Self-Organizing Broadcast Network

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Abstract

The SON (Self-Organizing Network) technology is proposed to be applied to the single-frequency NGBT (Next-Generation Broadcast Television) system. The SON technology is expected to result in reduced cost of the network installation and operation expenditure. The proposed scheme is based on the measurements at the transmitters/repeaters and receivers using reference signals and the return channel for interactive feedback of the measurement results. The application of the SON technology to the NGBT network is simpler than that for telecommunication systems in some aspects, but also has challenges to be resolved.

I. Introduction

In the current terrestrial broadcasting networks, whenever a new transmitter, translator, or repeater is deployed, the transmit power of the new equipment must be controlled based on the measurements made on abundant test spots. If necessary, the adjacent equipments must also be re-arranged accordingly. In the case of an SFN (Single Frequency Network), it is especially more complicated since the transmit timing of adjacent transmitters should be coordinated as well.

According to the current ATSC standard documents, we can measure the reception power and timing at each test spot by exploiting the TxID (Transmitter Identification) signal. However, instant service recovery is still impossible with the current network coordination method since the measurements by drive test take significant time. It can be critical when an unexpected problem happens to one or more transmitters or when the radio channel condition of a part of the service area changes due to some reason. It is a especially serious problem to an emergency alerting service using the terrestrial DTV network.

In this paper, the SON (Self-Organizing Network) technology is proposed to be applied to the NGBT (Next-Generation Broadcast Television) system. Recently, the SON technology has been defined and is under discussion in the most advanced telecommunication standardization meetings such as IEEE 802.16m and 3GPP-LTE. The SON technology requires feedback from each UE (User Equipment) which is a TV or STB in the broadcasting network. The feedback information includes reception power and timing and the next-generation TV can easily measure them by using TxID or some other methods. Such information is sent to a central or local network administration which coordinates the transmitters based on the feedback information. As for the return channel for the feedback information, the return network considered in the ATSC 2.0 New Work Item Proposal for service usage measurement and reporting can be a good solution.

II. SON for Telecommunication Systems

The SON is a dynamic network where all the components are organized to interact each other to achieve optimal performance at the minimal human intervention. In this section, the features and component operations of the SON for telecommunication systems are briefly described as a reference.

A. Functional features of SON

The SON technology can be effective in both stages of initial deployment and operation of a telecommunication system due to its self-configuration and self-optimization features, respectively.

The self-configuration feature offers a plug-and-play function for simple installation. A self-configurable BS (Base Station) may download the system parameters from a server or auto-detect them for load balancing, ICI (Inter-Cell Interference) coordination, energy savings, coverage and robustness optimization, random access channel configuration, and so on.

The self-optimization feature extends the self-configuration to dynamic adaptation during the subsequent network operation. For example, dynamic ICI control can provide close-to-optimal performance and throughput with dynamic resource allocation while non-SON systems offer average or limited performance using predefined resources. The self-optimization can be extended to the auto-reconfiguration on environment changes. This includes the scalability with the number of UEs and robust operation against unexpected system defects and damages. The auto-reconfiguration feature for the latter is often called as self-healing.

B. Component operations for SON

The SON operation comprises as follows: measurements at BSs and UEs; reporting the measurements from BSs and UEs to the SON server; and network re-configuration as directed by the SON server. The measurements include the reception quality of the serving and neighbor BS signals, ICI, BS identification, time and location of UE measurement, and load information of neighbor BSs. The optimization may be performed either in centralized or de-centralized manner.

III. SON for SFN Broadcasting Systems

In the typical broadcasting network, when an additional transmitter or repeater is installed (See Fig. 1, an example of additional repeater installation for a shadow area), it takes a lot of time, cost, and human resource to perform drive tests at abundant test spots. The drive test cannot be accurate since it is performed at limited locations on the road at limited time while the viewers are not watching TVs on the road nor at the specific time.

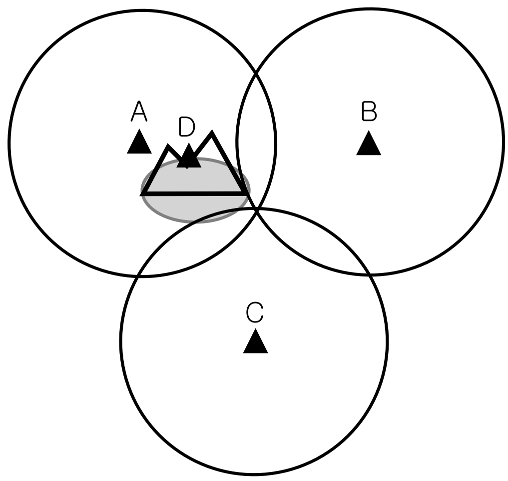

Fig. 1. Example case of additional repeater installation (A, B, C: existing transmitters, D: additionally installed repeater).

If the SON technology is applied to the terrestrial broadcasting system, the following advantages are expected: (1) New transmitters and repeaters can be easily deployed with minimal human intervention; (2) The “real” viewer environment is measured directly and instantly at the receivers and transmitters, not by the limited drive test. This can greatly reduce the cost of initial deployment and maintenance and enable more accurate network optimization; (3) The service can be dynamically recovered fast from network impairment, possibly with lower spectral efficiency for higher robustness to cope with the impairment. It is especially effective in the case when the broadcasting network serves as an emergency alerting system, where robust and reliable service must be guaranteed in every possible situation.

Let us denote the SON for SFN broadcasting systems as SOBN (Self-Organizing Broadcasting Network).

A. Functional features of SOBN

Just like the SON for telecommunications, the self-configuration feature offers simple installation of transmitters and repeaters at minimal human intervention to enable SFN interference coordination, energy savings, coverage and robustness optimization, and seamless service on deployment of additional transmitters and repeaters.

The self-optimization feature enables dynamic adaptation to provide good quality of service to as many viewers as possible. The optimization criteria for SOBN can be different from those for SON. For example, in a telecommunication system, one of the optimization criteria is to individually maximize each UE’s data throughput in a selfish manner but the criteria for SOBN can be to minimize the reception failures all over the service area. Again, the self-optimization can be performed in either centralized or de-centralized manner.

Finally, the self-healing is more critical in SOBN than SON for telecommunication systems since a transmitter or repeater is associated with much more users than a BS and the service areas of the transmitters usually overlaps only in narrow area. Therefore, if a single transmitter/repeater is disabled due to a disaster for example, a significant number of viewers lose chances to be properly alerted of an emergency in time.

B. Component operations for SOBN

Like the SON for telecommunications, the SOBN operation includes measurements at transmitters/repeaters and receivers, reporting the measurements to the SOBN server, and network re-configuration (See Fig. 2).

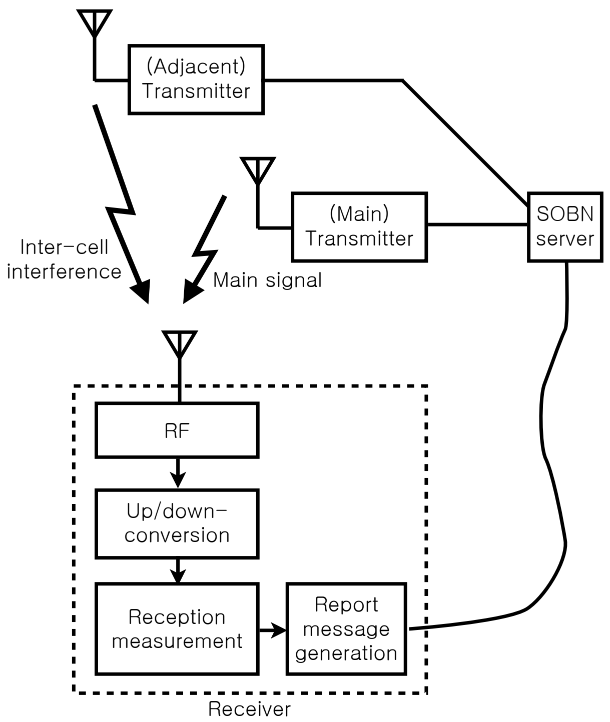

Fig. 2. SOBN system diagram.

The TxID (Transmitter Identification) signaling specified in the ATSC standard document A/110 already provides the method to measure the signal quality and ICI.

The reporting message can be transmitted to the SOBN server via any kind of return channel, either wireless or wired.

The network re-configuration can be performed by re-configurable transmitters/repeaters which can change their transmit parameters such as the transmit power, timing, and antenna pattern. More flexible design can provide re-configuration of the modulation scheme, channel code, and diversity and spatial multiplexing schemes.

C. Advantages and challenges in comparison with SON for telecommunications

The SON concept for broadcasting systems proposed in this paper is quite similar to that for telecommunication systems. However, the former can be much simpler than the latter. For example, the ICI is much easier to resolve since all the transmitters in an SFN would transmit an identical signal. Also, the optimization is not required for each individual receivers but has only to take care of the receivers operating at the reception threshold.

The SOBN also has challenges to resolve. The most important is the network optimization algorithm. Also, the receivers as well as transmitters/repeaters are required to have reconfigurable antenna pattern. The large number of receivers per transmitter/repeater can also be a big burden in reporting message traffic and network optimization. However, the former can be greatly mitigated if only the receivers suffering from reception failure are to report to the SOBN server. Also, the latter can be reduced by employing different time scales for measurements and optimization since the optimization can be safely performed in much slower time scale than the measurements.

IV. Summary

In this paper, the SOBN is proposed for the NGBT system. The two essential components for SOBN are the network measurement technology using TxID-like reference signaling and the return channel for measurement reporting. There are many challenges for SOBN but the SON in IEEE 802.16m and 3GPP-LTE will be a good reference for the resolution.

References

[1] D. Galda, N. Meier, H. Rohling, M. Weckerle, “System concept for a self-organized cellular single frequency OFDM network,” -.

[2] A. Akella, G. Judd, S. Seshan, P. Steenkiste, “Self-management in chaotic wireless deployments,” *Wireless Networks*, Vol. 13, Issue 6, pp. 737-755, Dec. 2007.

[3] A.L. Stolyar, H. Viswanathan, “Self-organizing dynamic fractional frequency reuse in OFDMA systems,” *Proc. IEEE INFOCOM*, pp. 1364-1372, 2008.

[4] B. Rengarajan, G. Veciana, “Architecture and abstractions for environment and traffic aware system-level coordination of wireless networks: the downlink case,” *Proc. IEEE INFOCOM*, pp. 1175-1183, 2008.

[5] NEC, “Self organizing network: NEC’s proposals for next-generation radio network management,” White Paper, Feb. 2009.

[6] K. Son, Y. Yi, S. Chong, “Adaptive multi-pattern reuse in multi-cell networks,” *Proc. WiOpt*, pp. -, 2009.

[7] C. Brunner, D. Fore, “Generation of pathloss and interference maps as SON enabler in deployed UMTS networks,” *Proc. VTC Spring*, pp. 1-5, 2009.