A statistical multiplexing coding technology and its application in broadcast television

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Abstract: With the deployment of radio and television 5G networks, the construction of smart radio and television, and the revitalization of smart radio and television villages, radio and television services put forward higher requirements for the efficient use of spectrum. This paper proposes a statistical multiplexing coding technology, which adopts the spatiotemporal statistical multiplexing coding method to dynamically adjust the coding bitrate of all programs in a TV channel and dynamically allocate the inter-program code stream, which significantly improves the spectrum utilization. This technology can be easily applied to the work of terrestrial digital television broadcasting, 700M frequency cleaning and high-definition transformation of cable TV networks.

Keywords: statistical multiplexing, coding, terrestrial digital television, cable television

1. introduction

Radio and television are still the main channels for disseminating social information, and they have many functions, such as propaganda and education, information transmission, social resource orientation, and entertainment and leisure. With the development of society and technological progress, people have put forward higher requirements for the high quality and diversity of information obtained, and how to use limited resources to transmit programs with richer content and higher definition is a process of constant pursuit. In the source processing stage, traditional radio and television can generally improve spectrum utilization through the following two ways:

1.1 More efficient audio and video encoding

Audio and video coding is a specific algorithm that removes redundant information in time and space in audio and video data, and compresses audio and video data to the maximum extent at the cost of minimal information loss (or lossless), so as to facilitate the storage and transmission of audio and video information. Audio and video coding technology is constantly evolving, and with each generation of coding standards, coding efficiency will be significantly improved. The MPEG-2 standard used at the beginning of the digitization of China's radio and television, a set of standard-definition program coding bitrate of about 2Mb/s, and then the use of more H.264 or independent standard AVS+, the coding bitrate is about 1.5Mb/s, and the latest H.265 or AVS2 standard, under the premise of meeting the requirements of broadcasting, the standard-definition program coding bitrate can be lower than 1M.

Broadcast and television operators can improve the utilization rate of spectrum by adopting more efficient audio and video coding standards, but if the original system is replaced, in addition to the front-end encoder, a large number of user terminals need to be upgraded or replaced.

1.2 Statistical multiplexing techniques

The digital television program multiplexer mainly realizes the reuse of the input transport stream (TS) to form a multi-program transport stream (MPTS) for transmission within a TV channel.

"Statistical multiplexing" is a type of time-division multiplexing technique. Traditional time division multiplexing assigns a common channel to each input program stream a time slot fixedly. Generally, the bitrate of each program is not constant, and the complexity of the image at the same time is different, and the fixed allocated time slot is often wasted. Statistical multiplexing implements "on-demand allocation" of time slots on common channels, and dynamically allocates time slots between various program streams in the same channel according to image complexity (corresponding code rate is different), so that the limited bit rate can be dynamically allocated among all programs as reasonably as possible, thereby effectively improving transmission efficiency.

In the current broadcast and television front-end system, encoding and multiplexing are cascaded, and there is no relationship between the two. The statistical multiplexing coding technology proposed in this paper comprehensively considers coding and multiplexing, dynamically adjusts the coding code rate of all programs in one TV channel, and further significantly improves spectrum utilization without changing the original coding format and without changing the receiving terminal.

2. Principles of statistical multiplexing coding

Statistical multiplexing coding technology statistically analyzes the current and future possible bitrate of each program stream from the two dimensions of time and space, and dynamically adjusts the encoding parameters of each frame of video of all programs in the channel according to the analysis results. This is shown in Figure 1.

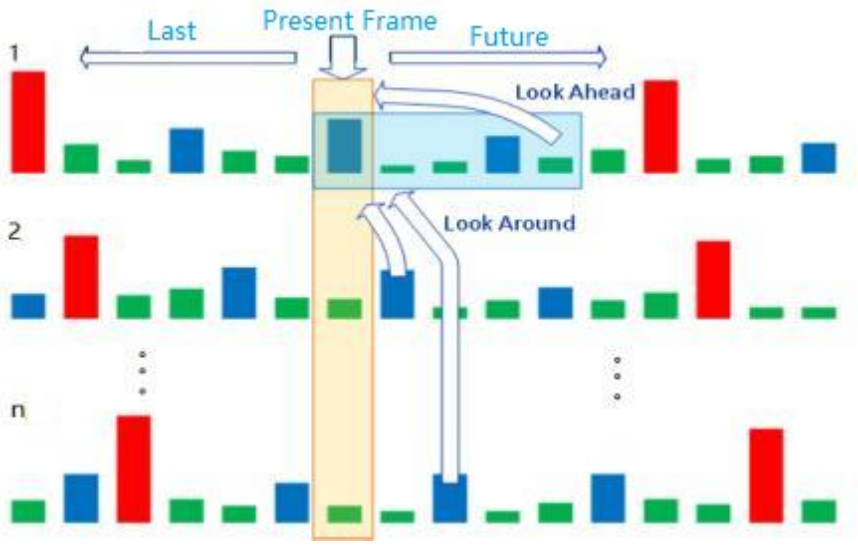

Figure 1: Space-time statistical multiplexing coding technology

2.1 Coding process

1. Pre-encode the input programs according to the original coding standard, and put the encoded code stream into the cache
2. Analyze the code rate of the current frame and future frames of each coded code stream, adjust it appropriately, and perform statistical multiplexing output
3. If necessary, within a certain time range, adjust the encoding parameters of one or more programs, re-encode and assign the code

rate, and meet the statistical multiplexed output without reducing the image quality

2.2 Technical characteristics

1. Using spatiotemporal domain statistical multiplexing coding technology, using non-correlation between programs, each program in the channel shares the bandwidth of a channel, and the code stream is dynamically allocated between programs, as shown in Figure 2, which improves the coding efficiency by 2-3 times.

Figure 2: Real-time distribution of coding bitrate

2. Without changing the encoding format of the original system, the system upgrade does not require upgrading or replacing the receiving terminal
3. Replace the original multiple encoders and multiplexers with one statistical multiplexing encoder to save cost and space in the front computer room

3. Application of statistical multiplexing coding in the field of radio and television

With the gradual deepening of radio and television 5G construction, deep media integration and smart radio and television development, as well as the development of radio and television rural revitalization and support work, the statistical multiplexing coding technology and

products proposed in this paper can play an important role in the field of radio and television.

3.1 Terrestrial digital television broadcasting

At the beginning of the promulgation of China's terrestrial digital television transmission standards, in order to meet the needs of the vast number of rural areas for watching television programs, many localities launched terrestrial digital television broadcasting services, and it is still the main way for many peasants, especially the elderly in rural areas, to watch television programs.

To deploy 5G networks nationwide, the first task of China Radio and Television is to complete the 700M frequency cleaning work. Eliminating the 700M frequency points occupied by terrestrial digital television broadcasting, without shutting down the terrestrial digital television broadcasting business, can be achieved in the following two ways:

1) Frequency point migration: Migrate programs originally broadcast in the 700M frequency band to frequency on-demand broadcast in non-700M frequency band. Since the current frequency band usage is highly saturated, it is difficult to find suitable migration frequency points.

2) Program migration: Upgrade the system with more efficient coding standards, improve spectrum utilization efficiency, and migrate programs broadcast in the 700M frequency band to other non-700M frequency bands on the air for broadcasting. But the code efficiency improvement is limited, which cannot fully meet the broadcast needs, and the replacement of encoders and user terminals requires huge needs Quantitative capital and human input.

The use of statistical multiplexing coding products can increase the channel program capacity by 1~2 times without reducing the program quality, use one channel resource to broadcast the original 2~3 channel content, save channel resources and launch costs, successfully complete the 700M frequency cleaning work, and realize the unconscious transition of system business users.

3.2 Wireless digital coverage of Central Radio

China began to organize and implement the wireless digital coverage project of central radio and television programs in 2014, and has basically completed the national radio and television coverage network, but due to the limitation of frequency resources, although the frequency planning scheme of "provincial/regional single-frequency network as the mainstay, supplemented by multi-frequency network" is adopted, on average, only two terrestrial digital TV channels can be allocated to each transmitting site, which meets the national coverage of 12 sets of standard-definition programs in the central government and the local coverage of 1 (or 2) sets of standard-definition programs in local provinces, cities and counties, and the program content is small. Does not generate enough attraction.

By transforming the current system through statistical multiplexing coding technology, with limited investment, more than 60 sets of standard-definition programs (or high-definition programs of corresponding sets) can be transmitted in two frequency points, enriching the program content and allowing the wireless digital coverage network of the Central Radio to play a better role.

3.3 Cable TV networks

In the traditional TV business, the cable TV network continues to improve the clarity of transmission programs, popularize high definition, promote 4K, test 8K, etc., add IPTV, on-demand, OTT and other services, and enrich the content and form of programs; At the same time, it actively carries out two-way data business, expands 2B and 2G services, and participates in the construction and operation of smart cities, smart villages, emergency broadcasts and other projects. Business development is endless, scientific planning and efficient use of network bandwidth resources carrying these services can not only bring good social and economic benefits to cable network companies, but also effectively enhance the competitiveness of cable network companies.

If the cable television network transmits television programs in full HD and partial ultra-high definition, without significantly reducing the number of programs transmitted or comprehensively upgrading the network system (including front-end, network, and user terminals, etc.), the network bandwidth will be under tremendous pressure, and many cable

network companies will not even be able to achieve it. Statistical multiplexing coding technology is applied to cable TV networks, under the existing H.264 or AVS coding format, an 8M TV channel, depending on the adjustment mode, can transmit 10 to 18 sets of high-definition TV programs, under the premise of limited investment and does not affect the business of cable network companies, complete the high-definition transformation of radio and television programs, or save a lot of valuable network bandwidth resources.

4. Practical application cases

In 2021, statistical multiplexing coding technology and related products were applied to the upgrading and transformation of the terrestrial digital television broadcasting system in a county in Langfang City, Hebei Province, helping it to successfully clear the frequency points in the 700M frequency band without reducing the number of transmission programs and not affecting the user's viewing experience.

At the beginning of 2012, in order to solve the problem of the masses watching television programs throughout the county, the county's radio and television station decided to invest in the construction of a DTMB terrestrial digital television broadcasting system through preliminary investigation and investigation, as a supplement to cable television, eliminate blind spots in radio and television ratings, and instantly transmit the voices of national, provincial, municipal, and local party committees and governments to thousands of households, thus enriching the cultural and entertainment life of the masses. The system adopts the national standard recommendation mode 5 (C=3780 16QAM 0.8 PN=420 720), the net bitrate of the 8MHz bandwidth system is 21.66Mb/s, the source encoding format is AVS, and 48 sets of standard-definition TV programs are broadcast on demand through 3 frequency on demand. In 2014, one frequency point was added, bringing a total of 60 television programs to 4 on-demand frequencies. At peak time, more than 30,000 households in the county watched terrestrial digital television broadcasts, mainly in remote rural areas, townships, and urban-rural areas.

The DTMB terrestrial digital television broadcasting system is an important infrastructure for radio and television in the county, and is

the main platform for radio and television to carry out rural revitalization and assistance. In order to actively cooperate with the deployment and construction of radio and television 5G networks and clear the 700M frequency band frequency points occupied by terrestrial digital television broadcasting, in 2021, the county's radio and television station adopted the spatiotemporal domain statistical multiplexing coding technology to upgrade the original front-end system. As shown in Figure 3, only one superencoder based on statistical multiplexing coding technology needs to replace the original encoder and multiplexer at each frequency point, and the rest of the front-end system and the user terminal remain basically unchanged.

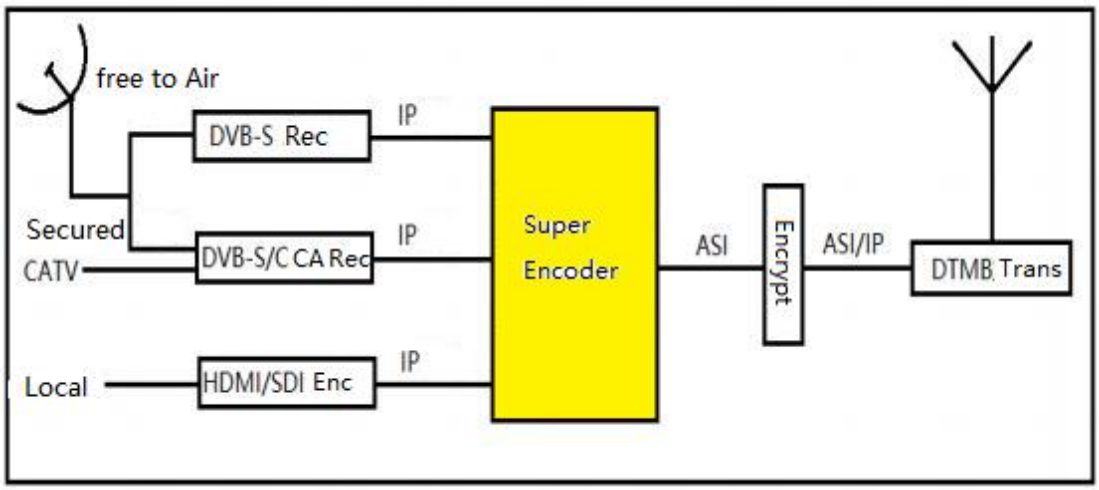

Figure 3: Schematic diagram of the front-end system after the transformation

Retaining the original national standard modulation mode and source coding format, the system can broadcast up to 32 sets of standard-definition TV programs at one frequency point, so the county only needs two frequency points to complete the original broadcast task. At present, the county broadcasts 58 sets of standard-definition television programs through two on-demand broadcasts, providing a certain spectrum space for subsequent business expansion. The system upgrade was completed within a day, and the user basically felt that the transition to the new system was no perceived.