A Low Energy APRS-IS Client-Server Infrastructure Implementation using Raspberry Pi

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A Low Energy APRS-IS Client-Server Infrastructure Implementation using Raspberry Pi

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Abstract – Radio communication has great history of innovations. A hobby which helped in pioneering many innovations in radio communications that we are using today is radio amateurism. Hams are radio amateur hobbyists, which use radio communication to communicate, research, and explore new radio technologies and applications, such as Automatic Packet Reporting System (APRS), which is digital communications information channel for Ham radio. Among other purposes APRS is used to report and map position of any stationery or mobile object via radio. In this paper we presented a low cost APRS client-server infrastructure using Raspberry Pi, APRSdroid, and software defined radio (SDR).

I. INTRODUCTION

Automatic Packet Reporting System (APRS) is real time radio amateur service able to transmit position reports, weather reports, messages between users which are processed and visualized. Position reports supported by APRS or more precisely APRS-Internet Service (APRS-IS) rely on GPS data. One of Internet places which visualize APRS data is aprs.fi web site which updates data in real time as they are sent over Internet via nodes which are able to communicate in the same time with Internet and radio amateur nodes and networks. These nodes which are able to send data from radio frequency (RF) networks are part of APRS-IS infrastructure. Because APRS position data are logged and visualized in real time on APRS-IS web sites, this can be used to support community in cases of emergencies [1, 2, 3]. To use RF and APRS-IS for testing and educational purposes, individual has to be licensed radio amateur within national radio amateur associations. Each licensed radio amateur must have assigned call sign number to participate in APRS-IS. One of reasons for experimenting with APRS-IS is trend of rapid growth of new ham licensees issued in United States [4, 5]. For the interest growth of RF usage, there could be reasons such as restructuring, and new frequency band plan [4, 5], but available and cheap technology play important role as well. In this paper we presented low cost and available technology for sustainable APRS-IS exploitation and infrastructure scalable for future developments. All mentioned could be reasons that trend of growth in USA will be followed in other parts of globe.

A. A short history of APRS

Inventor of APRS is Bob Bruninga [6] in 1980's, and this system in that time was called Connectionless Emergency Traffic System (CETS) and was developed for National Disaster Medical System [7]. In the 1990's there were no widely available digital and detailed geographical maps like today's google maps, and many maps have to be drawn manually. These maps were able to support smaller geographical areas compared with today's available mapping mechanisms which can span whole world. Today's technology allows usage of APRS-IS to transfer locally collected data, or local data collection point via TCP/IP using UDP, TCP, or HTTP directly to APRS-IS, or indirectly via RF and APRS Internet gateways [8] which is our choice since it eliminates need of operational GSM / GPRS or other network that would support TCP/IP communication between data collection point (GPS location data reporting using RF transceiver) and IGates [9] where IGate [9] is a gateway APRS station. IGate nodes are able to communicate in the same time with Internet and radio amateur nodes. The IGate's task is to allow packets to cross from the local RF network to the APRS-IS see Figure 1.

B. Current technology applications and advances in amateur RF and APRS

Today APRS-IS is used as infrastructure to map location using commercially available radio transceivers such as VHF Kenwood RF transceiver [10]. Following VHF frequencies are used for APRS services: in North America is in usage 144.390 MHz, in Europe, Russia, South Africa 144.800 Mhz [11] some other countries have different frequencies allocated for this purpose. APRS-IS is technology which brings different technological and open source advances at one place such as Linux operating system and open source applications which supports APRS-SI, TCP/IP infrastructure, cheap microcomputer hardware. One of indicators of how APRS-SI is used, can be seen at the aprs.fi web site. Referenced web APRS site is home for different information such as sensor readings, weather station reports. Different sensors can be used to collect data which might be crucial for early warnings on flood, fire, mudslides, and other potential nature disasters. These sensors can deliver information directly to Internet or as backup option via hamnet [12,13] network for rising alarms allowing proactive actions by those potentially affected, and to rescuers.

Services that Hams provide in critical situations in our opinion is and could be part of critical infrastructure because they provide information and technical support in cases of emergency when other means of communications does not work. Critical infrastructure is important for:

"health, safety, security or economic well-being of citizens or the effective functioning of governments" stated by [14].

In recent years cheap and energy efficient (low energy) microcomputer devices such as Raspberry Pi (RPi) microcomputer became available which are suitable for education purposes [15, 16, 17, 18] which we used in our project to establish infrastructure for APRS reporting. Together with RPi it is possible to use software (in our case open source software) called software defined radio (SDR) to avoid using expensive hardware components where functions of hardware components are performed by software components [19]. The SDR Forum, in collaboration with the Institute of Electrical and Electronic Engineers (IEEE) P1900.1 group defined SDR as:

"Radio in which some or all of the physical layer functions are software defined" [19]

Today there are numerous commercial SDR solutions (hardware and software) with prices in thousands of dollars.

C. Open source SDR, and hardware components for APRS client – server infrastructure

Together with SDR open source solutions such as pymultimonaprs [20] it is possible to use cheap hardware (digital receivers attached to PC) to capture analogue or digital signals and use them to process captured signals on microcomputers such as RPi. In this way it is possible to build cheap SDR solutions which can be used for APRS-IS infrastructure. Core hardware component for this solution is digital receivers which uses RTL2382U [21] chipset which are used as DVB-T tuner for reception digital signals. Functionality of this chipset is to capture radio frequency range from 22 to 1100 MHz [22]. This functionality of chipset which can be found in USB DVB-T dongles is discovered by Antti Palosaari and other researchers [23].

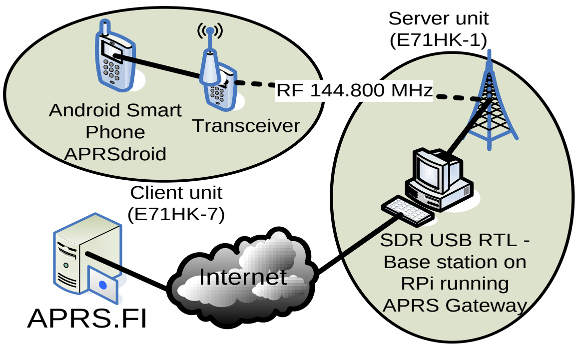


Figure 1. Local infrastructure for APRS-IS

This type of infrastructure allows location mapping and updates on APRS web site (aprs.fi) over Internet as some other Internet services with difference that remote transceivers can reach transceiver base station (IGate) from up to tens of kilometers when other infrastructure is not available.

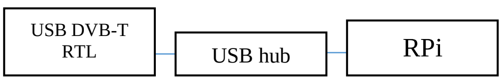


Figure 2. Block scheme of server side

D. Rationale for establishing APRS using IGate on Raspberry Pi

We wanted to achieve more than one goal in this project because of APRS-IS potential in [24]:

"Accurate position information about mobile & fixed stations, direction finding for precise beaming. Tracking a mobile station [useful during emergency operation/tactical situation], Non-ham family members of a ham can track him/her and read messages. During emergencies, if the Internet does not fail. Monitoring of real-time weather information originated from ham radio weather stations. Plotting of objects on the map. For example an accident site, crash site, intimation about a traffic jam for route planning, fire site, flood, cyclone, land-slide, road blockage etc. Allows important information to be exchanged without human intervention. This is important during a tactical or emergency situation, when we need to concentrate on other important jobs [for example 'Search & Rescue']."

First goal was to test, research, and to build infrastructure for other projects and for potential disaster situations where radio communication was used [1,2,3] and can be used, and to involve other education institutions in similar projects. This will contribute in future research activities by offering research students real playground for hands on and test activities instead of using simulators. Well educated individuals in alternative communication can play crucial role in any ongoing or post disaster situation. Second goal was to use lessons learned, to build and document study case and to propagate practical and hands-on knowledge for education purposes. Third goal was to build initial infrastructure with two iGate nodes located at two sites in Sarajevo city valley. This two iGates would be able to accept local connections and transfer data to APRS-is (Internet). This would open possibility for APRS test and research activities. With established infrastructure, it is possible to measure usage of pymultimonaprs [20] application usage by users and different antenna settings and designs.

E. Design of experiment issues and scenario description

As a practical part of this paper, our aim was to carry out different test and measurements: connectivity measurements, antenna quality, RPi hardware performances. According to the theory design of experiment (DOE) [25] we deliberately change variables such as hardware components (transceivers), smart phones, antennas, configuration options (TCP/IP, UDP, RF) for communication in aprsdroid application [26].

II. Required Software and Hardware Components

For this project, different hardware and software components were needed. While software is open source, purchase of hardware components is needed but for which budget is less than 160 Euros, if Internet connection exit with appropriate access device.

A. Hardware components

In order to setup fully functional IGate node there is need for 7 hardware components stated below:

1. Microcomputer, Raspberry Pi B System-on-Chip [27]
2. Power: Micro-USB, ca. 300…700 mA
3. SD memory card minimum 2GB, and minimum class6, supported SD cards can be found on this link [28].
4. USB RTL DVB-T dongle
5. USB hub with external power supplyPMR or radio amateur transceiver such as Baofeng UV-5RE, 1 / 5 W, output, with 7.4V 1800mAh Li-ion Battery [29].
6. Smartphone with suitable Android OS which supports aprsdroid [26] which are used for other purposes as well.

For initial system setup it is good to have USB Keyboard, monitor and HDMI / VGA convertor if needed because Raspberry Pi has only HDMI connector and not a VGA connector that most monitors are equipped with.

B. *Software components*

Three software components needed for installing local APRS infrastructure are available on referenced web sites Raspbian Debian (Wheezy) distribution [30], pymultimonaprs [20] and we used version PyMultimonAPRS 0.8.4, and aprsdroid [26].

C. *Budget estimation*

As stated above budget for hardware is less than 160 Euros and software is open source solution, and hardware is only expense of this project. Price of RPi is less 40 Euros, price of HDMI / VGA converter is 20 Euros (if this is option for installing RPi), price of SD memory card is 8 Euros, Baofeng transceiver 50 Euros, USB DVB-T dongle with RTL 2832U chipset (ASUS My Cinema U3100 Mini Plus V2 [31]) is less than 40 euros (other with RTL 2832U chipset which supports SDR and cheaper can be found) and audio cable expenses are less than 2 Euros.

III. INTERNET, RADIO, PHYSICAL CONNECTIONS

Prerequisites for establishment pymultimonaprs [20] node are to have Internet connection.

A. *Internet connection*

There is no need for special port forwarding on firewall if it protects RPi with pymultimonaprs [20] or other firewall configuration settings to operate.

B. *Radio and audio connections*

Above-mentioned hardware has to be physically connected (Figure 1.) so that Raspberry Pi (RPi) is connected to router or firewall directly through UTP cable or via WIFI to switch or other communication device. Transceiver has to be configured using VOX option (transmitting on 144.800 MHz) which initiate transmission once it is recognized that sound is coming from smart phone with installed aprsdroid application what actually simulates push to talk (PTT) button.

IV. BRIEF SETUP AND OPERATION INSTRUCTIONS

In order to operate pymultimonaprs [20] node with Rasbian operating system it is important to install, configure and run it as defined in manual web pages referenced below.

A. *Setup instructions*

Installation image of operating system on RPi is described on web site [32]. For initial Raspbian Debian (Wheezy) implementation on RPi it is advisable to use Win32 Disk Imager [33] to install Raspbian Debian (Wheezy) operating system into SD card from PC which has SD card drive. After operating system image is transferred to RPi it is possible to start and log on to RPi using keyboard and monitor. At the first log on to RPi it is possible to configure system settings which can be later started manually by issuing command `sudo raspiconfig`. To prepare Raspbian Debian (Wheezy) [30] distribution for pymultimonaprs [20] installation and to install pymultimonaprs [20], it is advisable to follow these installation instructions [34, 35].

B. *Operation instructions*

At the server side (RPi) after successful installation of pymultimonaprs [20], application can be started by executing command pymultimonaprs, or it can be configured to be started after each reboot by configuring /etc/rc.local file. At the client side smartphone has to be connected to transceiver with audio cable and aprsdroid application has to be started. A soon as smartphone catches GPS signal it will pass data to aprsdroid application which will then send audio signal to transceiver via audio cable. Transceiver will broadcast signal which will be received by antenna attached to USB RTL dongle connected to RPi running pymultimonaprs [20] application which will be sent to aprs.fi web site and will be updated automatically. If there is need to record everything that pymultimonaprs [20] log it can be used option –syslog which will place all logs in syslog file.

V. APRS DATA AVAILABILITY

As already described all APRS data are updated on the web site www.aprs.fi in real time as it is shown in Figure 3. In case for Sarajevo valley where we placed our APRS IGates or server unit shown in Figure 1. Figure 2., and marked with letter G (yellow letter in black diamond) in Figure 3.

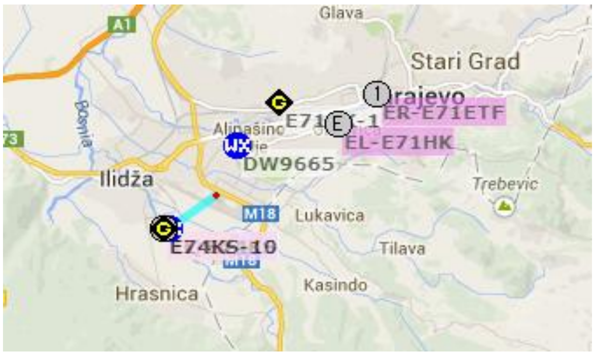
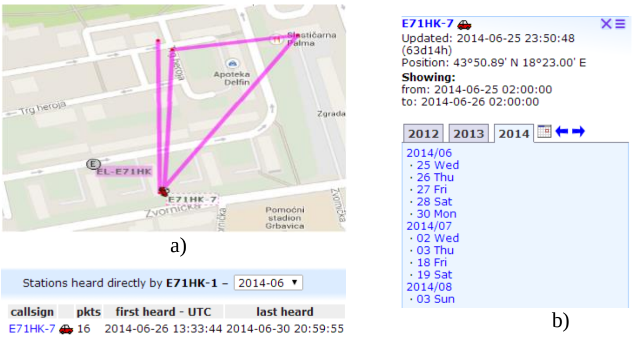


Figure 3. APRS shows two IGate nodes in Sarajevo valley

This APRS online view can be used as a dashboard for monitoring activities for specific node or group of nodes. In Figure 4. a) are shown results of tracking (on 26.06.2104) client unit (E71HK-7) where GPS location changes reports were sent to server unit (E71HK-1) via RF

144.800 MHz (Figure 1.) in radius of 200 meters using only supplied antenna for USB DVB-T dongle. In Figure 4. b) are shown dates when client unit (E71HK-7) was sending updates via server unit (E71HK-1) to APRS-IS (aprs.fi). In Figure 4. c) is shown info on number of packets sent on specific date from client unit (E71HK-7) which are directly received via RF by server unit (E71HK-1).



c)

Figure 4. APRS information for E71HK and neighboring stations

VI. Conclusions

From the preliminary results we may conclude that goals are reached because cheap and low energy APRS client – server infrastructure for research and education purposes is built which is ready to use. This opens research activities in designing and building different antennas because we have problems in reaching IGate server unit from client unit from specific distances.

VII. References

[1] Weinert, A.J. ; Breimyer, P. ; Devore, S.M. ; Miller, J.M. ; Brulo, G.S. ; Teal, R.S. ; Zhang, D. ; Kummer, A.T. ; Bilen, S.G. Providing communication capabilities during disaster response: IEEE Conference on Technologies for Airborne remote communication (ARC) platform, Homeland Security (HST), 2012 Publication Year: 2012 , Page(s): 395 - 400

[2] Rollema, D. Amateur radio emergency network during 1953 flood Proceedings of the IEEE Volume: 92 , Issue: 4 Publication Year: 2004 , Page(s): 759 – 762

[3] Uchida, N. ; Kawamura, N. ; Shibata, Y. Evaluation of Cognitive Wireless Based Delay Tolerant Network for Disaster Information System in a Rural Area, Seventh International Conference on Complex, Intelligent, and Software Intensive Systems (CISIS), 2013

[4] R. Lindquist, New Licensees, 98 QST Journal, Vol 98. No3, The National Association for Amateur Radio, March 2014

[5] Amateur Radio Showing Steady Growth in the US, 08.01.2014 http://www.arrl.org/news/amateur-radio-showing-steady-growth-in-the-us

[6] Bruninga B., A brief history and bibliography of APRS, Available from: http://www.aprs.org/APRS-docs/ARTICLES.TXT [Accessed on 25.06.2014]

[7] Bruninga B.,CONNECTIONLESS EMERGENCY TRAFFIC SYSTEM, , Packet Radio Magazine, pp 4-5, July 86.

[8] Dimse S, Setting Up an APRS/Internet Gateway, Available from: http://www.aprs.net/vm/DCC97/internet/ [Accessed on 25.06.2014]

[9] APRS iGate, Available from: http://info.aprs.net/index.php?title=IGate [Accessed on 26.08.2014]

[10] Kenwood TM-D710A http://www.universal-radio.com/catalog/fm_txvrs/0710.html

[11] APRS Frequencies, http://info.aprs.net/index.php?title=Frequencies

[12] Hamnet Information et actions engages, Available from: http://www.ref-union.org/index.php?view=article&catid=85:hamnet&id=706:informations-et-actionsengagees&format=pdf&option=com_content&Itemid=413, [Accessed on 24.09.2013]

[13] The Hamnet-Database – Interactive map, Available from: hamnetdb.net [Accessed on 13.05.2014]

[14] R. Leszczyna I.N. Fovino M. Masera, Approach to securit assessment of critical infrastructures' information systems, Vol. 5, Iss. 3, pp. 135–144, Published in IET Information Security, doi: 10.1049/iet-ifs.2010.0261, The Institution of Engineering and Technology 2011

[15] Ali, M. ; Vlaskamp, J.H.A. ; Eddin, N.N. ; Falconer, B. ; Oram, C. Technical development and socioeconomic implications of the Raspberry Pi as a learning tool in developing countries, 5th Computer Science and Electronic Engineering Conference (CEEC), 2013, Page(s): 103 – 108

[16] Mitchell, G.The Raspberry Pi single-board computer will revolutionise computer science teaching [For & Against] Engineering & Technology Volume: 7 , Issue: 3, 2012 , Page(s): 26

[17] Srinivasan, M. ; Anand, B. ; Antony Venus, A.J. ; Victor, A.N. ; Narayanan, M. ; Sree Rakshaa, S.P. ; Vijayaraghavan, V. GreenEduComp: Low cost green computing system for education in Rural India: A scheme for sustainable development through education, Global Humanitarian Technology Conference (GHTC), 2013 IEEE, 2013 , Page(s): 102 – 107

[18] Skoric, M.M. Amateur radio communications, software and computer networks in education, International Conference on Signal Processing, Computing and Control (ISPCC), 2013 IEEE

[19] SDRF Cognitive Radio Definitions, Available from: http://www.sdrforum.org/pages/documentLibrary/documents/SDRF-06-R-0011-V1_0_0.pdf, [Accessed on 26.08.2014]

[20] pymultimonaprs, Available from: http://asdil12.github.io/pymultimonaprs/, [Accessed on 26.08.2014]

[21] RTL2832U, DVB-T COFDM Demodulator + USB 2.0 Available from: http://www.realtek.com.tw/products/productsView.aspx?Langid=1&PFid=35&Level=4&Conn=3&ProdID=257, [Accessed on 26.08.2014]

[22] Specifications for RTLSDR, Available from: http://sdr.osmocom.org/trac/wiki/rtl-sdr, [Accessed on 26.08.2014]

[23] History and Discovery of RTLSDR Available from: http://rtlsdr.org/#history_and_discovery_of_rtlsdr, [Accessed on 26.08.2014]

[24] APRS benefits, Available from: http://www.riverdevil.org/APRS/vu2mue/ [Accessed on 26.08.2014]

[25] DoE What is experimental design, Available from: http://www.itl.nist.gov/div898/handbook/pri/section1/pri11.htm [Accessed on 03.05.2014]

[26] APRSDROID Available from: https://aprsdroid.org/ [Accessed on 03.05.2014]

[27] Raspberry. Available from: http://www.raspberrypi.org/help/faqs/ [Accessed on 05.05.2014]

[28] RPi SD cards, Available from: http://elinux.org/RPi_SD_cards [Accessed on 05.05.2014]

[29] Baofeng UV-R5E, Available from: www.baofengradio.com/ [Accessed on 05.05.2014]

[30] Raspberry Operating system distributions, Available from: http://www.raspberrypi.org/downloads/ [Accessed on 12.05.2014]

[31] ASUS My Cinema U3100 Mini Plus V2, Available from: http://www.asus.com/Multimedia/My_CinemaU3100MINI_PLUSTRC/ [Accessed on 12.05.2014]

[32] Raspbian installation process, Available from: http://www.raspberrypi.org/documentation/installation/installing-images/linux.md, [Accessed on 12.05.2014]

[33] Win32 Disk Imager, Available from: http://sourceforge.net/projects/win32diskimager/ [Accessed on 13.05.2014]

[34] APRS iGate using Raspberry Pi Board, Available from: http://yd0nxx.wordpress.com/2013/04/30/aprs-igate-using-raspberry-pi-board/ [Accessed on 26.08.2014]

[35] APRS Rx-only IGate with Raspberry Pi and DVB-T dongle, Available from: http://www.kubonweb.de/?p=130 [Accessed on 26.08.2014]