A Systems Approach to Amateur Radio Communications.

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S1.56 ***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.
S1.57 ***amateur-satellite service***: A **radiocommunication service** using space stations on earth satellites for the same purposes as those of the **amateur service**.
From the Radio Regulation. (ITU-R). [1].

Foreword:

For more than 50 years, observing, from my corner of the world, being a Ham and using my training and expertise as a systems engineer and communications engineer I watch the development and deployment of radio amateur - step by step in parallel with and from time to time ahead of the commercial and military communications. I recall the MCW and CW than AM, SSB, the digital modes AMTOR (maritime TOR), AX25- Packet and so on. During the last decade I have seen some new development within the amateur community, namely: - the PSK31, Pactor and others. [2]

All of the above applies for local and DX, terrestrial and satellite communications, from VLF to HF and to the high UHF and Microwaves bands. And, probably, I missed some.

The development has been technology driven concurrent with the development of analog signal processing using transistors or operational amplifiers, filters, diodes, resistors and capacitors.

In the last decade, it is commonly accepted that the digital signal processing has became a common practice. The power of a PC, DSP plug in board, the Sound Blaster Board or Chipset on the PC Motherboard can handle enormous computation requirements. The price of a PC, DSP board or a Sound Blaster is not a significant expenditure in comparison with the hams expenditure on transceivers, antenna and other peripheral equipment.

Since we are not bound any longer by analog signal processing, and can use the power of digital processing this is the time to rethink what we wish our hobby to look in the coming years. Will it stay with CW, SSB, and the known digital modes? Or, to my point of view, can we have a "Master Plan" or a "Model" for the future to enable a new era of radio amateur communications based on the power of the digital processing.

To keep this paper short I recommend the readers to go and seek supplementary information. The Bibliography and further reading list at the end of this paper could be used as a starting point.

It would like to point out here that this paper is the result of my work presented in the AMSAT UK Colloquiums in 2000, 2001, 2002 and discussions with many Radio Professionals and many Radio Amateurs, professionals as well, whom I met in professional conferences (EMC, HF Radio during the years 1999 to 2003) in Europe. Many thanks to them all for the good ideas they provided.

The Vision:

My vision is that amateur radio will shift from the limited analog processing world (CW, AM, SSB and simplified data modulations) to the almost unlimited digital processing world. This is to provide the charter of amateur radio: [1]

- **Self-training,**
- **Intercommunication.**
- **Technical investigations.**

I will define the communications needs as "Multi Media", it means what ever one wishes: - voice, music, picture, movie, data, keyboard to keyboard or computer to computer and so on.

The communication channels are the frequency bands that are allocated today with the QRM, QRN, regulations on transmitted power, antenna sizes and so on.

All this under the understanding that: - our bands are crowed, some of them are rather bandwidth limited, and we are under the threat of old and new intruders and interferers.

The model should provide a common set of "Radio Interfaces" and common set of "Protocols" that will serve all amateur radio services.

The model should provide interoperability with in all amateur radio services, and will enable better frequency sharing and utilization, to reduce congestion on the amateur bands.

The model should be open, updatable and accepted by many.

This paper is neither a design nor a blueprint, it is a proposal for a model that can be accepted or another one will come. My major saying is that this is a systems approach to the future of radio amateur in the changing and mostly hostile environment, and it is unlike the singular solutions that we see in the radio amateur community, daily.

The Solution: Or the proposed Model.

1. ITU, National, and Amateur's Requirements.

1.1. ITU's Requirements

Being Radio Amateurs the proposed Model has to fulfill the requirements imposed by the International Telecommunications Union (ITU) written in the "Radio Regulations" (RR) for the amateur radio services. Some of them were quoted above. [1]

1.1.1. First requirement - self-training.

It is obvious that a new model of communications will support this requirement fully. Furthermore, this model will be closer to the modern area, the digital area, to which our youngsters are born to, and will provide them with a familiar environment, unlike the CW/SSB that is common to day. Probably this new model will require old timers to study as well, this will be a blessed effort.

1.1.2. Second requirement - intercommunication.

The radio communication requirements of the hams can be limited only by the imagination, and there are no technical restriction imposed by the ITU on the type of communications to be used by radio amateurs. The model will support this idea.

1.1.3. Third requirement -The technical investigations.

Needless to say that the scope of technical investigations in radio communications is almost unlimited. But the cumulative research with in the analog communication is almost exhausted.

On the other hand the scope of research in the digital communication is only at its first stages. That is because the power of cheap digital processing is expanding daily and we can not foresee the limit. Clearly all the effort within the scope of this model supports this requirement.

1.1.4. Other requirement -The technical characteristics of amateur emissions.

Searching carefully the RR we could find that the RR does not restrict radio amateurs in the technical usage of the frequencies or the emissions. Radio amateurs, as other services should not cause harmful interference to other services and users, should identify the emissions and should avoid out of band transmissions. It is obvious that the proposed model will answer these requirements.

1.2. National requirements

Most national requirements, at least in the countries that are regarded free world countries follow the ITU's Radio Regulations (RR) requirements. Some free world countries like the USA has some more restrictions that are "ad hock" regulation, meaning that they follow the current technology, and are changing from time to time to follow the advance in technology. Thus, they will probably allow or accept the new model.

1.3. Amateur's Requirements:

It might be sufficient to generalize the requirements as "Multi Media". One way to summarize the requirements is presented in Table 1.

	Applications	Data Rate Required	Quality of service (QoS) required	Time critical data	Remarks and Time Slot
1.	Messaging (email, kb2kb, etc)	Low (1-10kbps)	High	No	Ford Model T
2.	Voice (over digital stream instead of the common SSB)	Low (4-20kpbs)	Low (BER < $1e^{-3}$) ???	Yes	Almost Current
3.	Database access	Low to high (>30kbps-1Mbps) depends on material.	Very high Depends on Material.	Depends on Material, generally not time critical	Current
4.	"Videoconferencing" or narrow band TV	High (100kbps-300 kbps)	Medium	Yes	Coming
5.	Video surveillance (Earth Exploration)	Medium (50-300kbps)	Medium	No	One way, Satellite? feature
6.	High quality audio and video clips	Medium (100 kbps -1 Mbps) 1M @MPEG4	Medium	Yes	One must be young to enjoy
7.	Web browsing	Medium or as high as possible (>10kbps-500kbps)	High (BER < $1e^{-9}$)	Depends on material, generally not time critical.	Needs 3rd party Facilities
8.	Movies	Up to 4M @MPEG4	High	Depends on material, generally not time critical.	Needs 3rd party Facilities
9.	The future	TBD – to be defined	TBD	TBD	TBD

Table 1: Ham radio communication applications or requirements.

2. The communication channel.

The signal transmitted from my antenna to your antenna is propagated using what is characterized as "The Radio Channel". In an ideal radio channel, the received signal would consist of only a single direct path signal, which would be a perfect reconstruction of the transmitted signal. This is probably so for a Ham having his station in an open rural area and using a directional antenna to a neighbor.

This will not be the case for HF paths, for a town dweller using small antenna to work with satellites or any other DXer in the HF, VHF and above bands. The path will be a combination of attenuated, reflected, refracted, and diffracted replicas of the transmitted signal. Reflection and refraction will arrive from buildings, pavements, passing busses, lories and passenger cars, Ionosphere and others.

Thus in a most common channel, the signal is modified, during propagation, in the channel. In addition, the channel adds noise to the signal and can cause a shift in the carrier frequency if the transmitter, or receiver, or reflecting surfaces are moving (Doppler Effect). Understanding these effects on the signal is important because the performance of a radio system is greatly dependent on the radio channel characteristics.

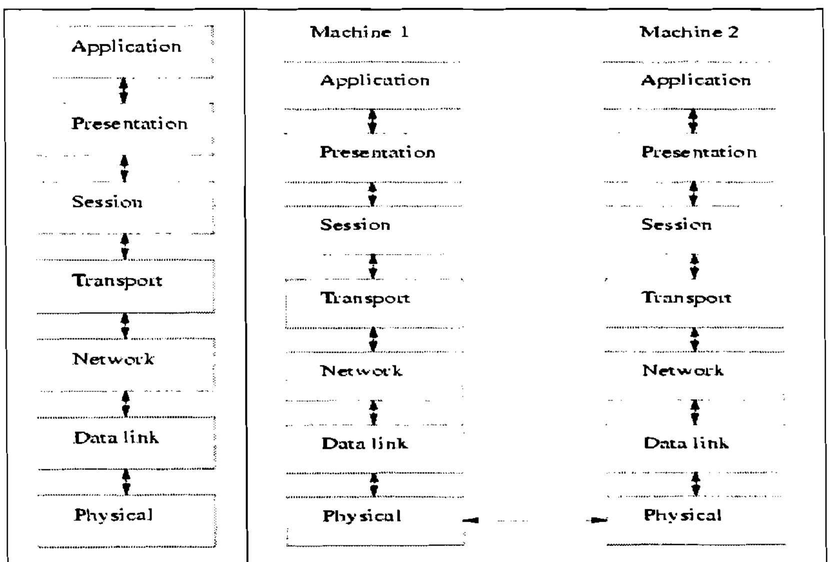
A description of the effect of the Channel will not follow; the problem is too complicated to be handled in this paper. For many Hams the Channel or Propagation Channel will it be HF or UHF, Terrestrial or Satellite is quite a vague phenomena. Probably defined in the terms: - Line of Sight, Not Line of Sight, Ground Waves, Ionospheric Propagation and others. Good conditions, Bad conditions and so on. This in not enough and I recommend the readers to seek more insight about the channel. Qualitive information could be found in the ARRL Handbook, more quantitive information could be found in ITU and IEEE publications that could be found in good technological libraries or via the "WEB". A word of caution to those who are searching the "WEB", the terms "Radio Communication" or "Mobile Communications" are used most of the times for the "Cellular Phones" technologies and problem, and not necessarily to describe the communications that Hams are interested in.

3. The Model:

3.1. Standards:

To provide communications and connectivity I will use well established standards. Some of them should be adapted to our environment; this adaptation work will provide new standards. I will start with probably the most known standard for networking and Internet working, the ISO (International Standards Organization) OSI 7 Layer model. This standard is probably well known to the readers and I will sum it up in Figure 1. I want to emphasis here that I will use the TCP/IP that preceded the OSI 7 Layer model, and does not comply exactly with it but it is much simpler to use this model. [3, 4]

Figure 1: OSI 7 Layer model



The Model | Interconnecting using the Model

3.2. Filling up the ISO Model

In table 1 – we stated the list of applications that we wished to use over our channel. In the following lines I will try to satisfy those requirements using the ISO OSI 7 Layer model.

The ISO OSI Reference Model is a layered model - with each layer providing certain services and calling upon the services of other layers, and The ISO/OSI model describes information exchange services and protocols, without making assumptions concerning:

a. programming language bindings.

b. operating system bindings.

c. application and user interface issues.

A model is simply a way of organizing knowledge and provides the common basis for discussion.

Each layer (called (n)-layer) provides a service to the layer immediately above it in the hierarchy ((n+1)-layer). It does this by using the services of the layer below it ((n-1- layer). Clearly the lowest layer uses the physical medium. Each layer is defined by the services it provides to the layer above.

3.2.1. Layer 1:

The physical layer is concerned with transmitting bits, on the radio signals over a communications medium. Specifications for wave shapes, signaling rates, radio equipment, cables and connectors are involved in this layer. I am looking for a common radio interface, a digital modulation wave-form and communications protocols that will of benefit to all variations of the amateur service including the amateur-satellite amateur services. All hams using line of sight, non line of sight communications on the HF, V/UHF and other bands. This wave form shall:

a. Provide better communications than the "Conditions" controlled communications provided today.

b. Increase the amount of information transferred on the available bandwidth.

c. Provide interoperability within the amateur services.

d. Be scalable up and down to accommodate the required throughput.

e. Will not cause interference in and out of our bands.

Thus radio amateurs could share the same technology, applications and frequencies in a way that they could communicate and have DX communications using the same frequencies, via direct HF communications or via terrestrial and\or high capacity satellite repeaters. Those repeaters might be almost the same and interconnected terrestrial repeaters.

3.2.1.1. Proposed Modulation Techniques.

The legacy digital modulation techniques e.g. FSK and AFSK could not answer the requirements of my model. A new modulation technique is needed. The first choice is to use PSK and increasing the baud rate or the number of phases. Increasing the number of phases increase the transmitted power needed to keep reasonable bit error rate, this is not feasible for us. Increasing the baud rate causes severe error due to the radio channel. The use of a single carrier suffers from frequency selective fading and narrow band interference. The solution is to increase the number of PSK carriers, and the number of phases and optimize these numbers with the baud rate to fit the communications need and the radio channel. This is exactly what has been done by the Orthogonal Frequency Division Multiplexing (OFDM) [5,6] which is thus recommended the universal modulation technique for layer 1.

OFDM is a Multi-Carrier Modulation (MCM) transmitting data by dividing the stream into several parallel bit streams, each has a much lower bit rate (baud), and by using these sub streams to modulate several carriers. Each sub carrier could be modulated using BPSK or QPSK or higher order modulations schemes. The subs carriers are densely spaced with overlapping spectra. OFDM do not use steep band pass filters that completely separated the spectrum of individual sub carriers. Instead, OFDM time-domain waveforms are chosen such that mutual orthogonality is ensured even though sub carrier spectra may overlap. Such waveforms can be generated using a Fast Fourier Transform at the transmitter and receiver [7, 8].

Each sub carrier could be modulated as described for the case of a single carrier. To decrease the vulnerability to interference, only the basic modulations schemes are used. To keep constant amplitude on the radio channel, we will, probably, start with QPSK (M=4) or BPSK (M=2) and during the life cycle of Hams implementation go to higher levels.

The principle of Multi-Carrier Modulation (MCM) is not new. The first systems using MCM were military HF radio links in the late 1950s and early 1960s. Radio amateurs are using MCM on the HF bands today. Symbols with 64 carriers within an HF voice channel are already in operation on the HF bands by radio amateurs (MT63 that was developed by Pawel Jalocha, SP9VRC) [9]

Orthogonal Frequency Division Multiplexing (OFDM) was patented in the U.S. in 1970 [1]. For a relatively long time, the practicality of the concept was limited. Implementation aspects such as the complexity of a real-time Fourier Transform was prohibitive, not to speak about the stability of oscillators in transmitter and receiver, the linearity required in RF power amplifiers and the power back-off associated with this. To-day many of the implementation problems had been solved and OFDM has become part of several communication standards. The mostly known user of OFDM is the DBA which is **Digital Audio Broadcast** (Radio) and some ADSL systems (wires).

3.2.1.2. Why OFDM: [11, 12, 13, 14]

3.2.1.2.1. Fast Fading:

Having the freedom to increase the single carrier modulation phases or to increase the number of sub carriers, we could tune the symbol rate (baud) to accommodate fast fading characteristics of the channel. This is similar with a single carrier PSK/QAM but without transmit power per bit penalty or an increased vulnerability to interference.

3.2.1.2.2. Frequency Selective Fading:

The OFDM are very little affected by Frequency Selective Fading, unlike the single carrier modulation, where the frequency selective fading will destroy a symbol or even a string of symbols. With OFDM the frequency selective fading will destroy only a single sub carrier. It means that only a small number of bits within the symbol will be corrupted or destroyed. This can be corrected with error correction coding within the symbol or in another symbol.

3.2.1.2.3. Scalability:

OFDM could be scaled up to the limits of available bandwidth and noise level. Starting from BPSK (one carrier two phase) up to any "N" carriers and "M" phases per carrier. These two parameters could be optimized with the baud rate to accommodate almost any need with in the amateur radio services.

3.2.1.2.4. Clock retrieval:

One of the most complicated problems with single carrier PSK/QAM signals as well as with spread spectrum signals is the clock retrieval. The transmitter and the receiver should be synchronized. The same goes for eliminating the Doppler Effect. With OFDM one or more of the sub carriers could be used for the purpose of synchronizing the clock and for Doppler Effect correction. (But there are other means as well.)

3.2.1.2.5. Interleaving in frequency domain:

Interleaving in frequency domain, i.e., across sub carriers, may be used to further improving performance. Signals from different applications or programs are interleaved to achieve greater independence of fading of sub carriers for individual user data streams.

3.2.1.2.6. Time Dispersion:

Unlike the single carrier modulation, a well-designed Coded OFDM system, modest time dispersion can improve, rather than deteriorate, the bit error rate. This interesting, counter-intuitive phenomenon can be explained using arguments of diversity. If the entire OFDM signal is subject to flat fading, i.e., if all sub carriers experience the same fading, bit errors occur on sub carriers are highly correlated. Error correction with code words spread across sub carriers may not be able to correct erased or wrong bits. In a channel with a larger delay spread, the coherence bandwidth can be such that fading only affects a limited number of sub carriers at a time. Forward error correction coding can successfully repair poor reception at those sub carriers. Thus MCM/OFDM is robust against fading caused by natural multipath. It should be noted that it can also work if signals are received from two different transmitter sites: - the mutual interference is experienced as artificial multipath propagation.

3.2.1.2.7. Single frequency networks:

Based on what was said above, it is possible to deploy single frequency networks. Main and relay transmitters may use the same set of sub carriers. Satellite and ground stations relays can use the same set of sub carriers. In areas with reception from multiple transmitters, site diversity gains are experienced. **This is in sharp contrast to the typical degradation by mutual interference seen with single carrier modulation and analogue transmission (SSB)**. This possibility guarantees very efficient use of scarce radio spectrum, particularly if countrywide coverage is aimed at. **This might change the known concepts of radio amateur frequency allocations.**

3.2.1.2.8. FEC – Forward Error detection and Correction coding.

Having the ability of redundancy with in the transmitted symbol enables to have forward error detection and correction codes with in the symbol, which provide many advantages to compare with similar technique integrated into the detected bit stream.

3.2.1.2.9. New fields of interest for Radio Amateur:

The signal waveform used for multi- carrier transmission has intriguing properties. The rapid increase in digital signal processing power in (software programmable) radio receivers has opened the way for large-scale use of this idea. There is no way to have OFDM modulation with the known hardware in common use today. One approach is to use general purpose DSP hardware, this include the "Sound Blaster" adaptor in a Personal Computer. The other is to use specialized components from the industry. Both will move Radio Amateur to an area of new technologies and new fields of interest.

3.2.2. Layer 2:

The Data Link Layer takes the bits passed by the physical layer and creates and recognizes frame boundaries; by this technique it transfers units of information to the other end of the physical link It also contains the rules governing access to the network media (Radio), Media Access Control (MAC) which are rules that are followed to move information into and out of the media.

For the link layer we will probably start with the famous AX25, this protocol was not optimized to our use since it assumes low and constant bit error rate. Not having these conditions fulfilled it increase the overhead of the higher layer to an unacceptable levels. A work should be done on improvement to this protocol in the following direction:

a. Adding forward error correction codes that are bit error rate dependent.

b. Providing packet length that will be dependent on the bit error rate.

c. Providing a media access rules that will not be semi random, as the Carrier Sense Multiple Access used by the AX25. These media access rules provides very low throughput. Some deterministic rules should be added. Choosing one way or another or combination of both will provide a more stable and usable link layer protocol.

Data Link layer: turns the raw (possibly with errors) transmission facility into an error free digital link. The well known AX25 is a good starting point but many modifications had to be introduced to make it an error free or "Reliable" layer:

Variable packet length and dynamic Foreword Error Correction (FEC) will provide an error free digital link. There are many approaches to FEC, I will recommend to start from the most advanced and most general one – the Turbo Product Code, to my best knowledge it could be implemented within Radio amateurs without offending the patents that has been issued. As a matter of fact one of these implementation has been offered by me' last year, to some "stake holders" with in the radio amateur community.

3.2.3. Layers 3 and 4

a. The Network Layer controls operations of sub networks that might intervene between the two communication devices. This layer routes information among different networks.

b. The Transport Layer splits up information into appropriate sizes (segments information) so it will fit into packets of the right size for the networks being used. It ensures all the packets arrive at the other end with no errors and assembled in order and without duplication. Therefore, it provides end-to-end data integrity and quality of service.

c. We will use, as the most of the world does the TCP/IP. This protocol has been ported already to Hams environment starting with the TCP/IP software written by Phil Karen KA9Q and others [15].

3.2.3.1. The three major weaknesses of the basic TCP/IP are:

a. Heavy overhead in poor links. - Having the above mentioned modified link layer, the heavy overhead problem will be minimized and became acceptable.

b. Do not support time critical data - This problem will not be solved now. It will be answered by version 6 of TCP/IP (IPV6) when it will be more common.

c. Provides Point to point communication and do not support multicast. The problem of Multi casting is solvable by porting the "Multicast TCP/IP" [16] to Hams environment. (It probably deserves another full size paper).

3.2.4. Layer 5, 6, 7

a. Layer 5, the Session Layer controls the establishment and continuation of a particular communication between devices. It coordinates interaction between end-application processes, keeping the two devices talking to each other and maintaining a connection.

b. Layer 6, the Presentation Layer performs conversions on information. These include conversion of code sets, encryption, text compression, and protocol conversion for virtual terminal communication. File formats that differ between devices may also be translated by this layer.

c. Layer 7, the Application Layer contains the final particulars required for programs to communicate. This layer establishes means for making the network appear transparent to user devices, joining the communications stream to the individual device.

3.2.5. Proposal for Layer 5, 6, 7.

a. It is quite clear that all protocols that work over TCP/IP are candidates for the last three layers (layer 5, layer 6 and layer 7), and that the boundaries are not clear with many protocols. Even the TCP/IP has got a good part in layer 5.

b. I will mention some protocols, which were ported into the Ham environment, and see Table 2:
   - The Post Office Protocol (POP).
   - Simple Mail Transport Protocol (SMTP).
   - File transfer Protocol. (FTP)
   - Telnet.
   - Worldwide Web (WWW) protocol.

c. Do these protocols cover our requirements? Where are the voice and video and video conferencing or the "Multi Media" applications? The solutions that could be found in use on the "Web" to day provide marginal quality and all suffer from the fact that the quality of service and delays over the TCP/IP.

d. The problem of time criticality is the more severe – luckily many others solved it for Audio and Video. The only set of protocols that accommodates all these applications is the Moving Picture Experts Group - MPEG-4. This set of protocols is designed to feed and be fed by TCP/IP or a Multicast TCP/IP.

Applications	**Quality of service required**	**Time critical data**	**Conforms with "Standard" TCP/IP**	**Known and ported protocols**
Messaging (email, kb2kb, etc)	High	No	Yes	SMTP, POP, FTP. Telnet.
Voice (digital instead of the common SSB)	Low (BER < $1e^{-3}$)???	Yes	No, Time Critical, Multi cast	?
Database access	Very high - Depends on material.	Depends on material, generally not time critical	Probably Yes	Telnet, native WWW
"Videoconferencing" or narrow band TV	Medium	Yes	No, Time Critical, Multi cast	? RTP /UDP

Table 2: Conformity Table

3.3. MPEG 4: [17]

MPEG-4 is an ISO/IEC standard developed by MPEG (Moving Picture Experts Group), the committee that also developed the Emmy Award winning standards known as MPEG-1 and MPEG-2. These standards made interactive video on CD-ROM and Digital Television possible.

MPEG-4 is the result of international effort involving hundreds of researchers and engineers from all over the world that worked for more than six years. MPEG-4, whose formal ISO/IEC designation is ISO/IEC 14496, [18] was finalized in October 1998 and became an International Standard in the first months of 1999. The fully backward compatible extensions under the title of MPEG-4 Version 2 were frozen at the end of 1999. Some work, is still in progress. It is the third (and not fourth) in a series of MPEG specifications that have a history of wide acceptance and use in the marketplace.

We as Hams could not duplicate this effort. The only alternative open is to port the MPEG – 4, gradually, in parts, into our environment.

3.3.1. The MPEG-4 standards:

To describe in details the MPEG – 4 will be out of the scope of this paper. I will bring in only some highlights. It is recommended that the interesting person will visit the MPEG-4 home page [17].

3.3.1.1. The standards provide:

a. A digital bit stream format and associated protocols for representing multimedia content consisting of natural and synthetic: - audio, visual, and data objects.

b. Users have a new level of interaction with the contents. It provides technologies to view access and manipulate objects rather than pixels, with great error robustness at a large range of bit rates. Application areas range from digital television, streaming video, voice and associated data to fixed and mobile multimedia and games.

c. A set of technologies to satisfy the needs of authors, service providers and end users alike. For all parties involved, MPEG seeks to avoid a multitude of proprietary, non-interworking formats and players.

3.3.1.2. MPEG-4 standardized ways are:

a. Represent units of aural, visual or audiovisual content and associated data, called "media objects". These media objects can be of natural or synthetic origin; this means they could be captured with a camera or microphone, or generated with a computer;

b. Describe the composition of these objects to create compound media objects that form audiovisual scenes.

c. Multiplex and synchronize the data associated with media objects, so that they can be transported over network channels.

d. Interact with the audiovisual scene generated at the receiver's end.

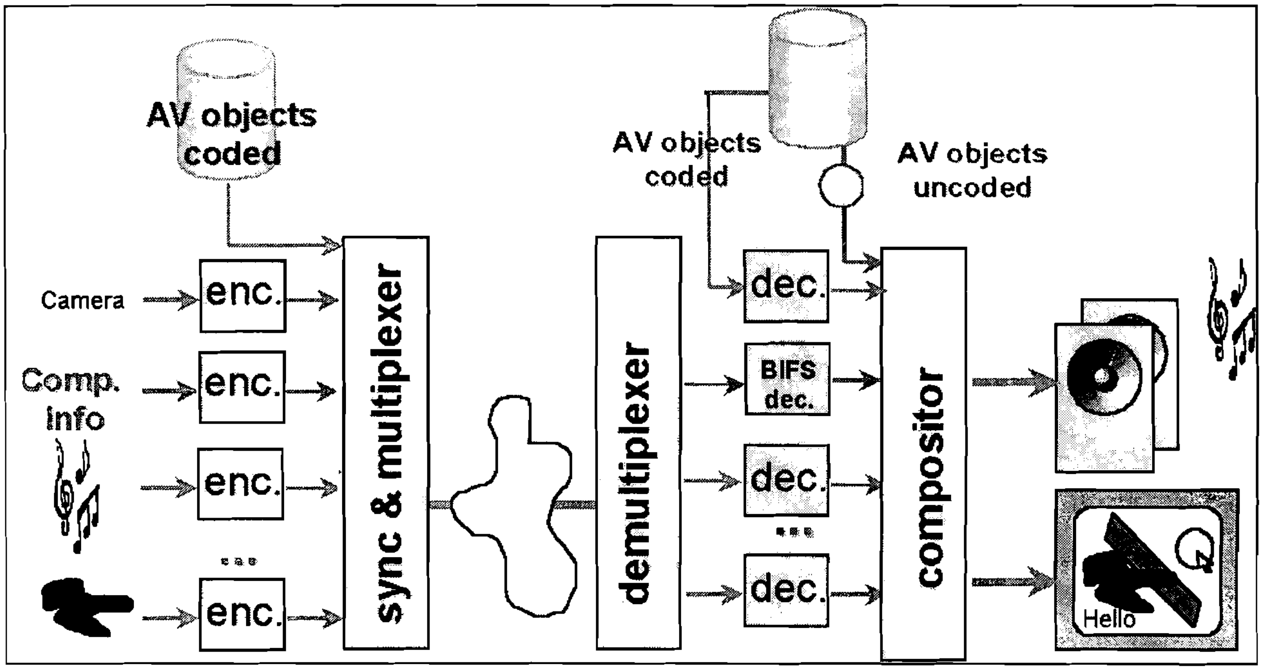


Figure 2: MPEG 4 – General functional diagram

3.3.1.3. The MPEG-4 tools functionalities and features:

a. Compression efficiency: Compression efficiency has been the leading principle for MPEG-1 and MPEG-2 and in itself has enabled applications such as Digital TV and DVD. Improved coding efficiency and coding of multiple concurrent data streams will increase acceptance of applications based on the MPEG-4 standard.

b. Content-based interactivity: Coding and representing video objects rather than video frames enables content-based applications. It is one of the most important novelties offered by MPEG-4. Based on efficient representation of objects, object manipulation, bit-stream editing, and object-based scalability allow new levels of content interactivity

c. Universal access: Robustness in error-prone environments allows MPEG-4 encoded content to be accessible over a wide range of media, such as mobile networks as well as wired connections. In addition, object-based temporal and spatial scalability allow the user to decide where to use sparse resources, which can be the available bandwidth, but also the computing capacity or power consumption.

3.3.1.4. The MPEG-4 bit rates:

MPEG-4 has been explicitly optimized for three bit rate ranges:

a. Below 64 kbit/sec, down to about 2400 bit/sec.

b. 64 kbit/sec - 384 kbit/sec

c. 384 kbit/sec - 4 Mbit/sec

For high quality applications, higher bit rates are also supported while using the same set of tools and the same bit stream syntax for those available in the lower bit rates.

Who, How and When.

In short: - It is needless to say that to accomplish the vision outlined above is a huge task. Can we do it, shell we do it how and when?

From discussions with many the Hams and research done on the "Web" I got the impression that , the radio amateur community, world wide, got the people with the technical and management expertise to handle successfully this task and switch the radio amateurs into new epoch in our hobby.

The effort should be agreed upon by a large and active organization that could provide the management and leadership, such an organization is probably among ARRL [19], RSBG [20], TAPR [21] and others or any combination of the above.
Integration technical and management leaders should be appointed and an integration lab established to test before alpha versions will be delivered to Hams community for evaluation, testing, deploying and so on.
When: Why not now? Is there a reason to delay the effort?

Summary:

In this paper I tried to present a systems approach to the future communications mode of Radio Amateurs. A technology driven solution that will enable Radio Amateurs to exist with in the regulations, interferes and intruders, increase effectively the bandwidth available and decrease the problems of frequencies allocations within Ham bands.

The paper is based on the notion that it is due time to switch from analog signal processing into the world of digital signal processing, using DSPs, Sound Blasters and so on to do it.

The paper proposes to use a family of OFDM waveforms in the physical layer. Dynamic length packets using FEC codes for the Link layer. TCP/IP for the Network and Transport layers and many available applications for the Session Presentation and application layers.

The paper presents the advantages of MPEG4, as well.

This paper shows the great picture, and avoids going into bits of singular solution. It is not to say that the whole system could be build with out working on the details.

Bibliography and further reading:

Note: - the URL's used in this list where correct on the day I found them. I have not tested all of them recently.

[1] INTERNATIONAL TELECOMMUNICATION UNION, Radio Regulations, Available in *pdf form. Vol2 para S1.56 and S1.57, {it is recommended to search the RR, for Amateur}.

[2] HF Digital Handbook Third edition, © 2003, The American Radio Relay League, Inc. (ISBN: 0-87259-915-9) http://www.arrl.org/tis/info/digital.html

[3] ISO OSI 7 Layer model - on the WEB:

- http://www.sonic.net/~n6gn/ARtalk/layer.html
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[4] TCP-IP on the WEB.

- http://www.pcsupportadvisor.com/c04100.htm
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- The MPEG Home Page http://www.chiariglione.org/mpeg/index.htm and go to MPEG-4

[18] ISO/IEC 14496 http://www.iso.ch/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=34903&ICS1 =35 Yes, This is another organization that live out of our taxes and still ask money for information that belongs to everyone. Go to a good library.

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