ALGORITHM DESIGN FOR ASSIGNMENT FREQUENCY CHANNELS FOR SERVICES IN CATV NETWORK

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Summary This article describes algorithm design for assignment frequency channels for services in CATV network. QAM modulated channels in designed system are dynamically switched and frequency adapted. On introduction, there is shortly described principle of providing analog video, digital video and data services in CATV network. Object of the article is focused on method of allocation individual TV and data channels on the frequency band. The conclusion compares advantages and disadvantages present and design system.

1. INTRODUCTION

Cable television is a distribution system that uses a network of coax cables to deliver multiple video and audio channels. CATV systems can have up to hundred and twenty 6 MHz RF transmission channels or approximately one hundred 8 MHz RF channels. For analog cable systems, each transmission channel provides one video program. For digital cable systems, each transmission channel can provide 4 to 10 television channels. When using the large available bandwidth of coax cable, this can provide more than 1,000 digital video channels to consumers.

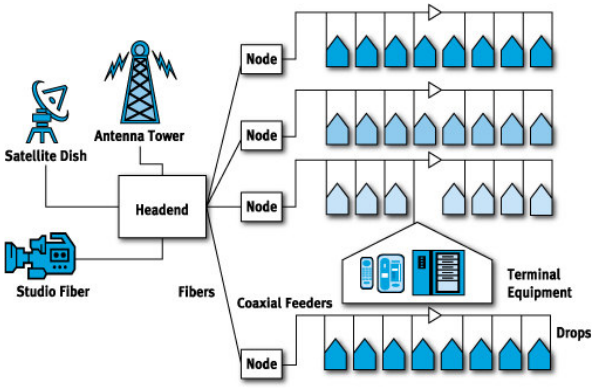

Fig. 1. Distribution CATV system

Video broadcasting is the process of transmitting video images to a plurality of receivers. The broadcasting medium may be via radio waves, through wired systems (such as CATV), or through packet data systems (such as the Internet). Television involves the transmission and reception of visual images via electrical signals. Video is an electrical signal that carries TV picture information.

Data RF channels are designed to efficiently transfer user data (such as Internet data) between users and the cable system. Data RF channels can use a very efficient form of modulation (such as QAM) from the system to the end user allowing the cable system to provide high speed data from the system to the receiver (up to 30 Mbps to 40 Mbps) per RF channel. Because signals from multiple users are combined when they are sending data to the cable system, this increases the amount of noise level so a more robust (less efficient) modulation form is used (such as QPSK), which can provide medium speed data from the users to the system (up to 2 to 5 Mbps) per RF channel. Data channels are defined in the DOCSIS specification available from CableLabs. [4]

	Bandwidth	Operating Frequencies (RF range)	Number of Channels
Small	170 MHz	50 MHz-220 MHz	12-22 (single coax)
	220 MHz	50 MHz-270 MHz	30 (single coax)
Medium	280 MHz	50 MHz-330 MHz	40 (single coax)
	350 MHz	50 MHz-400 MHz	52 (single coax)/104 (dual coax)
Large	400 MHz	50 MHz-450 MHz	60 (single coax)/120 (dual coax)
	500 MHz	50 MHz-550 MHz	80 (single coax)
	700 MHz	50 MHz-750 MHz	110 (single coax)
	950 MHz	50 MHz-1,000 MHz	150 (single coax)

Fig. 2. Downstream signals: ranges of operating frequencies and channels [1]

Fig. 3. Frequency band of coax cable [1]

2. CHANNEL BONDING

The DOCSIS system allows transparent bi-directional transfer of Internet Protocol (IP) traffic, between the cable system head-end and customer locations, over an all-coaxial or hybrid-fiber/coax (HFC) cable network.

The main advantage of **DOCSIS 3.0** standard is notable increased transfer rate. One of the ways to increase transfer rate is possibility of usage of multiple downstream channels instead of single downstream channel. There are most of the

downstream channels used for TV signal distribution and only one downstream channel is used for internet access in present days. But, there is possibility to merge multiple channels to increase transfer rate for the internet access purpose. As a good example can be considered that, one can merge four downstream channels 30Mbps each, to achieve transfer rate of 120Mbps. [3]

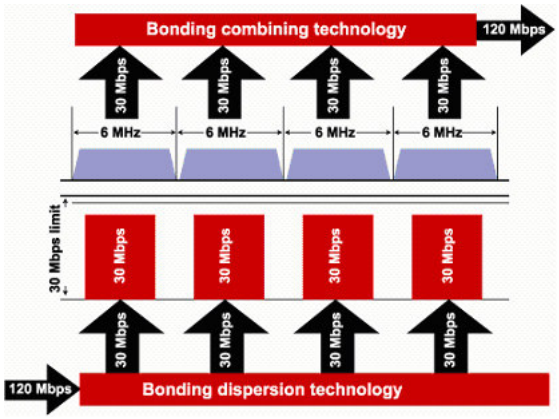

Fig. 4. Channel bonding in DOCSIS 3.0

This way is proper firstly because, we it doesn't need any big interposition to the infrastructure CATV network. Operator has to install only new active elements of CMTS and users will also need new cable modems. [3]

3. ALLOCATION FREQUENCY CHANNELS FOR VIDEO AND DATA SERVICES

Designed algorithm allows more effectively protocol DOCSIS 3.0 utilization. TV services are transmitted on demand to customers. On the base bandwidth capacity utilization of coaxial cable can by CMTS (cable modem termination system) allot one until sixteen frequency channels for each cable modem.

Individual frequency channels are occupied on the basis of request in this design method. Frequency band is divided into two segments. First frequency segment is given for TVoD or VoD services. In optical node are TV programs switched and insert into first segment. Second segment is given for data services that are transmission over DOCSIS 3.0. These segments can be assigned for upstream and downstream too.

Process of individual channel allocation is showed on fig. 5. Random number generators generates arrival time and departure time *ti* and *to* for individual service. Matrix C is created from vectors ti and to. Every element of un-pair column is arrival time and every element of pair column is departure time. Matrix rows are individual frequency channels.

Example for five services in first segment:

Generated vectors:

$$tin = [2{,}4692 \quad 0{,}4478 \quad 0{,}4176 \quad 1{,}3061 \quad 0{,}9192]$$
$$tou = [4{,}4652 \quad 0{,}7322 \quad 0{,}3766 \quad 1{,}2110 \quad 2{,}0309]$$

$$ti = [2{,}4692 \quad 2{,}9170 \quad 3{,}3346 \quad 4{,}6406 \quad 5{,}5598]$$
$$to = [6{,}9344 \quad 3{,}6492 \quad 3{,}7111 \quad 5{,}8517 \quad 7{,}5907]$$

Final matrix:

$$C = \begin{bmatrix} 2{,}4692 & 6{,}9344 & 0 & 0 \\ 2{,}9170 & 3{,}6492 & 4{,}6406 & 5{,}8517 \\ 3{,}3346 & 3{,}7111 & 5{,}5598 & 7{,}5907 \end{bmatrix}$$

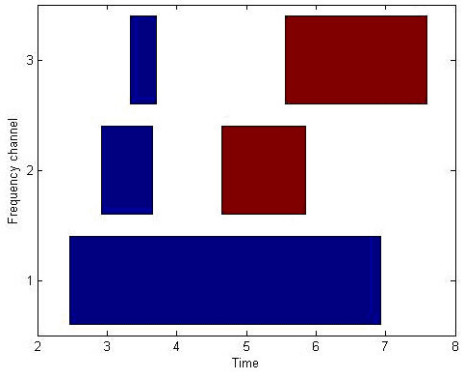

Fig. 5. Allocation five services in first segment

Algorithm occupied of frequency band is showed on fig 6. First step in algorithm is initialization of simulation time t and number of frequency canal. On the basis of arrival intensity λ and departure intensity μ first generator generate arrival time and departure time of service for first segment. Second generator is generated arrival time and departure time t or second segment. These times are written into single elements of matrix A and B on the basis of conditions in algorithm core. Matrix of arrival times is matrix A and matrix of departure times is matrix B. Matrix C is created from matrix A and B that is graphic showed at the end of algorithm.

Time generators generates exponential divided arrival time and service time distributions, each with the respective parameters λ and μ. Frequency band in CATV network is system MM100 in queueing theory. The M/M/100-Queue has the same divided arrival time and service time distributions as the M/M/1queue, however, there are 100 servers in the system and the waiting line is infinitely long [2]. As in the M/M/1 case a complete description of the system state is given by the number of customers in the system (due to the memory less property).

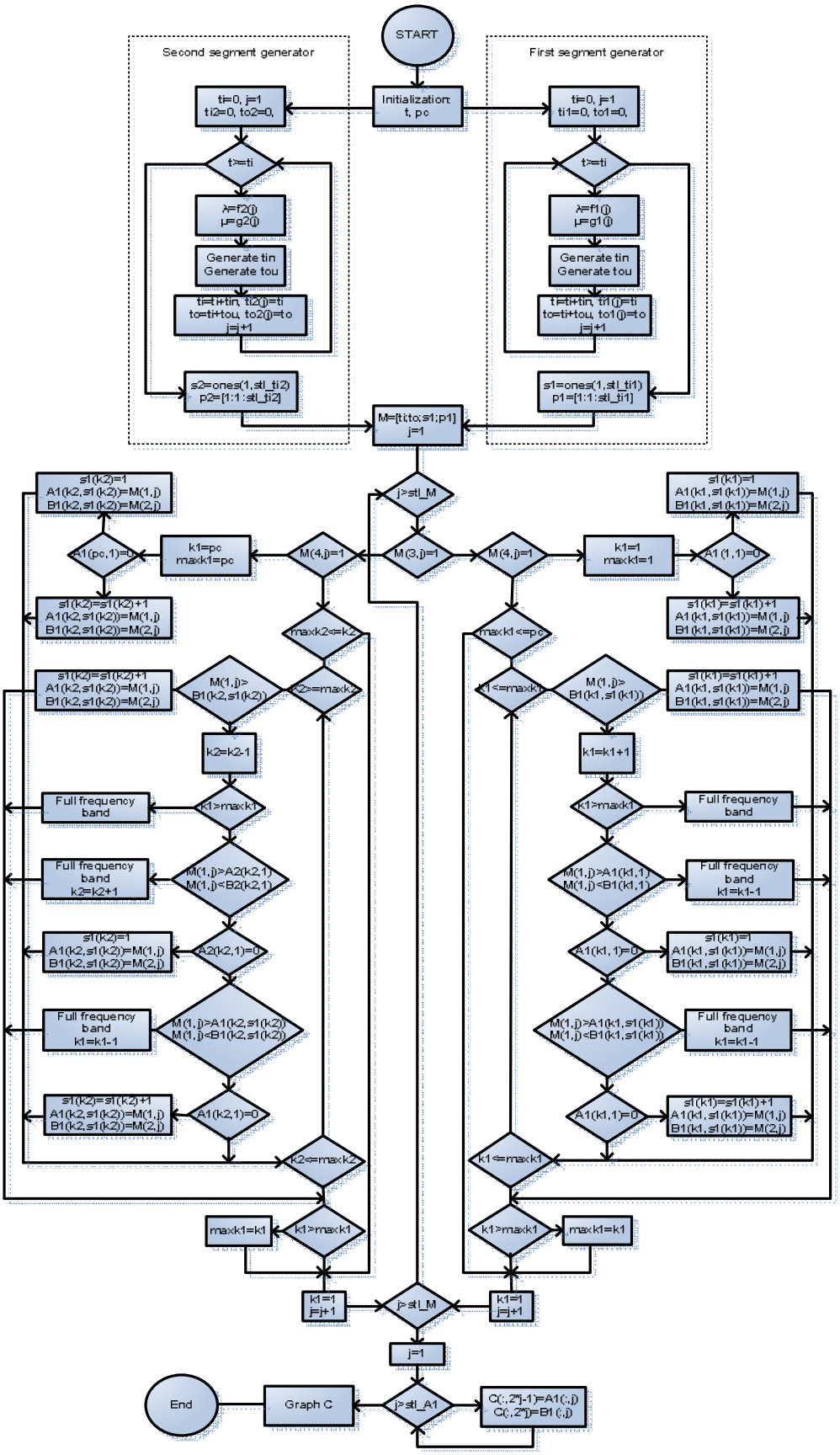

Fig. 6. Design algorithm for assignment frequency channels for services in CATV network

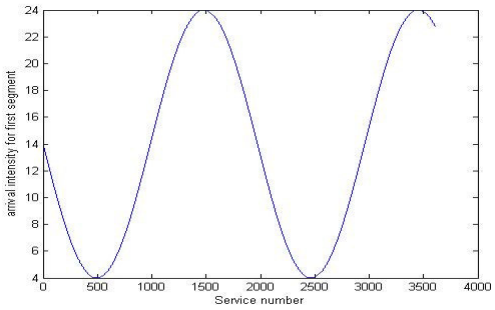

Fig. 7. Arrival intensity for first segment

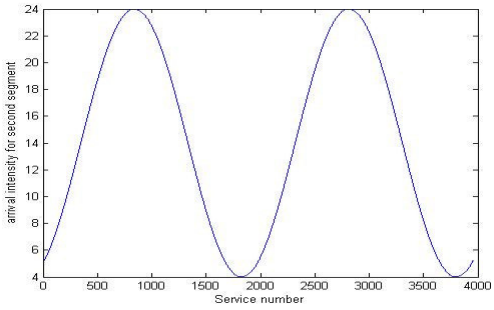

Fig. 8. Arrival intensity for second segment

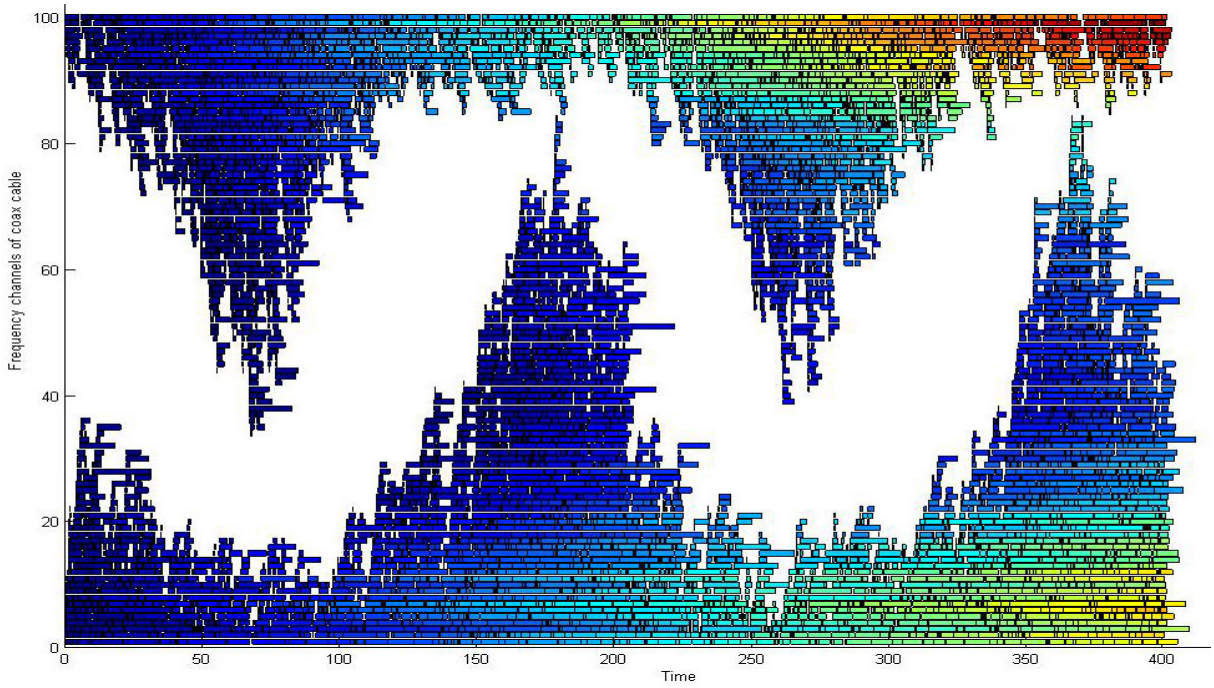

Fig. 9. Assignment frequency channels for services in CATV network

In the simulation has been served 7982 requests in simulation time 400. If frequency band is full system refuses next requests.

4. CONCLUSION

The main advantage of this system is flexibility of assigning frequency channels. System is based on request to assign single frequency channel. Free frequency band can be used for DOCSIS 3.0 data services. Cable television operators with this HFC network system should be able to compete with FTTH technology.

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