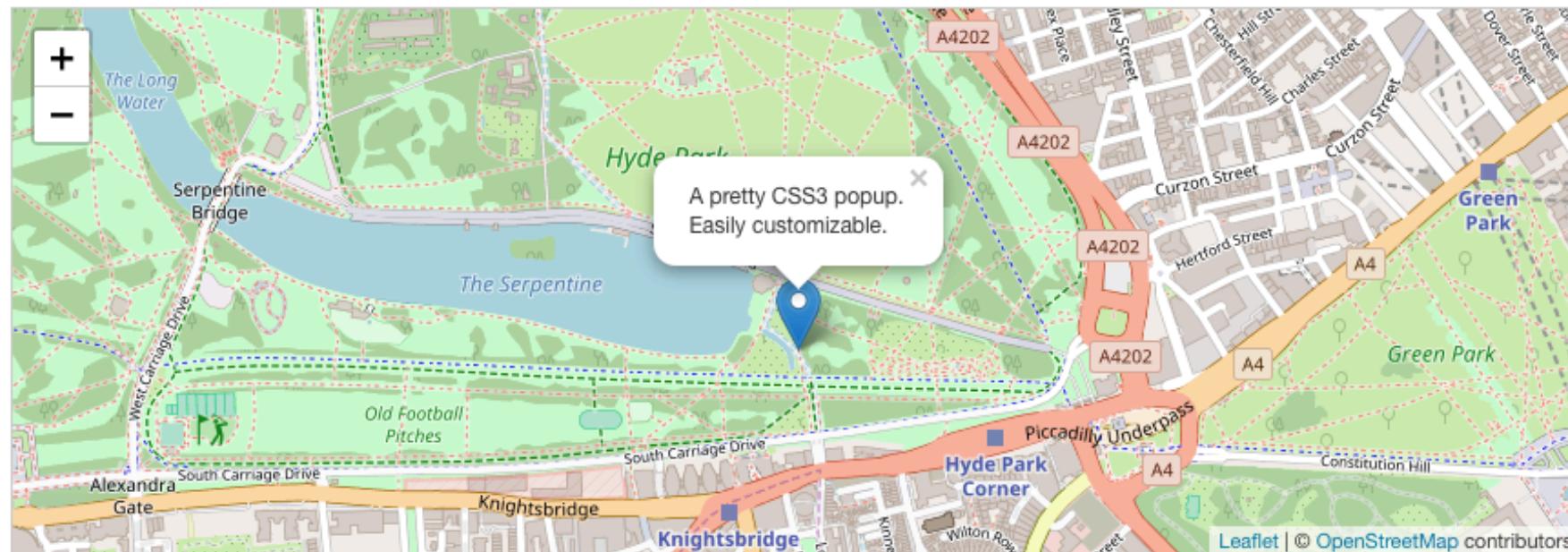
an open-source JavaScript library
for mobile-friendly interactive maps

[Overview](#) [Tutorials](#) [Docs](#) [Download](#) [Plugins](#) [Blog](#)

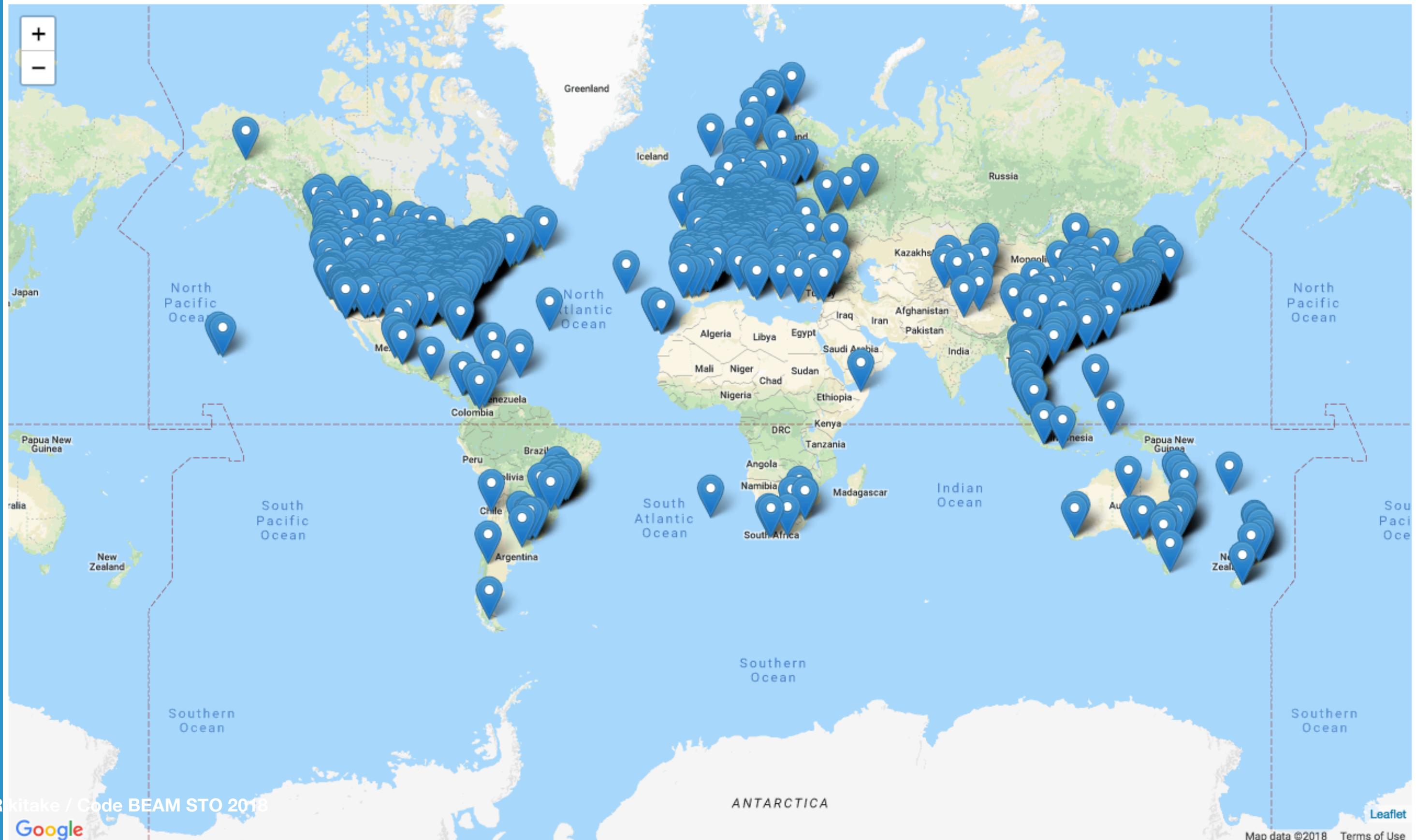
Jan 18, 2018 — [Leaflet 1.3.1](#) has been released.

Leaflet is the leading open-source JavaScript library for mobile-friendly interactive maps. Weighing just about 38 KB of JS, it has all the mapping [features](#) most developers ever need.

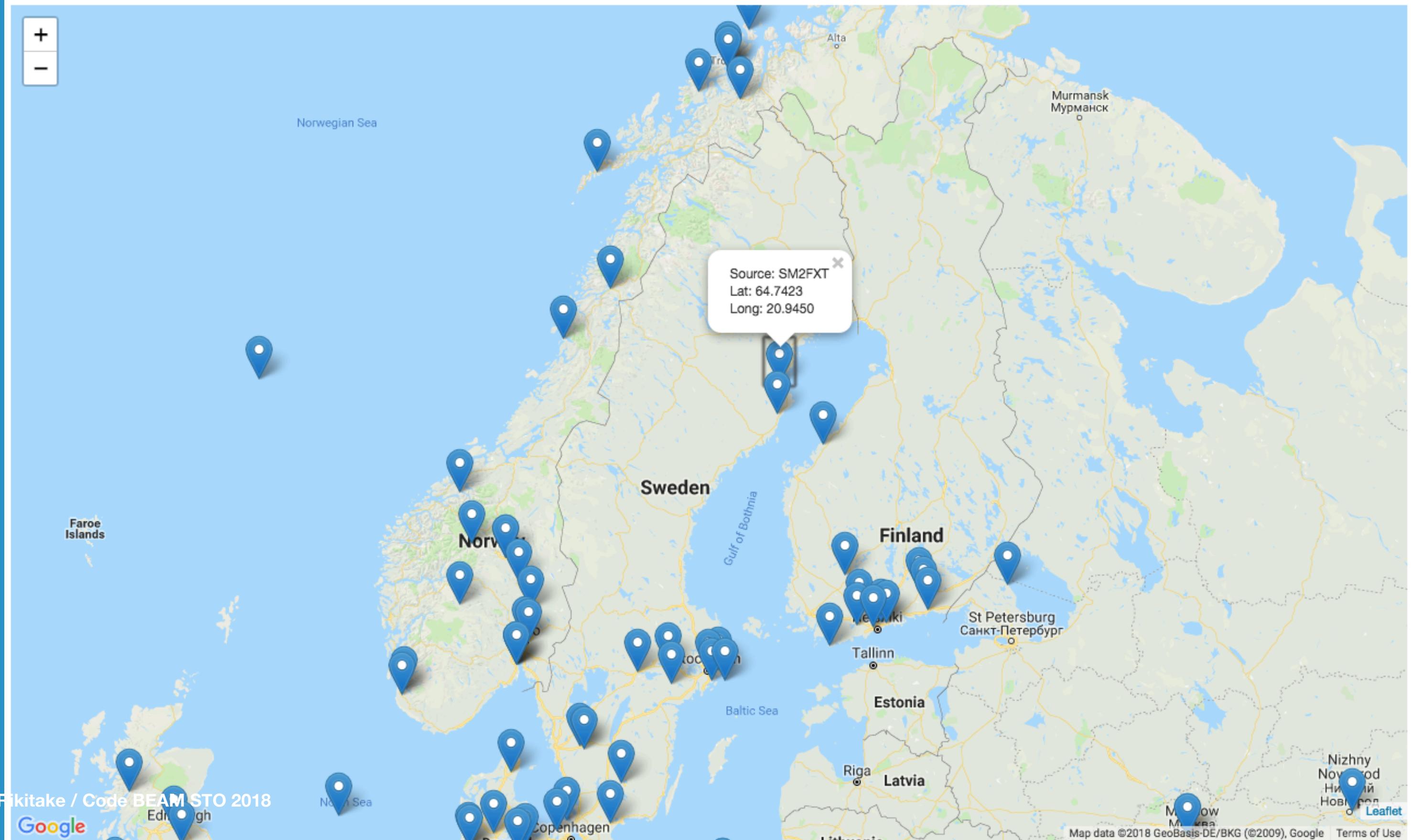
Leaflet is designed with *simplicity, performance and usability* in mind. It works efficiently across all major desktop and mobile platforms, can be extended with lots of [plugins](#), has a beautiful, easy to use and [well-documented API](#) and a simple, readable [source code](#) that is a joy to [contribute](#) to.



apresse APRS map



apresse APRS map



How much code lines are needed for apresse 0.01

- Erlang code: 288 lines
- Elixir code: 121 lines without templates
- EEx template: 31 lines
- ... less than 500 lines in total

Summary

- BEAM is for large-scale/high-concurrency
- BEAM is *not* restricted to the large-scale projects
- Starting small with BEAM languages (Erlang/Elixir) is a good way to prototype quickly
- You can use BEAM for small projects too
- Elixir and Erlang nicely coexist with each other by using proper building tools (mix and rebar3)

Source code and data
Github: jj1bdx/apresse

Acknowledgment

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Thanks to Code BEAM Crew and
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... and thank you for being here!



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Thank you
Questions?

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