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TECHNICAL REVIEW

Freedom to Look, Freedom to Listen

Progress in Media Accessibility Technology

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1. Introduction

There is an English truism: "It takes all sorts to make a world". People are different. There can be cultural, physical, sensory, cognitive, and other differences. Today, media are an essential part of the human experience, and we should do all we can to bring the world to a time and place where everyone can share and participate in it. We should bring the 'freedom to look and listen' to the media - for as many of the peoples of the world as possible. Media content can be, and should be, a unifying force, helping us to find our identity, and allowing us to take the fullest part in society. In preparing and delivering the media, we need to take account of human differences whenever we can.

Up to a quarter of the population over sixteen in the developed world would benefit from media accessibility measures to accommodate sensory differences alone. In the future, the ageing population may mean that those who benefit will amount to 20% or more of the total population. Eventually, every one of us may need media accessibility measures.

The purpose of this article is to outline some of the options available, and some of the challenges we face. It is far from exhaustive, but it may encourage further actions and studies.

2. A new vocabulary and approach?

A discussion point in recent times in the ITU and elsewhere concerns our vocabulary - and how we approach accessibility. Today when writing and speaking about accessibility systems, we use phrases such as "persons with disabilities" to describe whom we are serving. This may unwittingly imply that we are talking about anonymous groups rather than equals with feelings.

There is an argument that it would be better to see society as a 'whole' - as a collection of individuals with 'differences', all of whom have equal rights. There is a follow-on argument that we should thus see the range of accessibility tools as a range of 'personalization' options that can be used by all those who so wish. The essential idea is that we should 'transpose' the discussion of 'tools to help those persons with disabilities', to a discussion of 'personalization options provided for all to accommodate human differences'. This could help those who use the options to appreciate that they are equal members of society - and eventually it may mean that using the tools of accessibility could become more normal practice.

Not all voices in broadcasting are in favour of such an approach. Some argue that by grouping all helping measures, including accessibility systems, together as 'personalization', there is a risk that human nature will see such a grouping as a reason to reduce individual budgets for specific measures. What do you think?

Whether or not the approach of specifying 'personalization options' takes hold, gateways to the media such as programme guides could begin with a common standard checklist, to allow the user to select personalization options. Ideally this might be common across all media forms, broadcast, cable, IPTV, or Internet. A common icon vocabulary for some accessibility tools for sensory differences has been developed in Denmark and is being discussed along with other ideas in the ITU (see box).

ITU-T Study Group 16 has developed a further idea - 'profiling' accessibility services for IPTV. The basis is that a system of profiles can be applied and understood at both the sending end and receiving end of an IPTV media service. They would amount, in the IPTV case, to having three levels of accessibility. The basic or **entry level profile** could include only subtitles. There would then also be an **enhanced level profile** and a **main level profile** that would give a progressively greater number of options to the user, provided they are available from the content provider, and within the capability of the receiver. It could be valuable to consider such a family of profiles for other media provision and delivery systems, such as broadcasting and future hybrid services.

3. The path ahead of us

How is the media technology world responding to the need for 'media accessibility', and what could we be doing to improve the situation?

One of the sources of guidance and encouragement is the UN Convention on the Rights of Persons with disabilities (UN-CRPD). This calls on signatory nations to provide greater media accessibility, to allow all to share the experience of society, and hence to lead a fuller life. Media access should be equally available to all. What can be done in practice depends on local conditions. True, we have not achieved everything called for in the UN-CRPD for media access, but we must continue to strive to fulfil its promises.

4. The media environment today

Today's media delivery environment includes (still, in some cases) analogue and digital terrestrial television, cable TV, satellite TV, IPTV and Internet. In addition, there are Integrated Broadcast Broadband (IBB) systems available that offer 'cooperative networks' of broadcasting and Internet, including HbbTV (Europe), Ginga (Brazil), and Hybridcast (Japan).

Media services can include 'linear services[1]', 'non-linear services[2]', 'catch-up TV[3]' and 'start-over TV[4]'. We are living in a multi-platform/multi-format environment. Furthermore, our media accessibility tools and measures need to consider all the elements of the end-to-end chain from camera to viewer.

There are those who believe we are witnessing a gradual transition from conventional broadcasting and wired broadband to the combination of conventional broadcast and wireless broadband serving all kinds of receivers. However rapidly this happens, we cannot deny that we are a fragmented industry with, though not deliberate, fragmented technical standards including those for accessibility tools. The provision of complete accessibility will be a major challenge.

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[1] A continuous channel of programming.

[2] On-demand content.

[3] On request, the programme previously broadcast is in an on-line library and streamed to the user by internet.

[4] On request, the programme being watched is in an on-line library, and a version is streamed to the user by internet, starting from the beginning of the programme.

5. The early accessibility tools

Subtitles and captions burned-in to the image as part of storytelling, or for different languages, have been around since the dawn of moviemaking. The potential value of subtitles and other accessibility measures for those with cultural and sensory differences has been recognized for many decades. The 1960s and 1970s brought pioneers[5] in 'subtitles for the hard of hearing' (termed 'closed-captioning' in North America). The developers were the pathfinders for accessibility technology. The subtitles were specifically intended to be available for those with hearing differences and they could be switched in-and-out at the discretion of the user (hence the term 'closed-captions' as opposed to burned-in captions which are 'open' for all to see). Their use today goes beyond serving those with sensory differences.

The first technologies for delivering optional subtitles with the image included using data in the analogue television waveform's hidden vertical interval. Since then, the number of tools available has increased. In Europe, for example, they now also include DVB-Teletext and DVB-Subtitling, as well as the original Teletext, each with distinct advantages. The DVB specifications also include a specification for a TTML[6] based system.

6. The increasing number of accessibility options

The digitizing of television and radio has brought many new possibilities for accessibility systems. Insertion of a sign language 'signer' can be now an option. They also include 'audio descriptions' (AD). These help those with sight differences to follow the action in the scene. Though not yet widely used, there is Clean Audio (CA). This technology helps those with hearing differences to discriminate between foreground and background sounds in media content. There are also techniques to slow down the apparent speech rate for radio. Many more details are given later in this article, and in the bibliography at the end of this article. More sophisticated digital processing could allow us to add further options.

It may be that, in the years ahead, the bigger problem will be deciding what technologies to use in practice, rather than the challenge of developing them.

7. The current texts on accessibility system in standards development organizations

There are very many texts that provide information and insights into accessibility technology options. They cannot all be included in the bibliography section of this article, though a selection of them are noted here.

The EBU has created a family of subtitling specs (EBU-TT) as a follow-up of the still widely used EBU STL (EBU Tech 3264) subtitling exchange format and it is active in ensuring that NGA technology can be used for personalisation / accessibility. ITU-R, ITU-T, and ITU-D have all developed texts that give present and future technical options. The W3C (the World Wide Web consortium) has agreed important specifications for TTML drawing on subtitling / captioning systems developed in the SMPTE and the EBU. The IEC and the IEC/ISO JTC1 have also done important work.

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[5] They included the late Julius Barnathan, Chief Engineer of ABC, who championed the first closed captioned TV show 'The Mod Squad'.

[6] Timed Text Markup Language is an XML-based W3C standard for timed text in online media. The DVB system is given in ETSI EN 303 560 V1.1.1 .

There have been several collaborative projects, such as 'Easy TV' that have been developing accessibility measures. The box below gives recent conclusions on the steps the ITU should take regarding accessibility, which were drawn up at a conference session with which the author was associated.

**ITU Workshop on the Future of Television for Europe
Conclusions of the Session on making television accessible
Geneva, 7 June 2019**

The outcome report of the ITU Workshop on "The Future of Television for Europe" is available at:
www.itu.int/en/ITU-T/Workshops-and-Seminars/20190607/Documents/Outcome_Report.pdf

1. Access to the media by persons with disabilities is a 'right', not a 'privilege'. The social model tells us that a disability arises when the environment does not support a person's capabilities. Whilst this is especially important for people who generally need adaptations to the environment, such as those who have difficulties hearing, moving or seeing, a consequence is that accessibility features are used by all people at different times (including older persons, refugees, illiterates, or based on specific needs or circumstances of any users); for example the number of people who will use subtitles is now actually three or four times the number with severe hearing loss.

2. ITU should recognize that accessibility can provide business opportunities that can help pay for services. A key concept that must be taken into account is financial viability of accessibility propositions. Further, it should be recognized that the growing ageing population makes accessibility systems ever more necessary, and work should be planned accordingly.

3. It should be recognized that the needs of persons with disabilities with 'interactive media', in addition to conventional media, are becoming important.

4. The media needs of persons with cognitive differences, for example 'neuro-atypical' people should also be incorporated in the related accessibility work developed by the ITU.

5. The process of creating accessibility services can begin at the design/script stage in programme making, given this is practical

6. The potential need for accessibility services for 360VR should be recognized and developed.

7. ITU-T Rec H.702 should be circulated to ITU-R SG6 and ITU-T SG9 for possible incorporation in their broadcast and cable systems. H.702 has many features including closed sign language, and a system of video relay to provide telephone calls for the deaf.

8. The ITU should investigate automatic subtitling systems and methods of slowing down audio playback rate to make it more understandable to the aging population.

9. The relevant accessibility requirements documents of the W3C should be circulated in the ITU groups concerned for possible adoption, e.g. W3C work on Audio Descriptions (TTML).

10. 10 Open source projects to develop software for accessible services should be initiated and encouraged.

11. The ITU should consider adopting a global standard set of icons for different accessibility systems (e.g. the icon set developed for use in Denmark).

12. Increase the participation of persons with disabilities in the standardization process. Standardization should always be done in consultation with stakeholders and end users' representatives

13. ITU should provide accessible remote participation in meetings. It should also look into providing automatically subtitling all meetings, and possibly also automatic signing.

14. All ITU (study) groups should coordinate and examine the related Recommendations it agrees to for accessibility implications.

15. Though the ITU-D does not develop standards, ITU-D SG1 Q7 should become a member of the IRG-AVA, perhaps as an observer, to ensure appropriate coordination of related

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accessibility work among ITU sectors.

16. We must recognize that convergence of media organizations and media technology is occurring, and this should guide our thinking.

17. Standards developed originally for the web (e.g. W3C standards and WCAG 2.1 requirements) are taking over in all media, and this needs to be recognized for all media. This is the manifestation of 'convergence'.

18. The ITU should provide appropriate ICT accessibility policy and strategy advice and develop and/or make available appropriate resources (including through enabling forums of discussion, raising awareness, sharing good practices, building capacity, develop specific tools and guidelines) – to help members to implement the UN CRPD.

19. The ITU should consider developing and/or offering training course in development and remediation of digital accessible content and promote the existing video tutorials made available by Digital Inclusion in BDT.

8. Questions to consider when making the choice of accessibility systems and services.

Policies about media accessibility services need to take account of a series of interrelated issues.

- *For which attributes, of those with differences, should accessibility measures be available?*

There are differences in the population in many areas, as explained earlier. The largest groups with different sensory sensitivities are those with different sight and different hearing. There are also motor and cognitive differences to try to serve. The fundamental purpose of measures is to allow users with differences to readily find, take-in, understand, and follow the media content.

- *What measures could be taken with the media content to achieve accessibility?*

The following is not exhaustive. Those with different hearing can be helped with subtitles / captions, and by in-view signing. Subtitles / captions can also help those learning to read. Spoken versions of the subtitles can serve those who find them easier to follow than written subtitles. Those with different sight (and sometimes the elderly) can be helped by audio descriptions (AD) of the action taking place in the scene.

If speech rates for radio can be adjusted to suit the user, it can be helpful. This can be done by adjusting the pauses between words. Having adjustable relative levels of foreground and background sound for television and radio can be valuable, particularly for the elderly. Simplified audio tracks and, when needed, explanations of complex concepts used in the programme, may be valuable.

Remote control systems and programme guides activated by speech or limited movement can be of value and can be an attractive feature for a wide range of users.

Production of certain accessibility content and their use in the home can be aided by Artificial Intelligence (AI).

Future systems may include tactile measures, such as audio transmission to appropriate clothing, which could enhance the sensory experience of those with reduced hearing.

Radio drama, intrinsically the 'theatre of the mind', can be unbelievably valuable to those with reduced sight (and those with screen fatigue). There may be radio content that would be valuable for those with reduced hearing, and an ITU-R system has been developed that would provide speech-to-text conversion for appropriately equipped radio sets.

- *What measures could be taken to arrange the delivery of the content to reach audiences?*

The accessibility service may need to be delivered by one component, or a combination of components working together. Delivery can be made by using the digital multiplex of a broadcast or broadband channel whose main task is carrying the main programme - or the 'load' can be shared between several channels. These can be channels designed to bring accompanying internet protocol services to the user (IPTV, Internet alone, or Integrated Broadcast Broadband (IBB)).

The services can be arranged to be seen on the main screen, or separately on a 'Companion Screen'. If it is more convivial for a family, and the service is available, the user can access the specific accessibility services they need on a tablet, smartphone or PC, at the same time as the programme is shown on a main TV screen.

The Advance Sound System / Next Generation Audio (AdvSS/NGA) system that has been specified by the ITU could provide channels for accessibility services as well as its conventional role in 'immersive audio'.

Adaptive Bit Rate (ABR) internet delivery systems could also encompass accessibility channels in their manifest.

- *If funding is needed, how should it be arranged?*

It may be true that the cost of providing accessibility services is much smaller than the cost of making the main programme itself, but when taken as annual costs, the budgets for providing the accessibility services can be significant.

The cost implications for the user, if they need new equipment, are also critically important and must be considered and resolved.

In addition, there could be benefits in having additional permanent staff on content production teams, whose job would be to ensure the content is 'accessibility-friendly'. This could mean more and 'better' accessible content - but this would bring additional costs.

The main point here is that when deciding on additional accessibility services, we need not only decide what they should be - but also how they should be funded by both the programme maker and where needed by the user.

9. Can we find universal accessibility systems for subtitles / captions?

One of the hopes of those working in this field is that there could be a universal system for decoding and displaying optional subtitles (closed captions). Volume production of the decoding electronics could mean that the costs of enabling the service in receivers would shrink to almost nothing, and it could be an integrated feature of all receivers. There are already excellent national and regional subtitling formats in use, but there would be even more benefit if the world used the same system.

Candidates for a universal subtitling format may be those developed by the W3C - IMSC. These use a subset of the TTML, developed by the W3C for a wider range of applications. The IMSC format is also a superset of the EBU-TT-D subtitling format developed in the EBU.

The IMSC formats allow a range of character sets, including Roman characters, Chinese characters and Arabic, as well as different fonts, colours, images and other features. The scope of these new formats will be limited only by the creativity of the editorial staffs that prepare the sub-titles and captions. Why not make them more eye-catching, and more enjoyable to watch?

But we need to be mindful that those schooled in the current subtitling formats may be cautious about using these new technologies, as they may call for new skills and new funding.

The W3C is also developing formats for Audio Descriptions, so this might also be a candidate for a worldwide standard.

10. How can optional signers be provided?

There are a number of ways in which 'optional signers' could be made available to viewers, each with their own advantage. One of the decisions broadcasters need to take is which would be best for their circumstances. They are given below in summary.

- *Using a second terrestrial or satellite broadcast, cable, or broadband channel.* The second channel can duplicate the first, but an appropriate part of the screen can include the signer. An advantage of this approach is that the user has only to select the second channel, so there is no need for additional systems in the receiver. In addition, the programme provider can use their experience to adjust the geometry of the inset image to give a more pleasing composite image for the user. The image could also include optional or burned-in subtitles/captions if valuable. The 'disadvantage' is that a second channel must be available. Finding them would be difficult for the tens of thousands of TV channels on air in the world.

- *Using a separate set top box to create a combined image.* This approach is based on the system described in ITU-T H 702. A separately supplied set-top box takes in the RF signal that would be input to the TV tuner. The set top box also takes in a second signal, provided by internet or IPTV, of the signer, and if valuable the subtitles/captions. The set-top box then creates a composite signal which includes all the elements – original image, signer, and possibly subtitles/captions. This is fed back to the TV set as a composite image. The advantage of this method is that no additional components are needed in the TV set itself. The system does require an internet or IPTV connection,

and of course the service providers needed. Either the content providers themselves or an independent body can provide the accessibility elements.

- *Using an Integrated Broadcast Broadband (IBB) system to provide the overlay with the signer.* There are several IBB systems in use in different parts of the world. They include HbbTV and Hybridcast. The IBB-equipped TV set takes in the television signal and a signal delivered by internet, and the two work together to provide what can be termed 'cooperative content'. If the TV set with IBB includes two separate video decoders, and the signer is sent as a separate IBB signal. The signer can be combined and overlaid with the main image in the smart TV set, and the user can be in control of the relative position and size of the signer. The TV set needs to be equipped with IBB in such a version that a second video decoder is available.

- *Using IBB to provide the second channel for the composite of the main image and the signer.* The IBB channel can itself provide the composite image of the main image and signer. In this case, a second case a second decoder is not needed. The layout of the composite image can be decided by the programme maker.

- *Using an Augmented Reality headset to provide a composite image*. Using IBB, or other means, an Augmented Reality system can be arranged to give the user a composite image of the image, as seen directly through the AR headset on the screen, and the signer, seen between the user and the screen via the AR headset display. The system would require an AR headset that the user would feel comfortable wearing for a prolonged period.

Can we achieve photo-realistic avatars for signing?

Providing sign language overlay on the screen can be a valuable accessibility tool. The conventional way to create the signer image is via a human signer. The trained human signer can use not just their arms as elements of vocabulary, but also facial and body gestures to convey nuances of meaning.

If an 'avatar' were useable and acceptable as a signer there would be advantages. Signing could be made available for more programmes, possibly even all programmes. There can be times when a human signer is not available.

There are several projects intended to discover whether an acceptable avatar can be developed and used for signing. Progress has been made, but we are not there yet. Avatars can be satisfactorily used for the types of content where there is a limited range of vocabulary such as weather forecasts, but we are not yet at the stage where photo-realistic avatars can replace human signers for all content.

11. Can we help those with other differences?

Accessibility tools and services may be of value to groups beyond those with different sensory and motor abilities. One may be the range of cognitive conditions on the 'autistic spectrum'.

It was only in the 1990s that the diagnostic manuals first included 'Asperger syndrome'. In the past, the wish for societal acceptance may even have led people to 'mask' their autism,

which may be done, but possibly at some internal cost to them. We have a duty to understand their needs.

Those on the spectrum, who constitute more than 1% of society, contribute considerably to their families and to society. One common element they may share is a greater need to understand, and to be in control of, what is happening around them. This can lead to anxieties. This might be seen as the greater need for 'predictability'.

To understand how they feel, imagine, for example, that you were in the middle of Moscow, unable to speak any Russian, or suddenly thrust into playing a game without knowing of any the rules.

Imagine that you found it difficult to separate what people mean from what they are saying by their tone of voice and the expressions on their faces. These are the kinds of frustration those on the autistic spectrum can face.

Are there areas where media providers can help those on the autistic spectrum?

Subtitles / audio description helps users to comprehend what is happening. Going beyond that, having subtitles where colours match the characters can also help more - for example, green subtitles for the Incredible Hulk, red for Iron Man.

Another option may be to provide a text of the running order of the programme that can be seen at the same time as the programme, on the same or a second / companion screen, so the viewer knows what is to come. This can make the media experience more predictable - and possibly less frustrating.

Furthermore, the story line itself of a drama can be, and usually is, 'unpredictable' - we might call this property 'plot entropy'. So, it may be valuable to also explain hidden meaning in dialogue via an auxiliary channel.

12. Conclusions

There is growing awareness of the value of media accessibility for society. In responding to this, we are faced with the challenge of matching an ever-growing number of accessibility tools with a complex and dynamic multi-platform environment.

In general, it may be more appropriate to consider 'accessibility measures' as personalization measures.

The strategy the industry chooses should take account of the communities to be served, the cost of providing the services, and the user's convenience and costs. Current challenges include whether acceptable photo-realistic avatars can be developed for signing, whether we can move to common formats for sub-titles / captions, and the best ways to deliver optional signing.

It may also be timely to reflect on whether media technology can begin to help those on the autistic spectrum. With the will and energy to do so, we can move towards giving all the freedom to see and hear the media.

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15. Author biography

David has chaired several standardisation groups in the ITU and DVB Project over many years, including groups that developed television subjective quality evaluation methodology (BT. 500), digital television (BT. 601), HDTV (BT.709) and UHDTV (BT.2020). He is a co-chair of the ITU IRG-AVA group and Rapporteur of ITU-R SG6 RG33. He has worked in the DVB Project on UHDTV Phase 1 and 2, stereoscopic television systems and virtual reality systems. David has won many international awards, including the prestigious SMPTE Progress Medal, the highest award of the SMPTE. David has taken a great interest in the development and standardisation of systems for improving media accessibility for those with disabilities. David is now a Consultant to the EBU's Technology and Innovation department, where he worked for many years.