Amateur Radio Communications, Software and Computer Networks in Education

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$\mathcal{T}$he amateur radio is an old fine hobby from the days of inventing the Morse alphabet and implementing telegraphy. Since the second half of the 19th century, millions of volunteers learned new skills in communications – while attending the amateur radio courses and successfully passed examinations; got their first radio licenses and started transmitting signals to the spectrum.

The electronics industry recognized the incoming 'flood' of the new communicating enthusiasts, coming from all over the world and predicted them to be a good market very soon. Today we have a lot of opportunities to purchase sophisticated and computerized amateur radio 'gadgets' – that include fascinating traditional and brand new communication modes. Besides telegraphy and radio telephony, there are a variety of computer-related possibilities to explore. As a result, today the modern radio amateurs are capable to establish exciting radio paths via Moon or artificial satellites, conducting short discussions with crews on the space ships, even to make an urgent search for medicines – using their computers.

My first contact with the amateur radio was in early eighties when I signed for a radio course. In those days there were no personal computers available so I had to take a manual Morse alphabet school. I must admit, I haven't learned more than few telegraphy characters and soon after – I gave up. Then appeared a pretty long period of time when I did not make much effort to re-join the amateur radio community. I had to finish with my early school days and make an important decision on what profession I would like to continue to educate for. You bet, I quickly found an answer and it was the electrical school. I knew that there would be lots of various instruments, electronics circuits, antennas, early pocket calculators and other interesting stuff. And after some years, I became a qualified electrician – likely to learn more and explore new worlds of technology. Then it was the time to pick a university and the best bet was to sign with the electrical engineering one. Well, you know, those days I preferred music and dating with young ladies – rather than to visit department's physics labs – so I switched to a business computing faculty. I graduated with over-an-average marks, as an informatics system designer.

But, at the time of getting my first engineering degree, I was deeply involved in local amateur radio activities. In fact, during my undergraduate education, I got in touch

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[1] If local radio-amateurs, who live in areas around the conference venue, provide technical equipment for practical demonstrations, it will be a workshop. Otherwise, it will be a tutorial.

with computer systems and knew I would handle them through the rest of my career. Somehow, the first "Commodore 64" computer found a place in the local 'ham' (ham is the amateur radio) club and my buddies and me made a wired link to the radio station. After the years of speaking to microphones, it was exciting to establish our very first keyboard-to-keyboard chat. You know, during the late eighties, in this area almost nobody knew of things like the Internet e-mail, messages via cell telephones etc. Besides chatting we were able to exchange text and binary (program) files. And not only that: We did that at almost no cost, because we only used our radio transmitters! I mean, there were no ISP services included; neither was we given bills for communicating over the fixed or mobile infrastructure. Having an opportunity to move the club's technical equipment to the local school we got a chance to motivate the students to join us. Soon after, a bunch of school kids became the regular club's members and participants of the amateur radio courses we offered. The same or similar history many ham groups can tell. That is why we want to motivate more educational institutions to join the global amateur radio family. The hobby gives various opportunities for all – some of them are very affordable solutions for remote schools in rural areas or developing countries. This tutorial intends to give more instructions on how to start with the amateur radio and how to use both radio and computer technology for the same purpose.

Abstract

The tutorial begins with introductory information about the amateur radio communications and continues with studying one of the most popular computer-related radio communication modes: the VHF/UHF and HF "packet-radio" (other popular modes, like "amtor", "pactor", "g-tor", "clover" etc. are also the options). The tutorial discusses (with examples) on how to choose inexpensive hardware and software needed for establishing the amateur radio links from either home or work. The tutorial explains step-by-step how to build an AMUNET – the Amateur Radio University Network – a grid of radio stations within or between universities' campuses and surrounding schools, including an opportunity to become a low-cost solution for communicating in educational institutions in rural areas and developing countries.

Scope

This is a survey of several topics:

- Scientific and social roles of the amateur radio in a community;
- Description of basic two-way computer-related radio links, as well as more complex communications over 'digipeaters' (digital repeaters, relay stations);
- Using of the amateur radio satellites; Security in the amateur packet networks;
- Connectivity to the TCP/IP world i.e. the Internet;
- Hardware choices (modems, radios, antennas, computers) and software (servers, clients, repeaters);
- Regulatory questions, consequences and solutions (new proposal of ADL license);

- Influence of the amateur radio to the national and international regulatory system;
- AMUNETs – the Amateur Radio University Networks, funding the further projects and development.

Intended Audience

- IEEE, ACM, IAENG student members (and other students as well);

- Teaching personnel of academia, high-grade and elementary schools;

- Authorities and institutions in developing countries and rural areas in general, humanitarian entities (first aid etc), scientific expeditions organizers etc;

- Local radio amateurs, local ham clubs and national radio union(s); non-for-profit societies, and other technical-related volunteers;

- Officials of ITU (Int'l Telecommunication Union), WARC-WRC (World Administrative Radio Conference), agencies and ministries of communications, science and education;

- Businesses like civil engineering, road and train builders etc., which can also build their own radio infrastructure and private networks – using the same or similar principles as the amateur packet-radio.

Motivation

According to the instructor's two-decade experience in the amateur radio, the significant percentage of school kids (and youngsters in general) – being involved in that traditional and useful technical hobby – continues with their education in areas of telecommunications, computing, mathematics, electronics and other engineering disciplines. That means the early stage of practicing the amateur radio activities is a high motivating factor for many young students. On the other side, after the initial investments in the amateur radio communicating equipment, described in the tutorial – there are almost no other costs – either before, during and after establishing exciting amateur radio communications because there are no fixed and cell telephony infrastructure included, nor the commercial Internet service providers. That significantly improves the ROI and offers a lot of opportunities for education institutions in poor countries and remote communities elsewhere. Having in mind that the radio amateurs live all around the world – that is for sure their equipment and knowledge can and should be used on behalf local and global communications. After all, some of the radio amateur enthusiasts participate to scientific and professional events, contribute technical papers, tutorial and seminar proposals, as well as magazine or journal articles – and all of them improve the state of technical culture. One important role that the radio amateurs often perform is to re-establish communications after natural disasters (tornadoes, hurricanes etc). In addition, the tutorial includes topics such as network, database and system security; security simulation and tools with implementation of cryptographic algorithms, critical infrastructure management, e-learning, IT management, digital libraries, identity management, and more.

Objective

What will the participants learn?

- What is the amateur radio, who are the radio amateurs, how to find and join them;

- What is needed to establish a simplest computer communication between two users;

- How to solve the problem of natural or artificial obstacle between two (or more) users;

- What are the advantages of communication with the amateur radio satellites;

- How to exchange an e-mail without an ISP connection or without a telephone;

- How to choose the proper modem, radio, antenna and computer;

- How to fight against potential amateur radio 'pirates' (hackers);

- What regulatory changes are needed to establish more amateur computer networks;

- What topics and questions belong to the new suggested ADL license's curricula;

- How to make the local AMUNET and how to link it to a neighboring one;

Prior History

Tutorials of the same or similar type were presented during the conferences: INFOTECH 2004, 2005, 2007, 2008 (Vrnjacka Banja, Serbia); JISA 2004, 2005 (Herceg Novi, Montenegro), IEEE-EESTEC Technical Conference 2004 (Rende-Cosenza, Italy, http://www.asiunical.org/eestec/workshop/2004/cosenza/eng/intro.php), WSEAS CSCC 2006 (Athens, Greece, http://worldses.org/conferences/2006/greece/iccom/), IEEE EUROCON 2007 (Warsaw, Poland, http://eurocon2007.isep.pw.edu.pl), WSEAS EE 2008 (Heraklion, Greece, http://www.wseas.org/conferences/2008/greece/education/), IARIA ICWMC 2008 (Athens, Greece, http://www.iaria.org/conferences2008/ICWMC08.html), TELFOR 2008 (Belgrade, Serbia), IAENG IMECS 2009 (Hong Kong, China, http://www.iaeng.org/IMECS2009), WSEAS EE 2009 (Rhodes, Greece, http://www.wseas.us/conferences/2009/rodos/education/), IEEE ICACT 2010 (Phoenix Park, Korea, http://www.icact.org/), DIRF NDT 2010 (Prague, Czech Republic, http://www.dirf.org/ndt2010), IAENG IMECS 2011 (Hong Kong, China, http://www.iaeng.org/IMECS2011), and SDIWC ICIEIS 2011 (Kuala Lumpur, Malaysia, http://www.sdiwc.net/kl/), SDIWC DICTAP 2012 (Bangkok, Thailand, http://www.sdiwc.net/thi/), SNDS'12 (Trivandrum, India, http://www.snds-conference.org/wt.html), and SDIWC EBW 2013 (Bangkok, Thailand, http://sdiwc.net/conferences/2013/ebw2013/tutorials/). Full-day workshops were conducted with BMSCE in Bangalore and TINJRIT in Udaipur (India). Parts of the tutorial (basic principles, hardware, software, security and privacy, regulatory issues) were presented as technical papers during the conferences: INFOTECH 2001, 2002, 2003, 2007, 2008; JISA 2002, 2003; YU-INFO 2002, 2003 (Kopaonik, Serbia); INFOFEST 2002, 2003 (Budva, Montenegro); TELFOR 2002, 2003; LINUXFEST 2002

(Belgrade, Serbia); IEEE ICALT-TEDC 2004 (Joensuu, Finland); PSU-UNS ICEE 2005 (Novi Sad, Serbia); WSEAS CSCC 2005, 2006, 2008, 2009 (Greece).

Outline

❑ Introduction of the amateur radio (basic principles, main ideas and goals)

- What the radio amateurs do and how they establish their communications
- How to find and join an amateur radio group (a 'ham club', a union etc)

❑ Simple computer-related radio communications, 'packet-radio'

- Direct link between two computer users
- Description of splitting information to smaller 'packets'
- Indirect link over a repeater (incl. 3D simulation)
- Security and privacy in the amateur digital radio

❑ Opportunities of amateur packet-radio satellites (PACSATs)[2]

- Additional equipment needed (special antennas and positioning devices)
- Two protocols used ('broadcast' and 'ftpl0')
- Signal flow diagram

❑ Exchanging e-mail using an amateur radio BBS system   1st hour

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❑ Hardware needed for the amateur computer-related communications

- Special modems (several examples of types, speeds, connectivity etc)
- Radio stations (types, output capabilities, power supply etc)
- Antennas
- Computers (PC XT, AT, i386, i486, Pentium, non-PC etc)

Features:

○ Independence from wired/cell telephony
○ Low power consuming
○ Long lasting communication link at low cost
○ Real-time communication
○ Text and binary files exchange
○ Mobility on remote locations
○ E-mail system included

❑ Software solutions

- Server side (DOS, Windows, Linux systems)

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[2] "Calling all radio amateurs"

Radio amateurs worldwide are being asked to help collect data from the student-built SSETI Express satellite, due to be placed in orbit on 27 September. To encourage them, ESA's Education department has organized two competitions and is supplying free downloadable software.

http://www.esa.int/esaCP/SEMARJ7X9DE_index_0.html

- Client side (OS-included software, other software)
- Repeaters' programs (incl. relay simulations in wired LANs)   2nd hour

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- ❑ Regulatory environment – national and international legal issues
  - Obligatory manual Morse code course and test (comparison with other ICT areas)
  - ADL – Amateur Digital License, requirements/curricula and opportunities
- ❑ Foreign experience
  - Universities on the West (examples on what they have been doing in the amateur radio)
  - General approach on the hobby in developed nations
- ❑ Networking opportunities
  - AMUNET – Amateur University Network (local area, MAN etc)
  - Widening the network (surrounding countries, global connections)

ADL
- ○ Computer and radio hardware
- ○ Operating systems and 'ham' digital software
- ○ Configuration of radio modems and other equipment (antennas, ground etc)
- ○ RFI – Radio frequency interference issues
- ○ Regulatory set of questions (band plan etc)
- ○ Foreign language (in written test)

3rd hour

- ❑ Radio amateurs and their roles in a society
  - Voluntary and humanitarian role of the radio amateur communications: examples on recent disasters, as Katrina hurricane in the USA – where the amateurs voluntarily helped to the local community to save human lives, etc[3]
  - Scientific role – Improving the level of technical knowledge in a society
  - Joining the professional communities and education (IEEE, ACM etc)
  - Conference and journal papers

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[3] "Ham Radio Operator Heads South To Aid Post-Katrina Communications" ("Computerworld")
- After watching steady stream of TV coverage showing the horrific conditions in the wake of Hurricane Katrina, ham radio operator Dennis Motschenbacher had had enough. He headed for Mississippi, and Computerworld plans to follow him along his journey.
http://www.computerworld.com/newsletter/0,4902,104446,00.html?nlid=MW2

"Ham radio volunteers help re-establish communications after Katrina" ("Computerworld")
- Volunteer ham radio operators are coming to the aid of relief agencies and emergency officials to help with badly needed communications in areas of Louisiana, Alabama and Mississippi ravaged early last week by Hurricane Katrina.
http://www.computerworld.com/securitytopics/security/recovery/story/0,10801,104418,00.html

- Improving domestic and international regulatory environment
- ❑ What else can be done
    - Scientific expeditions to remote and developing areas[4]
    - Connecting with astronauts, ship crews
    - Interconnections to/from TCP/IP world
    - International summer (winter) school on the amateur radio   4th hour

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Biography

The instructor has 20+ years of experience in computer network administration and system maintenance (B.Sc. in Business Computing) and 20+ years of practice in the amateur radio (licensed amateur since 1989, amateur radio call sign YT7MPB). The instructor has been maintaining various types of amateur radio bulletin board systems (MS DOS, Windows and Linux platforms) with VHF/HF radio frequency and Internet inputs/outputs in the local amateur radio union and clubs-societies. The instructor voluntarily served as the information manager and union's secretary during the nineties – where he was compiling technical and scientific information for

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[4] There is a variety of research projects conducted at remote areas all around the world and some of their announcements can be seen on the amateur radio mailing lists from time to time, like this one:

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>
>expeditionradio <expeditionradio@aol.com> wrote:
>
>Gulf Coast USA, Caribbean, or South America base station operators are needed for communication on the
>ham bands with a scientific expedition in July-August 2004.
>
>The 60 day expedition will explore deep caves in the high Andes mountains and jungle in the western Amazon
>area of South America.
>
>Expedition access to the remote areas is via trekking on foot and pack animal.
>
>Operators with good base stations, efficient antennas and/or low noise locations are needed to communicate
>with the expedition on the HF amateur bands 7, 10, 14, 18, or 21 MHz. Any of the following modes are
>available: PSK31, MT63, MFSK, CW, or SSB.
>
>The expedition will use a 20 Watt backpack transceiver with a wire dipole or vertical, combined with a
>miniature notebook computer for digital modes. Battery operation will be using solar power.
>
>The communications will consist of position reports, some short messages with families of expedition
>members, and any possible emergency or medical messages. Some relays of short text messages via email
>would be appreciated. All operation will be non-commercial.
>
>If you are interested, please reply by email.
>
>Bonnie Crystal KQ6XA
>2004 Expedition radio operator
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broadcasting via local amateur radio frequencies and repeaters. Teaching experience includes several classes in a local high-school amateur radio club; technical paper presentations during domestic and international events listed above; tutorials and workshops on the amateur radio in education, one round-table session, three book chapters and several magazine/journal articles, as well as a dedicated web page http://tldp.org/HOWTO/FBB.html having a popular amateur radio software users' manual. The instructor's researching efforts include his graduate studies in Computer Sciences, as well as his membership in IEEE Computer Society, IEEE Communications Society, IEEE Education Society, ACM, NIAR, and IAENG.

References

- Skoric, M. (2013). Security in amateur packet radio networks. In Khan, S., & Pathan S. (Eds.), *Wireless Networks and Security: Issues, Challenges and Research Trends* (pp. 1–47). Berlin - Heidelberg, Germany: Springer.
- Skoric, M. (2012). Simulation in amateur packet radio networks. In Al-Bahadili, H. (Ed.), *Simulation in Computer Network Design and Modeling: Use and Analysis* (pp. 216–256). Hershey, PA: IGI Global.
- Skoric, M. (2009). Amateur radio in education. In Song, H., & Kidd, T. (Eds.), *Handbook of Research on Human Performance and Instructional Technology* (pp. 223–245). Hershey, PA: IGI Global.
- Skoric, M. (2009). The new amateur radio university network – AMUNET (Part 4). In *Proceedings of the 13th WSEAS International Conference on Computers,* (pp. 323–328). Athens, Greece: World Scientific and Engineering Academy and Society.
- Skoric, M. (2008). The new amateur radio university network – AMUNET (Part 3). In *Proceedings of the 12th WSEAS International Conference on Computers,* (pp. 432–439). Athens, Greece: World Scientific and Engineering Academy and Society.
- Skoric, M. (2007). Summer schools on the amateur radio computing. In *Proceedings of the 12th annual SIGCSE conference on Innovation and Technology in Computer Science Education,* (p. 346). New York, NY: Association for Computing Machinery.
- Skoric, M. (2006). The new amateur radio university network – AMUNET (Part 2). In *Proceedings of the 10th WSEAS International Conference on Computers,* (pp. 45–50). Athens, Greece: World Scientific and Engineering Academy and Society.
- Skoric, M. (2005). The perspectives of the amateur university networks – AMUNETs. *WSEAS Transactions on Communications*, *4*, 834–845.
- Skoric, M. (2004). The amateur radio as a learning technology in developing countries. In *Proceedings of the 4th IEEE International Conference on Advanced Learning Technologies,* (pp. 1029–1033). Los Alamitos, CA: IEEE Press.

Supplementary Materials

The instructor's web page is: http://tldp.org/HOWTO/FBB.html

The visual presentation of tutorial in MS Power Point ™ format has 150 slides. Additional materials will be provided by amateur radio manufacturers, printed handouts, and quiz awards for most active participants!