The New Amateur Radio University Network – AMUNET

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Abstract: - The intention of this paper is to give the readers an opportunity to become familiar with non-official and often ad-hoc constructed, computerized amateur radio networks, that might be easily used as *AMUNETs* – the digital links between university centers, their cathedras and departments, and surrounding schools – particularly in rural areas that are suffering of not much of fixed and cell telephony infrastructure, as well as the Internet connectivity. The paper suggests several regulatory improvements that would help making closer connections between the radio amateurs and the academic research & development in technical areas world-wide, as well as supporting the amateurs' knowledge and experience – as an alternative way of multilateral communication and cooperation between educational institutions on local and global level.

Key-Words: - amateur radio, AMUNET, ADL, communication, computer, university, education, rural area

1 Introduction

Besides its well known benefits for a society (saving human lives after natural disasters, medicine searching alerts etc), the amateur radio service should always be an embryo of the official educational, professional and scientific activity in the ICT world. When it comes to the regulatory environment, the background is in researching some statistics: The numbers say that during the previous decade (at least in the author's country of origin) – there is a decreasing interest in some learning topics, i.e. some parts of the amateur radio curricula (manual Morse telegraphy at first). Newcomers, the young school pupils and university students, keep trying to avoid unwanted parts of the amateur radio examination question pool and, as a result, there are not enough new licensed amateurs who are legally allowed to use the international computer-related HF radio frequencies bellow 30 MHz. Such a trend prevents further implementation and development of the *AMUNET* – the Amateur University Networks in the educational environment. As a try to find a reasonable solution, this paper is going to suggest the implementation of a new kind of an amateur radio license, that we call the *Amateur Digital License* (or the *ADL* in short).

It is obvious that so many people do not have enough knowledge and information (if any) on that fine, old technical hobby that started to be popular in 19th century. The author's intention is to encourage the WSEAS conference audience to join the family of near-5-milion existing radio amateurs worldwide.

2 Packet Radio

As soon as first portable computers became affordable as home appliances during the early eighties, skilled radio amateurs implemented a new exciting way to establish radio links between amateur radio stations: the "Packet Radio". That name was chosen because larger peaces of information (say a sentence or like), were split into smaller particles of bits and bytes (say "packets" of data) – before they got transmitted to the receiving end. Using various technical constructions of special radio-modems, the amateurs have easily managed to establish not only local and regional computer links in metropolitan areas – but to build rather bigger networks at the global level.

Having in mind that during the eighties and early nineties we have not had many opportunities to run devices like cell telephones or use networks like the Internet, packet radio was an exciting option to chat in a keyboard-to-keyboard manner with the far correspondents. The value-added options like exchanging software for Commodore 64, Amiga or Atari computers – without having to visit the nearest post offices – were all the attractions for both young and old amateurs those days.

2.1 Technology challenges

Until a phenomenon of the "Internet Boom" happened, it seemed that the amateur radio networks really faced the splendid future. And soon after the first experiments with the packet radio on the VHF bands, highly motivated innovators rushed to

populate the international HF radio spectrum, as well as to use the microwave 'data' satellites.

Depending on local finances and enthusiasm, the simple and complex networks of specialized radio-relay stations – digital repeaters (a.k.a. 'digipeaters') were built all around the world. They offered more possibilities for users, especially those who have been entering the network with using the small output power. In the same time, several manufacturers opened the new markets for the amateur radio equipment, digital modems in particular. Those market competitions lead to the lower prices of most the equipment and accessories needed for the computerized amateur radio operations.

The first 'data' radio links were maintained using the B/W computer screens with almost none of any graphical user interface (GUI). That was not a problem to exchange lot of e-mail or text files – having such inexpensive computers. The radio amateurs always preferred sending and receiving e-mail using their radios whenever possible. It was also comfortable to forward radio messages via special 'gateway' systems – capable to exchange the traffic between the amateur radio networks and the early e-mailing systems on the Internet. But, the biggest challenge appeared with the Internet's World Wide Web – consuming much more channel width. In fact, browsing the WWW using the standard telephone lines was not a big deal at the first sight, because the actual wired infrastructure allowed the Internet traffic to increase significantly.

On the other side, the early amateur packet radio networks have not been planned for such large data traffic so they were running on speeds completely comfortable for non-graphical information. The amateurs also started to implement newer systems – capable to disseminate incoming 'flood' of full-color dynamic data, we have on modern web pages these days. Soon we realized those solutions would be very expensive for average home amateur radio enthusiasts and that was why the majority of the packet radio communicators have remained on their initial low speeds (1200-19200 bits per second). In the same time, the rigid regulations governing the whole amateur radio world have remained restrictive related to sending/receiving non-technical information via amateur radio waves. That was another reason why the majority of the amateur packet radio users have quickly adopted their own 'alternative' ways of communications, with using the Internet for exchanging commercial and similar information while, in parallel, using the packet radio for educative and other non-for-profit purposes.

2.2 Regulatory issues

On the other side, while the modern civilization and technology breakthroughs could not jeopardize the background of the amateur radio 'science' – it seems now that the main threat to the hobby's future comes from the old and outdated rules and regulations. Generally speaking, the legislative that governs the amateur radio has not much changed since the 19th century. In fact, any person who wants to transmit on the international HF radio spectrum (radio bands bellow 30 MHz) is still required to learn the manual Morse telegraphy alphabet and, after that, to pass an appropriate telegraphy skill examination test – regardless the candidate is going to ever use that kind of communication or not!

The author of this paper does not consider himself as qualified enough to discuss on the popularity of cell telephony and Internet services in the USA or Canada, but here in Serbia and Montenegro (former FR Yugoslavia) today we have significantly increasing interest for those ways of communications. On the other hand, since the early nineties we have also noticed the lower interest in Morse telegraphy operations. In addition, the so called "no-code" (no-Morse) amateurs and communication modes do not have general support from the national amateur radio unions. The main problem here is that we all have to be the members of the amateur union – if we want to be the legal part of the amateur radio community[1]. Actually, people who govern the radio unions seem not to be likely to accept the rapidly changing global science and technology, In opposite, the amateur newcomers rather pass no-code tests in order to join the hobby. One of the reasons for keeping status quo in the

[1] Citation: "... here we are not satisfied because there is an increasing number of the amateur radio operators of the class E (no-code ticket, M.S.) and the decreasing number of those in classes A, B and C (all of which are Morse ones, M.S.) … that is shown in the following table ..." /The Report of activities in the Amateur radio union of Serbia for the period of time September 1993 – May 1995, No. 02-33-3/10.05.1995./ So, in that Report there is a table describing that during 1993 there were 405 candidates for various ham radio tickets in Serbia and 199 of them (49%) were not interested in learning Morse and taking the appropriate CW test. During the next year, 1994, there were 410 candidates and 245 of them (59%) passed the no-code examination. The rest of candidates, who were the minority in percentages, chose to take one of the remaining five (!) telegraphy classes' tests: A, B, C, D and F.

regulations is a 'popular' (but wrong!) belief amongst the radio veterans, that only the telegraphers are valuable amateurs and 'good members' of the amateur radio community. They have also been claiming that any effort to liberalize the rules, related to the frequencies up to 30 MHz, would somehow lead to a 'flood' of non-competent newcomers to the international bands. As the result of such prejudices, all those who do not want to learn telegraphy should be fined this or that way[2].

3 Problem Solution

The previous WARC (World Administrative Radio Conference), held 2003 in Geneva, Switzerland, tried to make some slightly changes in a way of so called regulatory 'recommendations'. That means the conference suggested to the participants (the national telecommunication authorities) – to consider some individual approaches on how to improve their local rules and regulations. It is obvious that the recommendations are not mandatory, so it is up to a national regulatory body to decide which changes to adopt (if any).

Having in mind that almost any regulatory improvement is a slowly process, it is not clear if we are going to see some modern laws that handle the amateur radio activities soon. That is why we are going to support a 'transitional' solution for people who might be interested in computer communications on the HF.

3.1 Improved licensing system

New suggested radio permission, the Amateur Digital License (the ADL in short) would help the broad population of computer-educated people to enter the media of the amateur radio [2]. In the same time, that would bring much more 'fresh blood' into the average elderly amateur radio communities. Both of the advantages mentioned above should be supported by the engineering community if we want to face the prosper future of that inventing and rewarding technical hobby.

Let us continue discussing on the topics that might be required from the prospective ADL candidates to learn. The reasonable and not-much-time-consuming radio amateur curricula should consist of the following parts:

- Computer hardware, system software and amateur radio applications;
- Amateur radio equipment and accessories (radio transmitters, receivers, antennas etc);
- Proper connections (computer-modem, modem-radio, radio-antenna, antenna-ground etc);
- RFI – Radio frequency interference;
- Regulatory set of questions (band plan etc);
- Foreign language (in written test).

There are several computer applications needed for establishing reliable digital communications (for example: server-side mailbox software, client-side e-mail and chat applications, special ROM software for unmanned digital relay stations etc). Radio amateur hardware usually comes in either separate or combo enclosures ('transceivers'). Sometimes they only need rechargeable NiCd batteries, otherwise proper AC wall outlets must be used for continual emissions. In order to avoid personal

[2] Somewhere in 1996, as the secretary of the Board of directors in the Amateur radio union in Vojvodina province (YU7 radio area), the author participated to the meeting of the board. After considering the trends in the hobby, the board made a decision that the candidates for E ticket (no-code) have to pay 3 times more examination fees than those who wanted to take Morse test! And not only that: the attitude of the Board of the Amateur radio union of Serbia (YU1, YU7 and YU8 areas) was also very "interesting". Their draft of the "Proposal to the rulebook of the amateur radio stations and the requirements for their usage" (2001. year), suggested in the paragraph 43 that during the announced process of so called "harmonization" with the common rules of the European postal union association (CEPT), the existing domestic no-code E class should become a "national" status and as being a "national" one - it should not become a part of the CEPT licensing system! That means the existing no-coders in Serbia would not be allowed to travel all around the Europe with their VHF handy radios, for example. So discriminative rules can be hardly commented! In the same time, the union's governors know very well how much membership money coming from the no-coders (let us repeat that candidates for no-code ticket should pay 3 times more than the others). That is not all. If such a "proposal" got adopted by the national regulatory bodies that would mean that the European CEPT recommendations would have not been implemented in Serbia, because CEPT papers have made it clear that so called "CEPT examination level B" does not require Morse test, [1]. In fact, we can see in this example how the governing people in the amateur radio union of Serbia wanted to expel the no-code amateurs from the international amateur community.

injuries and/or technical damages – the adequate grounding and proper antenna installations are required. Having in mind that computer-related links have been maintained using computer keyboards, it is reasonable to expect from the candidates to pass simple English (or other major language) test.

After the successful examination, a new ADL ticket holder should be legally allowed to use the following:

- All available 'data' parts of the amateur radio spectrum – regardless they belong to the HF bands or not;
- All available 'data' types (modes) of radio communications;
- Dedicated radio devices (prepared for 'data'-only operations).

As mentioned earlier, without the manual Morse telegraphy test, it is not possible to run computer-related (as well as any other) communication modes bellow 30 MHz. Besides that restriction, there is another one linked: At 30 MHz and up, there is mostly VHF/UHF packet radio in use. On the other side, on HF bands, there are plenty of exciting digital emissions (just to list few: Amtor, Pactor, G-tor, Clover, PSK31 etc) – and some of them are more efficient than the 'ordinary' packet radio on HF.

To avoid further complaints coming from telegraphy veterans, it may also be required from the no-Morse ADL licensees to have their radios fully comply with, say 'other-than-digital-data' restrictions. It means, their stations might be easily modified not to use telegraphy keys and voice microphones (besides or instead their computer connectors). To satisfy that task, it would be enough to have a radio checked in the nearest electronic shop or service. In addition, the major amateur radio equipment manufacturers (in particular the big ones from Japan and USA), might be stimulated to make their new lines of cheaper radios, fitted for simple computer-to-computer communications – but without so many 'bells and whistles'.

3.2 New amateur population

When we discuss on who might be interested in the newly suggested ADL radio permission, it is obvious that the modern young and computer-educated generation is the best market target. During the years of experience in the hobby, the author of this paper met so many pupils and students – having no clue what to do with the Morse course requirement – while they have only been interested in changing communicating media to something other than the Internet and, as well, to reduce their high monthly ISP fees.

It might be expected that the 'early birds' of the ADL implementation would be actual Internet e-mail communicators and those who prefer exchanging SMS messages over the cell telephony. Those two groups are already familiar enough with the e-traffic using the conventional wired and wireless infrastructure. They could easily add the amateur radio stuff to their existing equipment and get more opportunities in the future.

On the other side, the Amateur Digital License would satisfy the increasing communicating needs of students in schools and academia. We should not forget that the majority of educational institutions (in particular on the West) already have computer-related subjects within their official curricula – even at the elementary levels of education – using personal computers, popular programming languages and games etc. Why should not we add the amateur radio option to these technical classes? In fact, many schools have already been practicing that for a while – including the radio paths being established with the 'Shuttle' astronauts a decade ago. In addition to various sport and literate clubs, the amateur radio groups should also be stimulated by the academic authorities, school boards etc.

3.3 Building the networks

When it comes to the implementation of the amateur radio communication in a school or university, it is needed to make an initial investment into the simplest affordable equipment [3]. It is not needed to spend a lot of money because battery-powered hand-held radios are cheap and, besides that, they are completely capable to establish the radio path to the other school in the city. The same goes for the antenna and computer (the older models of PC XT and AT compatibles can fit for the first experiments and you can easily find many of those devices resting in the school closets).

At the beginning it is needed to make the first reliable link with the other computer station (it may be placed in another school room or a building). If things are good, the experiments should be continued with colleagues and students in the neighboring school(s). That way the network has been built!

On the other side, there are much more funds at the academic level (compared to the elementary schools) – so the universities are expected to invest into more expensive international HF and/or amateur radio satellite equipment. At the universities, it is also expectable to use the amateur

radio experiments within the laboratories as the practical student training sessions or parts of wider projects.

It is also common that universities often have some other types of relationship and cooperation – related to their 'official' curricula and scientific projects. If that is the case, then it would be easier to motivate your colleagues (students or teachers) at the other universities to try making their own local university networks. And where there is enough technical and human resources involved around the region and/or a country – it is the right time to interconnect several academic communities, i.e. to re-build the amateur radio subnet sites into the complex regional or national *Am*ateur radio *U*niversity *Net*work – *AMUNET*. Using such a network, students can be in touch with their buddies from the other university centers. Having in mind that cathedras and departments in related sciences (programming, mathematics, mechanics, electronics, computer hardware etc) might be interested in some positive competition – when it comes to build faster radio links, it is obvious that the network growth might be significant.

In developing and rural areas, the AMUNETs may be further implemented for making connections between the universities and surrounding schools. Generally speaking, both parties would get benefits from such cooperation. For example, the academic centers would transfer a part of their high level knowledge to the lower levels of education (university → school) and, in the same time, the schools would return with better preparing the new prospective students for the university (school → university). So, better connections offered by the future amateur experiments may help closing the gaps in both human and technical resources between the parties involved.

3.4 Other opportunities

One of the further questions might be: What kind of data traffic is suitable for new established radio networks? According to existing regulations, it is allowed to exchange technical information – mostly related to radio devices, antennas, power supplies, computer systems, programming etc. Besides them, it would not be a problem to offer some interesting 'quiz' competitions with posing various technical questions related to engineering disciplines, sending some information related to studying applications, deadlines for applications and qualifications etc. The choice is yours!

Another frequently asked question is: Why should we support a pretty mature technology, in particular if it is obvious that newer types of communications have competitive advantages? The answer lies in the background of the amateur radio. To be more precise, cell telephony and/or Internet communications nowadays mostly end up as pure consuming of commercial products and services. In opposite, practicing the amateur radio and building the networks described in this paper, not only require from their 'builders' to go deeper into the electrical and mechanical engineering, as well as electronics, programming etc, but they also reward with bringing the new skills. From an ordinary consumer of the ISP services (exchanging e-mail, browsing the web sites etc) – nobody expects to have some special knowledge but to follow the general guidelines, provided by commercial service providers. An SMS-message communicator does not need to build a, say, communicating network node, neither to study functioning of fixed and mobile stations.

Contrary to that part of reality, it is almost impossible to be involved in a simple packet radio network or a more complex AMUNET – without having enough theoretical and practical knowledge to make and maintain the following: a bulletin board system for exchanging the e-mail; a reliable antenna system and/or transmitting station, capable to reach the distant correspondent's equipment. In addition, the experience says that many young radio amateurs have been getting motivated enough – while practicing the amateur radio communications during their early ages – so they later decide to continue their education in related sciences. That is remarkable heritage of that hobby.

4 Conclusion

After the reliable AMUNETs in the country have been placed in function – it might be the right time to apply for funding the wider projects. For example, we do not see reasons why not to apply for European Union's (EU) funds to enlarge the national and/or regional networks to the higher level of complexity (say more than 2-3 neighboring countries or something similar). The chances for a successful application are better if the idea is a 'joint' project of more than one cathedra, university or country. There are various funds for projects throughout EU; some of them are Eureka, FP6, Cards and others. It is expectable that, for example, university centers in Bosnia and Herzegovina, Croatia, Serbia and Montenegro, Macedonia, Greece and other countries in the South-East of Europe, would be interested in getting involved into some

projects of that type. In fact, some 10-15 years ago, most of these countries were busy developing the amateur radio links with each other, as well as with other surrounding amateur radio communities. There are no obstacles for not doing that again!

The author of this work has initiated several contacts with the radio amateurs worldwide in order to solve a technical problem with his radio station, a computer failure or something similar. Continuing those friendly amateur cooperation, he often discovered that his radio correspondents were people from universities, either teachers or students. These initial contacts made with the radio amateur enthusiasts were later continued via the amateur radio e-mail or the Internet e-mail.

What else the 'academic radio amateurs' can do? They explore various ways of communications – as a part of their primary 'business'. They can also construct and maintain special "gateways" between wireless (radio-amateur) and wired (Internet) infrastructure. On the other hand, universities do lots of things valuable for the amateur hobby activities. For example, at Macquarie University's Division of Information & Communication Sciences [4], located in Sydney (Australia), there is a radio station forming part of an experimental network supporting the investigation of digital data transfer using TCP/IP links over a network of remote computers linked by radio. These radio links use various radio frequencies within the VHF; UHF and HF amateur-radio bands (Note particularly that the word amateur is used here to indicate that no financial rewards are received for the use of those bands!). It is a collaborative effort, involving staff and students at the university, some appropriately qualified members of the local community and experimenters in other parts of the world.

The Concordia University Amateur Radio Club - CUARC [5], located in Montreal (Canada), also has lots of various activities. Among the other equipment, they have an amateur radio BBS computer, using the call sign VE2CUA, equipped with two radio ports on *2m* and *70cm* amateur bands. The BBS is wired to another computer that serves as a gateway to pass packets between the amateur radio world and the internet world. While it is not possible to directly connect to hosts on the internet, the gateway will send mail to and from users on the internet. In addition the gateway permits connections from amateur stations to amateur stations anywhere in the amateur radio class A internet network. (IP addresses starting with 44). From VE2CUA it is possible to telnet to stations in most parts of the world who are connected to similar gateways. Files can also be transferred. Those running one of the implementations of NOS (*N*etwork *O*perating *S*ystem) on their home packet radio systems may use VE2CUA as a gateway to communicate with other stations running the TCP/IP software. The BBS also offers a conference server.

At Clemson University [6], they keep experimenting with '…design and analysis of protocols for packet radio networks; adaptive routing, forwarding, and retransmission techniques; survivable radio networks; protocols for spread-spectrum packet radio networks; ARQ and hybrid ARQ schemes for data transmission; simulation of packet radio networks to determine throughput, delay, and other performance parameters for different signaling schemes and network protocols; evaluation of network performance in adapting to changes in traffic, interference, and topology; use of side information in network protocols…' etc.

The University of Hertfordshire Amateur Radio Society – UHARS, [7], has been involved in a number of activities including running a *Packet Radio Wormhole*. The wormhole/gateway simply allows the routing of amateur radio TCP/IP packet between other similar stations around the world. It does not allow radio amateurs to access internet sites, nor allow non licensed users to connect or exchange information with radio amateurs. The aim is simply to improve communications within the amateur radio community. At Stanford University (USA), there is also an active Stanford Amateur Radio Club [8] . Among its activities, there are "… packet radio & high speed data communications".

The Spartan Packet Radio Experiment – SPRE is also an amateur radio communications experiment [9]: '…The primary mission was to test satellite tracking using amateur packet radio and Global Positioning System (GPS). SPRE was developed and built by the University of Maryland Amateur Radio Association (UMARA) with assistance from NASA, volunteer engineers, and volunteer software professionals…'

There are also amateur digital links in developing countries like Cuba (Fig. 1). One of their university stations CO2BQQ (upper left corner) uses 14.107 MHz shortwave frequency for international trafic and CO8RCI (on the lower right side) uses 14.095 MHz. That way those two stations ensure more reliable connections with the outside world, without making radio interferences to each other. The »backbone« link in between has been established on the local *2m* band (144.675 MHz).

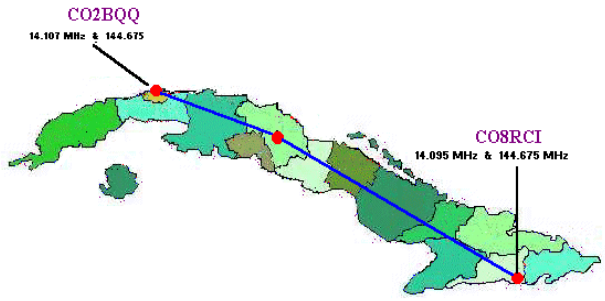

Fig. 1. CO2BQQ – The University City in Ciudad de la Habana and CO8RCI – The University of Santiago de Cuba

From the examples given in this section, it is for sure that the universities on the West are much more active and innovative when it comes to include local radio amateurs into their education and research processes. The examples should motivate both learning and R&D authorities in the area of the Southeast of Europe to try exploring something similar. It may be expectable that various academic and scientific societies would also be willingly to help. The WSEAS, ACM, and other conferences and publications also give the great deal of opportunities to bring some new ideas, related to this fine amateur hobby. It is a call for all of the participants and also the WSEAS members, to help this activity to become modern and up-to-date skill – in all places we study, teach or work.

How to link the radio amateurs with the academia? The best way is to search for the amateurs who are already involved into the education or research process at the nearest university. Contacts with local radio clubs and amateur radio unions may also help. They are sometimes available as parts of local civil emergency networks. In addition, there are several discussion groups and mailing lists on the Internet – devoted to the amateur radio. Such lists may also help to look for volunteers. If some of the actions suggested in this paper get real – there will be more chances for developing countries in the South-East of Europe to come closer to the level of European Union's prosperity and standards. That is true not only for them but for developing countries from the other parts of the globe.

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