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Edge Computing Connectivity maximization for narrowband IoT systems with NOMA for 5G Networks

M.Anu [1], R.Nathea M.E.,[2] , S.Karthick M.E., [3]

P.G. Student, Department of ECE, GRT Institute of Engineering and Technology, Tiruvallur, Tamil Nadu, India[1]

Assistant Professor, Department of ECE, GRT Institute of Engineering and Technology, Tiruvallur, Tamil Nadu, India[2,3]

ABSTRACT: The developing interest and wide organization of savvy remote correspondence systems, and the difficulties identified with its specialized plan and activities have required the work on the more effective utilization of the specific restricted radio recurrence range, constrained vitality assets and decrease of the conclusion to-end delay as a fundamental piece of the cutting edge keen remote systems. Non-orthogonal multiple access (NOMA) and device-to-device (D2D) communications have been recognized as promising techniques for the fifth generation (5G) networks due to their potential role in increasing the spectral efficiency.Three diverse Cognitive Radio Wireless Sensor Networks (CRWSNs) bunch structures are investigated; altered single-jump structure, multi-bounce group structure and half breed bunch structure. Cooperative NOMA presents a more attractive option since the two techniques are combined to provide better benefits and address some of 5G deployment purposes, and Internet of things (IoT) constraints and use cases. In this paper, considering recent and popular cooperative NOMA schemes, we first provide a compact taxonomical classification of the various approaches in the literature, and we present a comparative performance analysis based on outage probability and average throughput.

KEYWORDS: NOMA, CRWSN, 5G, IoT

I. INTRODUCTION

The growing demand and wide deployment of cost effective wireless communication networks, and the challenges related to its technical design and operations have necessitated the work on the more efficient use of the very limited radio frequency spectrum, limited energy resources and reduction of the end-to-end delay as an integral part of the next generation smart wireless networks. Three different Cognitive Radio Wireless Sensor Networks (CRWSNs) cluster structures are explored; modified single-hop structure, multi-hop cluster structure and hybrid cluster structure. The effects of the three structures in multiple setups are studied in regards to varying the selected area. The evaluation results of the suggested three structures are compared to the single-hop cluster. Based on the targets set by IMT2020 in terms of spectrum efficiency, connection density, mobility, energy efficiency, and user experience, the 5th generation (5G) of mobile systems is under standardization, and the first products are highly expected to be on the market by the end of next year. Compared to the previous generations, 5G networks should be supporting unprecedented numbers of connected devices as well as considerably larger volumes of data traffic. Many surveys in the literature discussed the key technologies to enable the emergence of 5G systems and networks; both from evolutionary points of view and disruptive revolutionary visions. For example, in, the authors have back then advocated five technologies that could lead to disruptive approaches to the design of 5G cellular networks, while the authors of present an extensive discussion of the architectural changes to the radio access network, and the role other key technologies can play in the new 5G eco-system. Device-to-device (D2D) communications are one of the promising options that have been highlighted by the research community in the past years, and have been adopted by several standardization groups. The aim is to boost the performance of conventional cellular networks, e.g. in terms of power consumption, spectrum

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efficiency, and throughput, by exploiting the possibility of direct interactions between devices in proximity. In the particular context of Internet of things (IoT) applications and use cases, D2D relaying schemes present several advantages, and can help improving reliability, fault tolerance, and network access scalability. On the other hand, multiple access techniques are also being discussed and, by many considerations, redefined to meet the high spectral efficiency targets of 5G. While the previous generations of mobile networks have been relying on user orthogonality in the time/frequency/code domains, and suffering from the inherently reduced resource allocation efficiency; the introduction of non-orthogonal multiple access (NOMA) is a key enabler to alleviate the increasing resource scarcity issues, and enhancing different performance metrics (e.g., multiplexing gains, spectral efficiency, scheduling complexity, and latency). We here focus on the power domain NOMA, where the signals from multiple users are multiplexed (superposed) on the transmitter side, and multi-user signal separation is performed on the receiver side based on a successive interference cancellation (SIC) process. In this paper, we discuss the different approaches to the implementation of NOMA-based D2D schemes in the context of emerging 5G and IoT eco-systems. First, as a reminder, we revisit the performance of basic NOMA (in contrast with the conventional orthogonal multiple access (OMA)), then we extend the discussion to cooperative NOMA schemes. For instance, we propose a taxonomical classification of the different system models in the literature, and we discuss their effectiveness through a comparative study showing the advantages and limitations of each scheme. In addition, in order to illustrate the discussion with practical examples, we present D2D use cases in industrial IoT applications. Finally, we discuss open research challenges, and propose a few directions of interest that may be investigated by the research community in the near future.

II. RELATED WORK

Low-Complexity Iterative Detection Algorithm for Massive Data Communication in IIoT- Yu Han, Zhenyong Wang, Dezhi Li, Qing Guo, Gongilang Liu

As the fundamental problem of Industrial Internet of Things, massive data communication based on non-orthogonal multiple access is attractive. An iterative multiuser receiver provides a substantial performance improvement, but suffers from a distortion that the overestimation of output reliability values for bad channels. Furthermore, the main challenge lies in the high computational complexity. This paper develops an improved iterative multiuser receiver with independent channel information. In order to analyze its performance, JS-divergence is introduced to measure the correlation of exchanged information between the detector and the decoder. Low-complexity iterative detection algorithm based on JS-divergence values is proposed in this paper. The simulation results demonstrate that the proposed iterative multiuser receiver reduces the overestimation of reliability values and improves the system performance when Eb/N0 is less than 3 dB. The low-complexity iterative detection algorithm can terminate in advance when JS-divergence values of all users reach to a threshold and reduce the number of outer-loop iterations and computational complexity greatly.

Physical Layer and Medium Access Control Design in Energy Efficient Sensor Networks: An OverviewTaejoon Kim ; Il Han Kim ; Yanjun Sun ; ZhongYi Jin

It is now well expected that low-power sensor networks will soon be deployed for a wide variety of applications. These networks could potentially have millions of nodes spread in complex indoor/outdoor environments. One of the major deployment challenges under such diverse communication environments is providing reliable communication links to those low cost and/or battery-powered sensor nodes. Over the past few years, research in physical (PHY)-layer has demonstrated promising progresses on link reliability and energy efficiency. In modern medium access control (MAC) design, energy efficiency has become one of the key requirements and is still a hot research topic. In this overview, we provide a broad view encompassing both PHY- and MAC-layer techniques in the field of sensor networks with a focus on link reliability and energy efficiency. We review work in systems employing various PHY techniques in spatial diversity, energy efficient modulation, packet recovery, and data fusion, as well as MAC protocols in contention-based duty cycling, contention-free duty cycling, and hybrid duty cycling. The latest developments in cross-layer MAC designs that leverage PHY-layer techniques are presented. We also provide a synopsis of recent development and evolution of sensor network applications in industrial communications.

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Very low rate convolutional codes for maximum theoretical performance of spread spectrum-multiple-access channels A.J. Viterbi.

A spread-spectrum multiple-access (SSMA) communication system is treated for which both spreading and error control is provided by binary PSK modulation with orthogonal convolution codes. Performance of spread-spectrum multiple access by a large number ofusers employing this type of coded modulation is determined in the presence of background Gaussian noise. With this approach and coordinated processing at a common receiver, it is shown that the aggregate data rate of all simultaneous users can approach the Shannon capacity of the Gaussian noise channel.

III. PROPOSED ALGORITHM

EXISTING METHODOLOGY

An alternative non-orthogonal multiple access scheme called interleave-grid multiple access (IGMA) is proposed. Depending on interleaving and grid-mapping process, IGMA is capable to provide reliable block error rate performance, marvelous user multiplexing capability, as well as robustness against inter-cell interference. Interleave-grid multiple access can apply various detection and decoding techniques at receiver sides to improve the detection performance with acceptable complexity. Both of link-level and system level results show the promising benefits of interleave-grid multiple access, in particular that nearly seven times user multiplexing gain compared with orthogonal frequency division multiple access has been observed in the system-level simulation. In addition, a hardware test-bed has been implemented to verify the interleave-grid multiple access performance and the testing results proved the strong competitiveness of interleave-grid multiple access over orthogonal frequency division multiple access in terms of block error rate performance in user overloading scenarios.

DISADVANTAGES

A channel error burst of length N symbols will affect a single symbol in a row of a B-by-N block interleaved sequence. Thus if the error correction code corrects a single error, then the interleaved code corrects bursts of length N symbols or less. Similarly, if the code corrects 'I symbols, then the interleaved code corrects any combinations of bursts of length 'IN symbols or less.

PROPOSED METHODOLOGY

Among the current research works on the cooperative relaying systems using NOMA we selected the articles. The use cases of the considered system models. Kim et al. in proposed a cooperative relaying system (CRS) using NOMA which can achieve more spectral efficiency than the conventional CRS; the destination can receive two symbols during two time slots unlike the case of conventional CRS where it can only receive one symbol. The system model consists of a source, a half-duplex (HD) relay, and a destination, all the links are assumed to be available. In a cooperative NOMA scheme was introduced where one base station sends a broadcast message to K users in the direct transmission phase and each of the K users resends it to the users with worst channel conditions in the cooperative phase during K time slots. A system model where a D2D device acts as a HD relay to serve the user with poor channel conditions. In phase 1, the source performs NOMA to serve UE-l and UE-2. In phase 2, Dl performs NOMA to serve D2 and to boost UE-2. Lastly, UE-2 performs maximal ratio combining (MRC) using received signal at phase 1 and phase 2. This system improves the system reliability and the spectral efficiency and have considered the case of a full duplex (FD) relaying. In , Zhong et al. considered a two user NOMA system where UE-1 directly communicates with the BS, while UE-2 requires the assistance of a FD relay employing decodeand-forward (DF). The system performance was compared with the case of HD relay and showed that it achieves lower outage probability for both users, and attains higher ergodic sum capacity in the low to moderate SNR range. Considered the case of D2D relaying. One source sends a superimposed signal to two users using NOMA, and the user with strongest channel conditions acts as a FD relay to help the weakest user. The authors have also proposed an adaptive multiple access scheme (AMA) to

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improve outage performance, which dynamically switched to a proper multiple access scheme (OMA, NOMA or Cooperative NOMA) based on the level of residual self-interference and channel conditions. In , the authors propose a system with a buffer aided relay and an adaptive transmission scheme in which the system adaptively chooses its working mode in each time slot. In two source-destination pairs share a common half-duplex relay employing decode and forward strategy. NOMA is applied at the relay level, both in uplink and downlink. Different from and have considered cooperative NOMA system with multiple relays. In a two-stage relay-selection scheme was proposed. In, a hybrid decode-forward and amplify-forward relaying scheme was proposed for a multiple relay cooperative NOMA system.

CONVOLUTIONAL INTERLEAVER

- A convolutional interleaver can be created as shown in Figure-1 by splitting
- diagonally the B-byN rectangular array of a block interleaver into two halves (two triangular arrays) . The first half is the interleaver which is inserted between the channel encoder and the modulator. The second half is the convolutional deinterleaver which is inserted between the demodulator and the channel decoder. This structure is referred to as the B-by-N or (B,N) convolutional interleaver, and a shift-register realization of it.

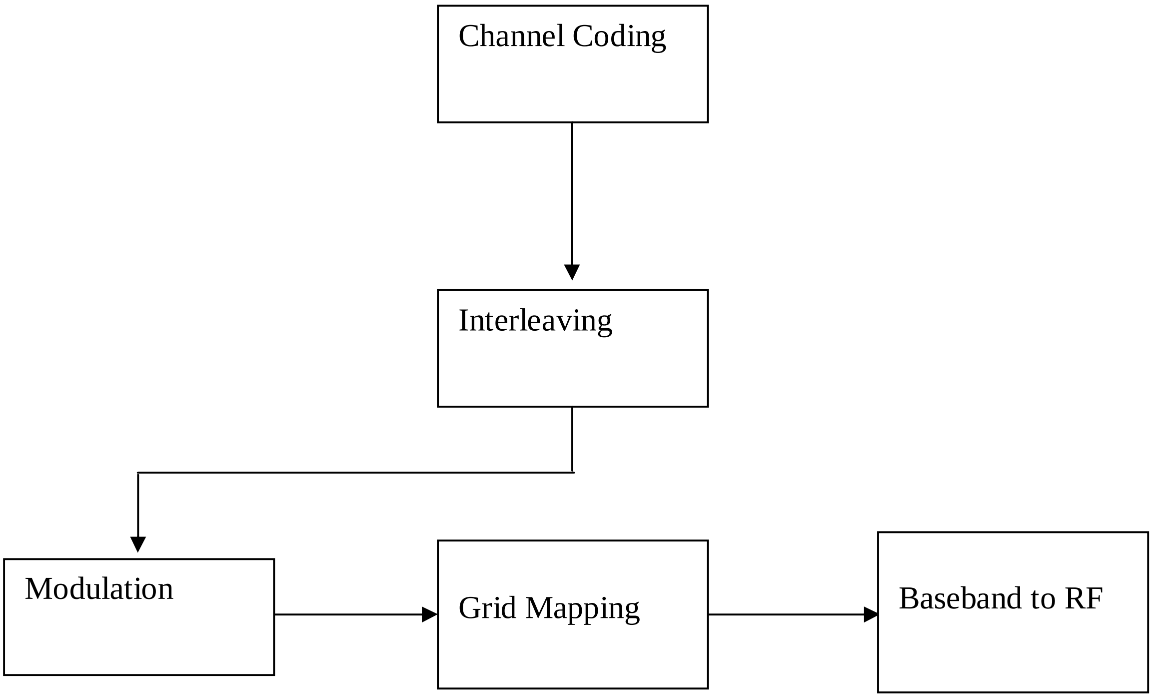

Figure 3.1 Block Diagram of the Project

CHANNELCODING

A way of **encoding** data in a communications **channel** that adds patterns of redundancy into the transmission path in order to lower the error rate. Such methods are widely used in wireless communications. See convolution code and Viterbi decoder.

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INTERLEAVING :

- Storage: As hard disks and other storage devices are used to store user and system data, there is always a need to arrange the stored data in an appropriate way.
- Error Correction: Errors in data communication and memory can be corrected through interleaving.
- Multi-Dimensional Data Structures

MODULATION

modulation is the process of varying one or more properties of a periodic waveform, called the carrier signal, with a modulating signal that typically contains information to be transmitted.

GRID MAPPING

A **grid** is a **network** of evenly spaced horizontal and vertical lines used to identify locations on a **map**. For example, you can place a **grid** that divides a **map** into a specified number of rows and columns by choosing the reference **grid** type.

BASEBAND

Baseband refers to the original frequency range of a transmission signal before it is converted, or modulated, to a different frequency range. ... When it is transmitted on a radio frequency (RF), it is modulated to a much higher, inaudible, frequency range.

IV. RESULTS AND DISCUSSIONS

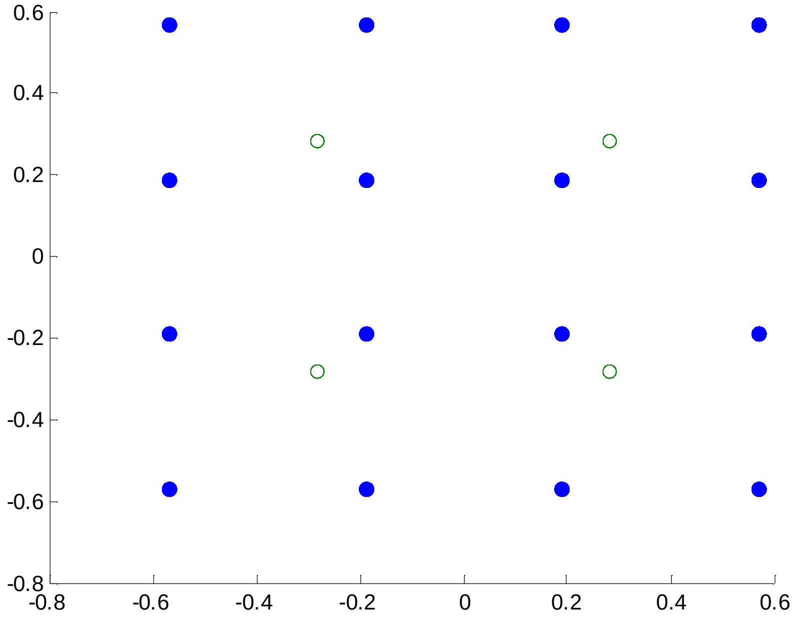

Figure 4.1 Selection of modulation scheme for codeword 0 or codeword 1

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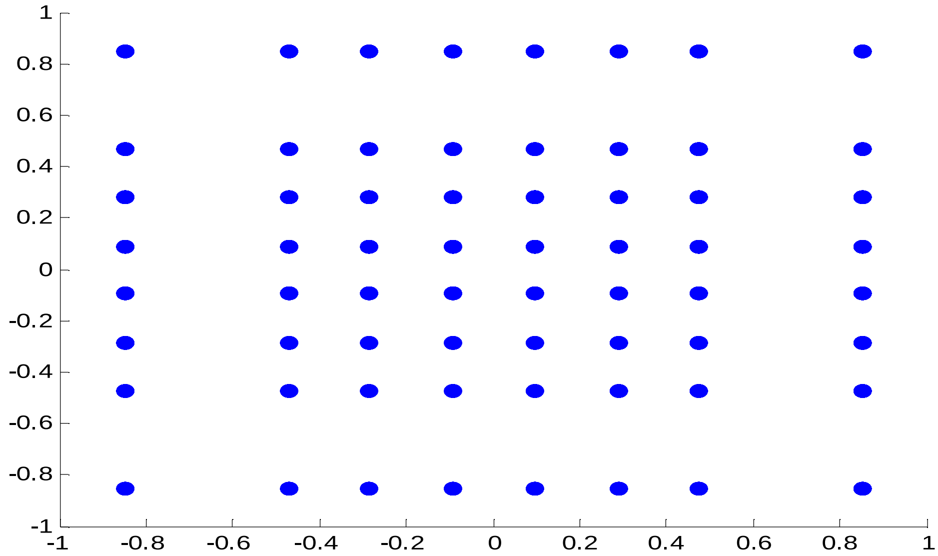

Figure 4.2 Scrambling plot for codeword 0 and codeword 1

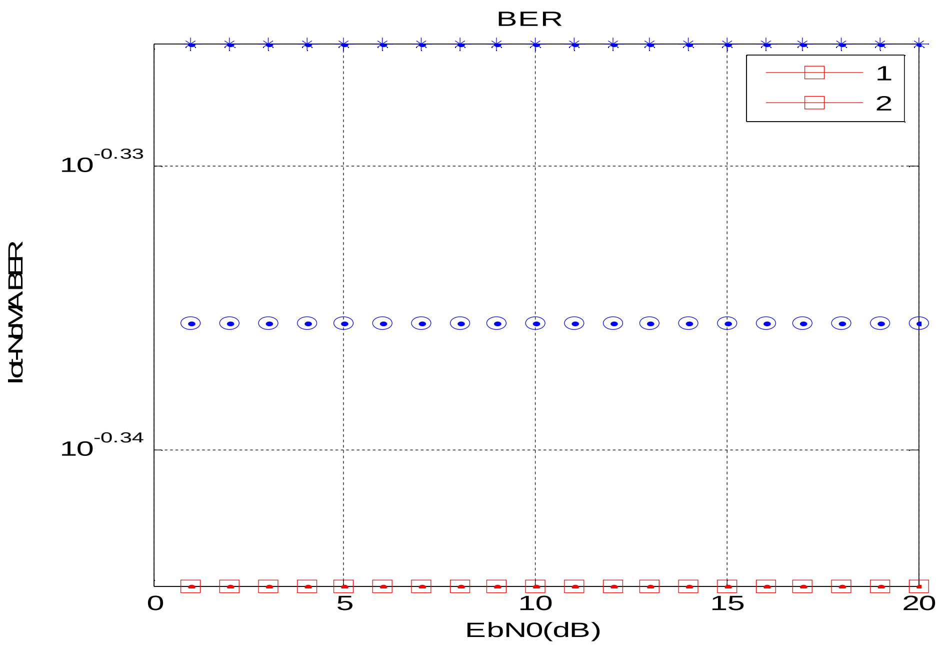

Figure 4.3 BER vs IoT-NOMA

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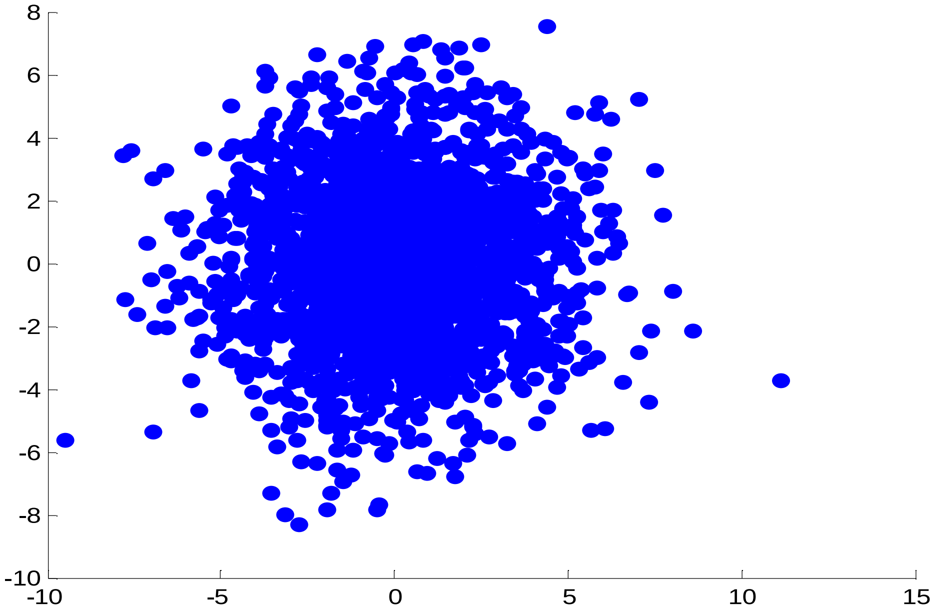

Figure 4.3 Scatter plot for fro received IoT-NOMA

IV. CONCLUSION AND FUTURE WORK

Industrial internet-of-things (IIoT) is a network consisted of multiple devices. Compared with cellular communication system, the number of devices is usually much larger, with relatively low data rates. Meanwhile, the low cost devices are more preferable in IIoT scenario and the reliability is also a key metric, especially for factory scenarios. In this paper, we have proposed an alternative non-orthogonal multiple access scheme, namely as IGMA. Typically, IGMA can provide high adaptability towards massive connections, and efficiently support higher capacity and robustness with greater flexibility by utilizing the interleaving and grid mapping process. Hence, IGMA is very suitable for IIoT scenario, since the number of supported devices can be increased. Considering low coding rate is used, reliability can be also guaranteed. Sparsity introduced by symbol-level grid mapping provides robustness to interference, especially inter-cell interference. Evaluation results, including LLS and SLS show that IGMA can achieve significant performance gain in terms of BLER, sum throughput, and supportable connection density in a limited bandwidth compared with LTE OFDMA, e.g., as much as 7 times in terms of supported UE number. Furthermore, a hardware test-bed verified the practical feasibility of proposed IGMA and proved the advantage of IGMA, e.g., as twice sum data rate as that of LTE OFDMA. Conclusively, the developed IGMA was motivated by industry interest of new 5G usage scenarios and turns out to be a strong enabler for 5G business thriving, with great practical potentials and implementability.

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