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主编序语

各位学者：

本期《分会季报》介绍高性能编码缓存设计，通过组合设计和图染色等方法设计放置分发阵列，实现更优的存储与分包；此外，还介绍记忆近似消息传递机制和大规模随机接入的有限码长传输能效分析，分别为复杂通信网络提供新的信号处理技术和传输速率分析方法。4 月 25 日，分会春茗在广州国际生物岛成功举办。6 月 25 - 30 日，IEEE 国际信息论年会在台北成功举办。展望未来，粤港澳大湾区将迎来信息论领域的两大盛事，2024 年 IEEE 信息论研讨会将在深圳举办，2026 年 IEEE 国际信息论年会将在广州举办。

陈立

From the Editor-in-Chief

Dear Chapter Members,

This issue introduces the design of high-performing coded caching schemes. It is shown that the PDA based-coded caching schemes can be designed through combinatorics and graph coloring to achieve a smaller subpacketization level and a good rate-memory tradeoff. This issue also introduces memory approximate message passing schemes and the energy efficiency analysis of massive random access with finite blocklength. They provide the new signal processing techniques and transmission rate analytical methodologies for complex communication networks. On Apr. 25, the Chapter's Spring Outing took place in the Guangzhou International Biotech Island. On Jun. 25 – 30, ISIT 2023 took place in Taipei. In the coming years, the Guangdong-Hong Kong-Macau GBA will host two important events, including the ITW 2024 in Shenzhen and the ISIT 2026 in Guangzhou.

Li Chen

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高性能编码缓存方案的设计
Design of High-performing Coded Caching Schemes

吴先章 [1]，程民权 [2]，陈立 [1]，李聪端 [1]
1 中山大学，2 广西师范大学
Xianzhang Wu[1], Minquan Cheng[2], Li Chen[1], Congduan Li[1],
1 Sun Yat-sen University, 2 Guangxi Normal University
wuxzh7@mail2.sysu.edu.cn; chengqinshi@hotmail.com; chenli55@mail.sysu.edu.cn; licongd@mail.sysu.edu.cn

The dramatic increase in the use of smart devices leads to an unprecedented growth in internet traffic. This generates a tremendous burden on smoothing the data transmission over the network, especially during the peak hours. Coded caching has been introduced as an effective technique to alleviate the network pressure by exploiting the network cache contents. The original coded caching network [1] consists of a central server which has access to a library of N files of the same size. It provides service to K users over an error free shared link. Each user has a cache memory with a size of M files. The system operates in two phases. In the placement phase, the server sends the properly designed contents to the cache of each user without knowledge of the demands. In the delivery phase, the server will be informed with the users' demands, and broadcast the coded packets of size R files to the users over an error free broadcasting channel. The user' demands can be satisfied with the assistance of the contents in their own caches. The quantity R is referred to as the transmission rate, i.e., the smallest number of files that must be communicated so that the demand of any user can be satisfied.

It is known that the coded caching scheme introduced by Maddah-Ali and Niesen [1], which is referred as the MN scheme, has the optimal transmission rate under the constraints of uncoded placement and $K \leq N$ [2]. However, its subpacketization level increases exponentially with the number of users K, which makes it impractical for large networks. It is important to design a scheme with a small subpacketization level and a relatively low transmission rate. In the work of [3,4], it has been discovered by the authors that placement delivery arrays (PDAs) can be designed through the proper orthogonal arrays (POAs) from the combinatorial design perspective. A novel PDA based coded caching scheme is obtained by a delicate selection of POAs. It generalizes the existing constructions, making it suited to the scenarios with a more flexible memory size. Meanwhile, it can achieve a considerable coding gain. Based on the proposed PDA construction, an effective transform is further proposed to enable a coded caching scheme to achieve a smaller subpacketization level. Furthermore, the design of coded caching schemes based on the injective arc coloring of regular directed graphs is investigated. It is shown that the injective arc coloring of a regular digraph can yield a PDA with the same number of rows and columns. This provides a new method for constructing PDAs from the graph coloring perspective. Based on this, some new coded caching schemes that can support a flexible number of users are proposed with a linear subpacketization level and a non-negligible coding gain. In addition, it is found out that in the proposed schemes, some packets cached by the users have no multicast opportunities in the delivery phase. By utilizing the maximum distance separable (MDS) code in the placement phase, performance of the proposed schemes can be further optimized. It is shown that the proposed schemes can achieve a low subpacketization level and flexible system parameters, aiming to facilitate their applications. Details of combinatorial constructions were recently published by the authors in [3,4].

Fig. 1 compares the subpacketization level and transmission rate of the schemes in Theorems 1, 3, [5-8] and the MN scheme. It can be seen that both the transmission rate and subpacketization level of the schemes in Theorems 1 and 3 are closed to those of the scheme in [8], which is able to achieve the minimum subpacketization level for a fixed transmission rate. This implies that the schemes characterized by Theorems 1 and 3 also yield a good performance. Since the proposals yield a more flexible memory size, they have a wider range of applications than the scheme of [8]. It can also be seen that with the same number of users, memory ratio and transmission rate, the scheme in Theorem 3 has a smaller subpacketization level than that of [5]. The subpacketization level of the scheme in Theorem 3 is even smaller than the above two, while maintaining almost the same transmission rate. When comparing with the MN scheme and the schemes of [6, 7], the proposed schemes in Theorems 1 and 3 have an advantage in the subpacketization level, but they are at the cost of some transmission rate.

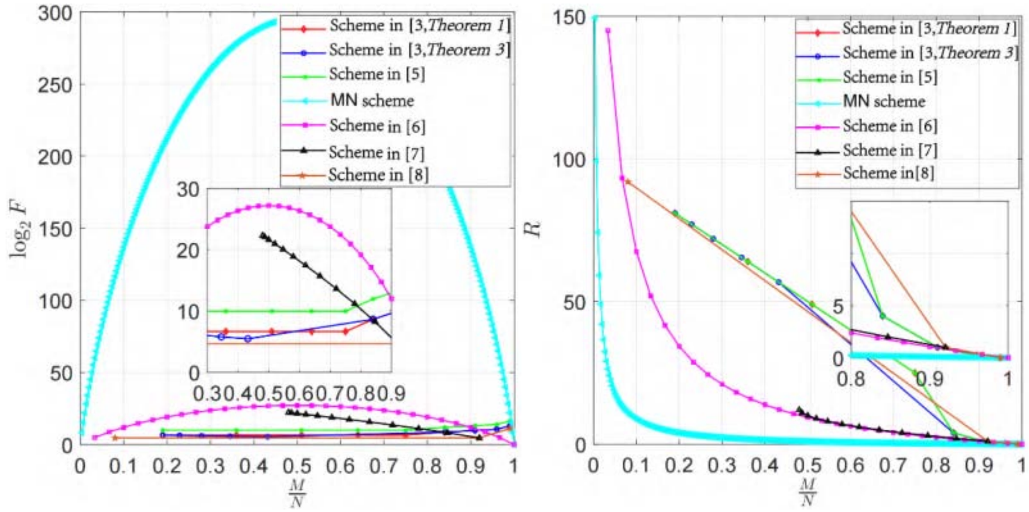

Fig. 1: Subpacketization level and transmission rate comparison between the schemes in *Theorems 1, 3*, [5-8] and the MN scheme, where *K*=300.

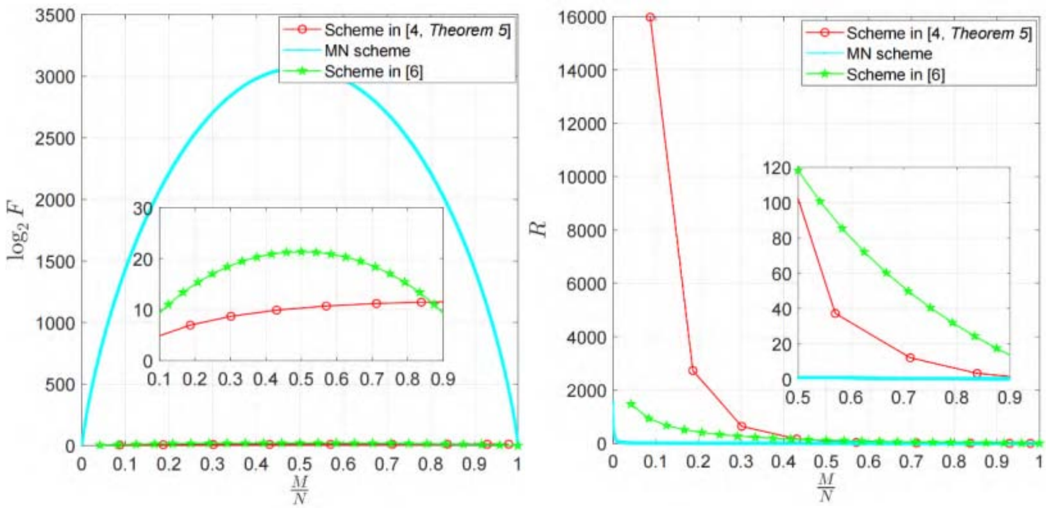

Fig. 2: Subpacketization level and transmission rate comparison between the schemes in *Theorem 5*, [6] and the MN scheme, where *K*=3072.

Fig. 2 characterizes the subpacketization level and transmission rate performances against the memory ratio between the schemes in Theorem 5, [6] and the MN scheme. It can be seen that with some sacrifice in the transmission rate, the proposed scheme in Theorem 5 significantly reduces the subpacketization level of the MN scheme. Meanwhile, for some memory ratios that are greater than 0.5, the proposed scheme in Theorem 5 has advantages in both the subpacketization level and transmission rate when compared with the MN scheme with grouping in [6].

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记忆近似消息传递
Memory Approximate Message Passing

刘雷[1]，黄顺棋[2]，Brian M. Kurkoski[2]
1 浙江大学，2 北陆先端科学技术大学院大学
Lei Liu[1], Shunqi Huang[2], Brian M. Kurkoski[2]
1 Zhejiang University, 2 Japan Advanced Institute of Science and Technology
lei_liu@zju.edu.cn; shunqi.huang@jaist.ac.jp; kurkoski@jaist.ac.jp

Background: In signal processing and communications, many applications can be formulated as unknown signal recovery problems of linear model, i.e., $\boldsymbol{y} = \boldsymbol{Ax} + \boldsymbol{n}$, where $\boldsymbol{y}$ is a length-M noisy measurement vector, $\boldsymbol{A}$ is an $M\times N$ transformation matrix, $\boldsymbol{x}$ is a length-N unknown signal vector, and $\boldsymbol{n}$ is a length-M additive white Gaussian noise vector. For solving such problems, approximate message passing (AMP) is a high-efficient approach by employing a low-complexity matched filter to suppress the linear interference [1]. More importantly, it has been proved that AMP is Bayes-optimal through the asymptotic behavior analysis, described by a simple set of state evolution (SE) equations [2]. Meanwhile, the information-theoretical (i.e., capacity) optimality of AMP was also proved in [3]. However, AMP is viable only when the matrix $\boldsymbol{A}$ has *independent and identically distributed* (IID) Gaussian entries. Otherwise, there are obvious performance losses in signal reconstruction. As a result, AMP has limited application scenarios.

To solve the problem, orthogonal / vector AMP (OAMP / VAMP) was proposed for *right-unitarily-invariant* matrices [4-5]. The SE for OAMP / VAMP was conjectured in [4] and rigorously proved in [5-6]. OAMP / VAMP can achieve the Bayes optimality when the SE has a unique fixed point [4]. The information-theoretical (i.e., capacity) optimality of OAMP / VAMP was proved in [7-8]. However, the Bayes-optimal OAMP / VAMP requires high-complexity linear MMSE estimation, which is prohibitive for large-scale systems. Additionally, low-complexity convolutional AMP (CAMP) was proposed for *right-unitarily-invariant* matrices [9]. However, CAMP may fail to converge, especially for ill-conditioned matrices. At this time, memory AMP (MAMP) was established for *right-unitarily-invariant* matrices [10]. MAMP has a comparable complexity to AMP since it uses a low-complexity long-memory matched filter to suppress linear interference. In addition, the dynamics of MAMP can be correctly predicted by SE. Most importantly, the convergence of the SE of MAMP is guaranteed, and MAMP achieves Bayes optimality when its SE has a unique fixed point.

Memory AMP Framework: Assume that both M and N are very large numbers with a fixed compression ratio $\delta = M / N$, $\boldsymbol{y}$ is a *right-unitarily-invariant* matrix, the entries of $\boldsymbol{x}$ are IID with zero mean, and the variance of $\boldsymbol{x}$ is normalized. As shown in Fig. 1, memory AMP is an iterative process that consists of a memory linear estimator (MLE) and a memory non-linear estimator (MNLE): Starting with $t = 1$,

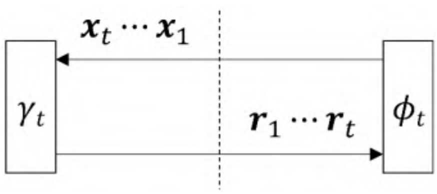

Fig. 1 A memory iterative process.

$$\text{MLE: } \boldsymbol{r}_t = \gamma_t(\boldsymbol{x}_1, \cdots, \boldsymbol{x}_t) = \boldsymbol{Q}_t \boldsymbol{y} + \sum_{i=1}^{t} \boldsymbol{P}_{t,i} \boldsymbol{x}_i,$$
$$\text{MNLE: } \boldsymbol{x}_{t+1} = \phi_t(\boldsymbol{r}_1, \cdots, \boldsymbol{r}_t),$$

where: (i) $\boldsymbol{Q}_t\boldsymbol{A}$ and $\boldsymbol{P}_{t,i}$ are polynomials in $\boldsymbol{A}^{\mathrm{H}}\boldsymbol{A}$, and γ_t is Lipschitz-continuous, (ii) For both two estimators, the estimation errors of outputs are orthogonal to the errors of inputs. Additionally, for MLE, the errors of outputs are orthogonal to $\boldsymbol{x}$. For a general MLE or MNLE that does not satisfy the orthogonality constraints, we can always construct an orthogonal MLE or MNLE by some methods. Refer to [10] for the details.

Memory AMP Algorithm: The Bayes-optimal memory AMP algorithm consists of an MLE and an NLE. The iterative process is: Starting with $t = 1$, $\boldsymbol{x}_1 = \hat{\boldsymbol{r}}_0 = \boldsymbol{z}_0 = \boldsymbol{0}$,

$$\text{MLE: } \boldsymbol{z}_t = \theta_t \lambda^{\dagger} \hat{\boldsymbol{r}}_{t-1} + \xi_t \boldsymbol{y} - \boldsymbol{A}(\theta_t \hat{\boldsymbol{r}}_{t-1} + \xi_t \boldsymbol{x}_t),$$
$$\hat{\boldsymbol{r}}_t = \boldsymbol{A}^{\mathrm{H}} \boldsymbol{z}_t,$$
$$\boldsymbol{r}_t = \gamma_t(\boldsymbol{x}_1, \cdots, \boldsymbol{x}_t) = \frac{1}{\varepsilon_t^{\gamma}}\left(\hat{\boldsymbol{r}}_t - \sum_{i=1}^{t} p_{t,i}\, \boldsymbol{x}_i\right),$$
$$\text{NLE: } \boldsymbol{x}_{t+1} = \hat{\phi}_t(\boldsymbol{r}_t) = [\boldsymbol{x}_1, \cdots, \boldsymbol{x}_t, \phi_t(\boldsymbol{r}_t)]\boldsymbol{\varsigma}_{t+1},$$

where

- $\lambda^{\dagger}$ is the average of the largest and smallest eigenvalue of $\boldsymbol{A}\boldsymbol{A}^{\mathrm{H}}$.
- θ_t is the relaxation parameter, which ensures that the algorithm has a potentially Bayes-optimal fixed point. It is optimized by minimizing the spectral radius of $\theta_t\boldsymbol{B}$, where $\boldsymbol{B} = \lambda^{\dagger}\boldsymbol{I} - \boldsymbol{A}\boldsymbol{A}^{\mathrm{H}}$.
- ξ_t is the weight parameter, which only affects the convergence speed. We optimize it to let the algorithm converges fastest.
- $\{p_{t,i}\}$ are the orthogonalization parameters and ε_t^{γ} is the normalization parameter, which ensure the orthogonality constraints of MAMP.
- $\boldsymbol{\varsigma}_t$ is the damping vector such that the sum of its entries is one. Different from empirical damping, $\boldsymbol{\varsigma}_t$ is optimized analytically by using the covariance matrix. In practice, we set the maximum damping length $L = 2$ or 3.
- ϕ_t is a separable and Lipschitz-continuous function, which is the same as that in OAMP / VAMP.

In brief, the memory AMP algorithm is potentially Bayes-optimal and ensures the convergence of SE for right-unitarily-invariant matrices with a low complexity comparable to AMP. Table I compares AMP, OAMP / VAMP, CAMP and MAMP from several aspects.

Table I
Companion between AMP-type algorithms.

<table>
<tr><th>Algorithms</th><th>Matrix $\boldsymbol{A}$</th><th>Optimality</th><th>SE convergence</th><th>Time, Space complexity</th></tr>
<tr><td>AMP [1][2]</td><td>IID</td><td rowspan="4">Bayes-optimal (potential)</td><td rowspan="2">Converges</td><td>Low $O(MNT)$, $O(MN)$</td></tr>
<tr><td>OAMP / VAMP (SVD) [4][5]</td><td rowspan="3">Right unitarily invariant</td><td>High $O(M^2N)$, $O(MN+N^2)$</td></tr>
<tr><td>CAMP [9]</td><td>Fails to converge with high κ</td><td rowspan="2">Low $O(MNT)$, $O(MN)$</td></tr>
<tr><td>MAMP [10]</td><td>Converges</td></tr>
</table>

Numerical Simulations: Consider $\boldsymbol{x}$ follows a symbol-wise Bernoulli-Gaussian distribution with sparsity μ, and we set the difference between adjacent sorted singular values of $\boldsymbol{A}$ is fixed. Let κ denote the condition number of $\boldsymbol{A}$, and SNR = σ^{-2}, where σ^2 is the variance of the Gaussian noise. Fig. 2 (a) shows MSE versus the number of iterations for AMP, CAMP, OAMP / VAMP and MAMP. For $\kappa = 10$, AMP performs poorly and MAMP converges much faster than CAMP. Furthermore, the SE of MAMP is accurate while SE of CAMP is not very accurate. Note that CAMP fails to converge when $\kappa > 15$. Fig. 2 (b) shows MSE versus the number of iterations for MAMP with $\kappa = 1000$. Even for a very high condition number, MAMP can converge to the same point as OAMP / VAMP.

Fig. 3 (a) shows MSE versus the number of iterations for an under-loaded system with compression ratios $\delta \in \{1, 4, 16, 64\}$. We set the sum of square of singular values is M. As can be seen, MAMP converges quickly to the same point as OAMP / VAMP with different δ. Fig. 3 (b) shows MSE versus the MATLAB running time of AMP, OAMP / VAMP (SVD) and MAMP. For an IID Gaussian matrix, the running time of MAMP is about 1.5 times that of AMP, which is much less than that of OAMP / VAMP. For matrix with $\kappa = 100$, the running time of OAMP / VAMP the running time of MAMP is only 1/4 of that of OAMP / VAMP. Note that the running time of OAMP / VAMP with ill-conditioned matrix ($\kappa = 100$) is almost the same as that of IID Gaussian matrix since both of them are dominated by the SVD of matrix $\boldsymbol{A}$.

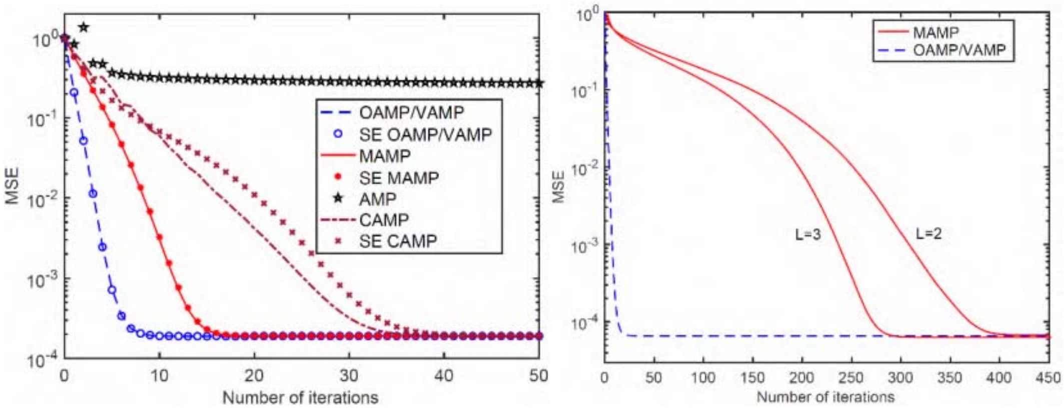

Fig. 2 $M = 8192$, $N = 16384$, $\mu = 0.1$, SNR = 30dB (a) L = 3, $\kappa = 10$; (b) $\kappa = 1000$.

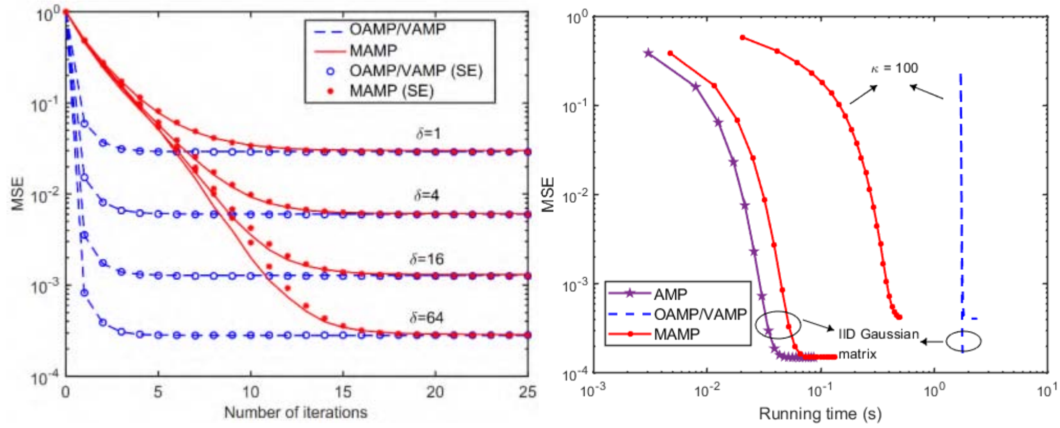

Fig. 3 L = 3, (a) $N = 512$, $\mu = 0.3$, SNR = 15dB, $\kappa = 10$, $\delta \in \{1, 4, 16, 64\}$; (b) $M = 2048$, $N = 4096$, $\mu = 0.1$, SNR = 30dB.

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最新结果 • RECENT RESULTS •

多天线准静态瑞利衰落信道大规模随机接入有限码长能效性理论分析
Energy Efficiency of Massive Random Access in MIMO Quasi-Static Rayleigh Fading Channels with Finite Blocklength

高俊园，吴泳澎
上海交通大学
Junyuan Gao, Yongpeng Wu
Shanghai Jiao Tong University
sunflower0515@sjtu.edu.cn; yongpeng.wu@sjtu.edu.cn

Background: As a typical use case in future wireless networks, massive machine-type communication (mMTC) has two distinct features different from traditional human-type communication: 1) there are a large number of users, while only a fraction of them are active; 2) active users send small data payloads to the base station (BS) with stringent delay and energy constraints. These features call for new information-theoretic analysis for massive random access.

To characterize the massive user population in mMTC scenarios, a model called the many-access channel was proposed in [1], allowing the number of users to grow unboundedly with the blocklength. In addition, finite payload size and blocklength should be considered to make the setting more relevant in practice. On this topic, the works in [2] and [3] derived non-asymptotic bounds for Gaussian and Rayleigh fading channels, respectively, under the per-user probability of error (PUPE) criterion. Notably, these results are established for the setting with a single BS antenna. Indeed, the use of large antenna arrays has great benefits. The fundamental limits of massive random access in MIMO channels will be investigated in this work.

System Model: Assume the BS is equipped with L antennas. There are K potential users each equipped with a single antenna. Only K_a users are active, and each of them sends J bits. Each user has an individual codebook of size M and length n. Consider a quasi-static Rayleigh fading channel model. The received signal over L antennas is denoted as $\mathbf{Y} \in \mathbb{C}^{n\times L}$. When there is no channel state information (no-CSI) at the BS in advance, we define:

Definition 1: Let $\mathcal{X}_k$ and $\mathcal{Y}$ denote the input alphabet of user k and the output alphabet, respectively. An $(n, M, \epsilon, P)_{\text{no-CSI},K_a}$ massive random access code consists of

1) An encoder $f_{\text{en},k}: [M] \mapsto \mathcal{X}_k$ that maps the message $W_k \sim \text{Unif}[M]$ to a codeword $\mathbf{x}_{k,W_k} \in \mathcal{X}_k$ *for* $k \in \mathcal{K}_a$. The power of each codeword is required to be no more than nP.
2) A decoder $g_{\text{de,no}-\text{CSI},K_a}: \mathcal{Y} \mapsto [M]^{K_a}$ that satisfies the PUPE constraint:

$$P_e = \frac{1}{K_a}\sum_{k\in\mathcal{K}_a} \mathbb{P}\left[W_k \neq \widehat{W}_k\right] \leq \epsilon. \tag{1}$$

Let $S_e = \frac{K_a J}{n}$ denote the spectral efficiency and $E_b = \frac{nP}{J}$ denote the energy-per-bit. The minimum energy-per-bit is defined as $E^*_{b,\text{no-CSI},K_a}(n, M, \epsilon) \triangleq \inf\{E_b: \exists (n, M, \epsilon, P)_{\text{no-CSI},K_a} \text{ code}\}$.

Non-asymptotic Results: Compared with traditional MAC, the number of users is greatly increased for massive random access, leading to a considerable increase in the number of error events. Thus, we resort to the bounding technique proposed by Fano [4] and upper-bound the probability of the event that there are t misdecoded codewords sent by users in the set S_1 as

$$\mathbb{P}[\mathcal{F}_{t,S_1}] \leq \mathbb{P}[\mathcal{F}_{t,S_1}, \mathbf{Y} \in \mathcal{R}_{t,S_1}] + \mathbb{P}[\mathbf{Y} \notin \mathcal{R}_{t,S_1}], \tag{2}$$

where $\mathcal{R}_{t,S_1}$ denotes a region around the linear combination of the transmitted signals, known as the "good region". In this work, we design $\mathcal{R}_{t,S_1}$ for massive random access as follows

$$\mathcal{R}_{t,S_1} = \{\mathbf{Y}: g(\mathbf{Y}, \mathbf{c}_{[\mathcal{K}_a]}) \leq \omega g(\mathbf{Y}, \mathbf{c}_{[\mathcal{K}_a \backslash S_1]}) + \nu nL\}, \tag{3}$$

where $0 \leq \omega \leq 1$, $\nu \geq 0$, $g(\cdot,\cdot)$ denotes a cost function, and $\mathbf{c}_{[S]}$ includes the codewords without power constraint sent by active users in the set S. On this basis, we establish an achievability bound on the minimum required energy-per-bit for massive random access in Theorem 1.

Theorem 1. For massive random access in MIMO quasi-static Rayleigh fading channels with no-CSI and known K_a, the minimum required energy-per-bit can be upper-bounded as

$$E^*_{b,\text{no-CSI},K_a}(n, M, \epsilon) \leq \inf \frac{nP}{J}, \tag{4}$$

where the inf is taken over all $P > 0$ satisfying that

$$\epsilon \geq \min_{0<P'<P} \left\{p_0 + \sum_{t=1}^{K_a} \frac{t}{K_a} \min\{1, \tbinom{K_a}{t} p_{t,S_1}\}\right\}, \tag{5}$$

$$p_{t,S_1} = \min_{0\leq\omega\leq1, 0\leq\nu} \{q_{1,t,S_1}(\omega, \nu) + q_{2,t,S_1}(\omega, \nu)\}. \tag{6}$$

Here, p_0 upper-bounds the total variation distance between the measures with and without power constraint. The term p_{t,S_1} denotes an upper bound on $\mathbb{P}[\mathcal{F}_{t,S_1}]$ and is obtained through applying Fano's "good region" technique. The terms $q_{1,t,S_1}(\omega, \nu)$ and $q_{2,t,S_2}(\omega, \nu)$ can be obtained through applying the Chernoff bound and moment generating function of quadratic forms.

Theorem 2 provides a converse bound on the minimum required energy-per-bit.

Theorem 2: For massive random access in MIMO quasi-static Rayleigh fading channels with no-CSI and known K_a, the minimum required energy-per-bit can be lower-bounded as

$$E^*_{b,\text{no-CSI},K_a}(n, M, \epsilon) \geq \inf \frac{nP}{J}. \tag{7}$$

The inf is taken over all $P > 0$ satisfying the following two conditions:

1) Under the assumption that codebook has i.i.d. Gaussian entries, it should be satisfied that

$$K_a(J(1-\epsilon) - h_2(\epsilon)) \leq Ln\log_2(1 + K_a P) - L\mathbb{E}_{\mathbf{X}_{K_a}}[\log_2|\mathbf{I}_{K_a} + \mathbf{X}^H_{K_a}\mathbf{X}_{K_a}|]. \tag{8}$$

2) The single-user finite-blocklength bound shows $M \leq 1 / \mathbb{P}[\chi^2(2L) \geq (1 + (n+1)P)r]$, where r is the solution of $\mathbb{P}[\chi^2(2L) \leq r] = \epsilon$.

Likewise, we can derive non-asymptotic results for the case with CSI at the receiver (CSIR).

Asymptotic Analysis: Assuming all users are active, we obtain scaling laws as shown in Table I. In the case of CSIR, to reliably serve $K = \mathcal{O}(n^2)$ users, when the number of BS antennas is increased from $L = \Theta\left(\frac{n}{\ln n}\right)$ to $L = \Theta(n)$, the required power can be decreased from $P = \Theta\left(\frac{1}{n}\right)$ to $P = \Theta\left(\frac{1}{n^2}\right)$, revealing the great potential of MIMO. In the no-CSI case, the number of BS antennas can be reduced from $L = \Theta(n^2 \ln n)$ to $L = \Theta(n^2)$ when we change from the joint error probability criterion to the

PUPE criterion. In addition, we have $E_b = O(1)$ in the considered regimes, which are crucial in practical systems with stringent energy constraints.

Table I
Comparison of scaling laws for massive access in quasi-static Rayleigh fading channels.

result	K	L	P	M	CSIR/no-CSI	error criterion	achievability/converse
our results	$O(n^2)$	$\Theta(n)$	$\Theta(n^{-2})$	$\Theta(1)$	CSIR	PUPE	both
our results	$O(n^2)$	$\Theta(n/\ln n)$	$\Theta(n^{-1})$	$\Theta(1)$	CSIR	PUPE	both
our results	$O(n^2)$	$\Theta(n^2)$	$\Theta(n^{-2})$	$\Theta(1)$	no-CSI	PUPE	both (Gaussian codebooks)
extended from [6]	$O(n^2)$	$\Theta(n^2 \ln n)$	$\Theta(n^{-2})$	$\Theta(1)$	no-CSI	joint error probability	achievability
[7]	O(n)	1	$\Theta(n^{-1})$	$\Theta(1)$	both	PUPE	both

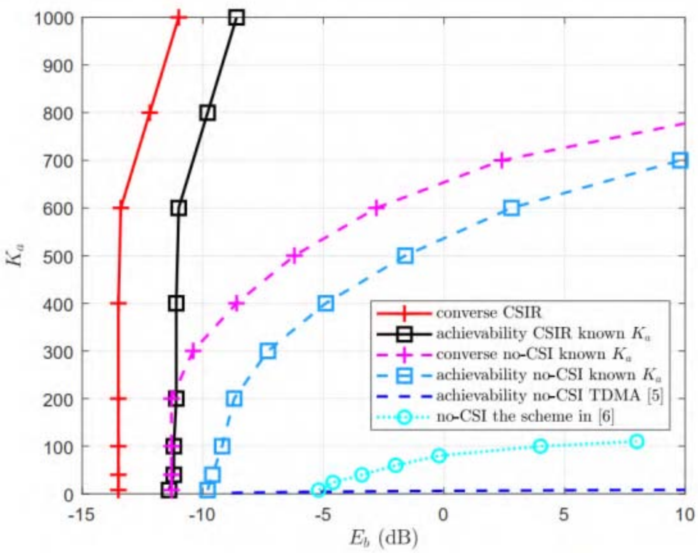
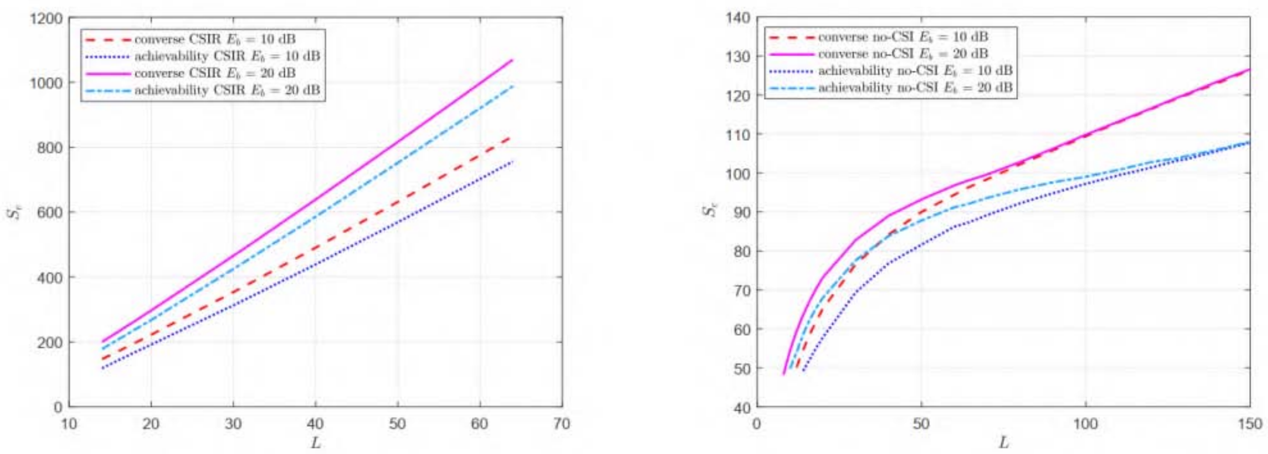


Fig. 1: The number of active users versus E_b with $n = 1000$, $J = 100$, $\frac{K_a}{K} = 0.4$, $\epsilon = 10^{-3}$, and $L = 32$.



(a)

(b)

Fig. 2: The spectral efficiency versus L with $n = 1000$, $J = 100$, $\frac{K_a}{K} = 0.4$, and $\epsilon = 10^{-3}$: (a) CSIR; (b) no-CSI.

Numerical Results: In Fig. 1, we present our achievability and converse bounds on the minimum required energy-per-bit. We can observe that our bounds are tight in both cases of CSIR and no-CSI. When K_a is below a threshold, the minimum required energy-per-bit is almost a constant, with the range for the CSIR case larger than that of no-CSI. Moreover, the TDMA scheme [5] and the scheme in [6] are inferior to our bounds, especially when K_a is large.

In Fig. 2, we present bounds on the maximum spectral efficiency against the number of BS antennas. We observe that, in the case of CSIR, S_e increases with L at an almost constant speed, whereas the increasing speed reduces in the no-CSI case due to the channel uncertainty.

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交流活动 • RESEARCH ACTIVITIES •

IEEE 信息论学会广州分会春茗活动
Spring Outing of IEEE IT Society Guangzhou Chapter

4 月 25 日，IEEE 信息论学会广州分会（以下称“广州分会”）春茗活动在广州国际生物岛举行。中山大学电子与信息工程学院教授、广州分会主席陈立，西安电子科技大学“国家特聘”教授沈八中，广东工业大学信息工程学院执行院长、教授韩国军，广东工业大学信息工程学院副院长、教授方毅，华为学术系统组织部部长潘秋菱，广州科奥信息技术有限公司（以下称“广州科奥”）董事长刘国兴、副总裁李雪梅等出席活动。本次活动旨在回顾广州分会的成长和发展历程，探讨年度发展规划，加深协会成员感情，并对学会发展的新路径展开讨论。

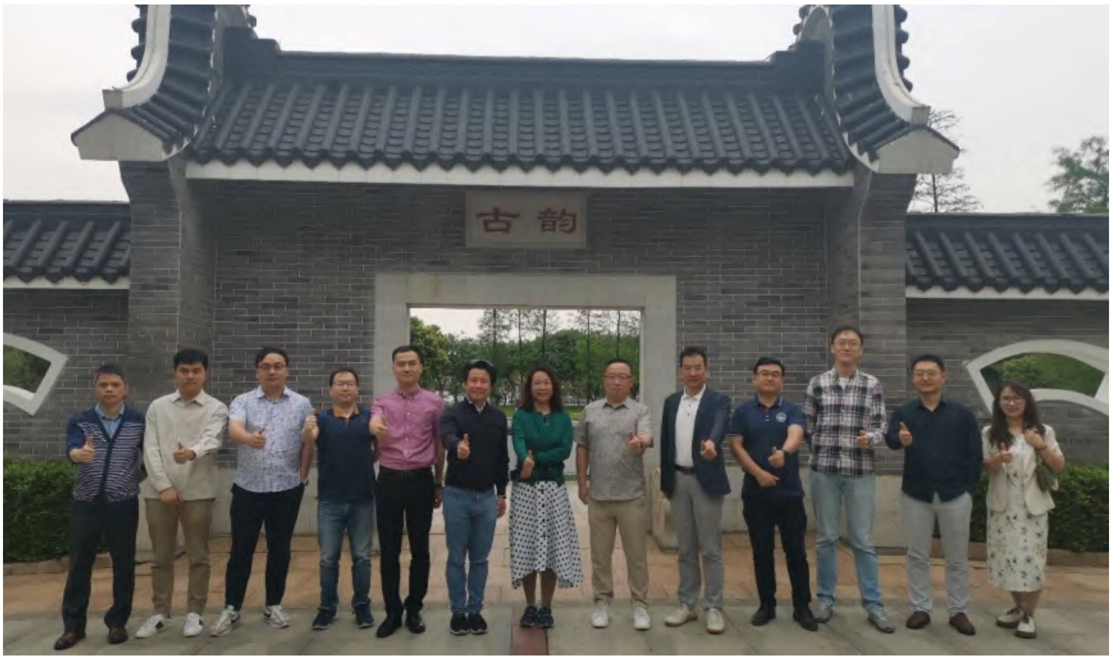
活动开始，沈八中教授首先致欢迎词，代表广州分会向各位参会人员致以最美好的祝福和最诚挚的问候。随后，广州科奥李雪梅副总裁向学会介绍了公司的发展情况、产品服务体系、核心成果等。

活动中，陈立教授向与会者们介绍了广州分会成立的宗旨 — “促进交流、服务学群”，分会将在高等教育和知识创新上发挥重要作用，服务区域社会的科技和经济发展，为区域内的学者们提供形式多样的交流平台。希望通过分会工作提升我国信息论基础研究的国际影响力，更好与通信产业界互动，助力产业发展。

为更好提升未来广州分会活动的影响力，陈立教授向成员们征求分会活动的改进意见与建议。沈八中教授与韩国军教授更是提出了举办比赛以及创办夏令营等议案，可让学生从多方面认识与了解到课堂以外的信息论，扩展视野的同时加强对大自然的科学发现。活动现场气氛热烈，各参会人员各抒己见，共谋发展。

最后，潘秋菱部长向各位介绍了华为学术系统组织部的工作内容、科研项目等。成员们对此深感兴趣，纷纷发言并表达合作意向。

室内座谈结束后，广州科奥吴焕联经理带领广州分会成员们在生物岛进行徒步活动。在此轻松的环境下，高校与高校、高校与企业、企业与企业之间均交换了许多合作意向，达成了一定的共识。



本次活动的举办，为广州分会未来一年的工作定下基调，也加强了广州分会与广州科奥的交流及资源共享，为日后开展深度合作打下坚实基础。

交流活动 • RESEARCH ACTIVITIES •

IEEE 2023 台北国际信息论年会
IEEE ISIT 2023 Taipei

2023 年 6 月 25 日至 30 日，IEEE 国际信息论年会 (ISIT 2023) 在台北成功举办。本次大会由 IEEE 和 IEEE 信息论学会主办，台湾大学、阳明交通大学和台湾智慧资通讯学会共同承办，华为、联发科和高通等公司或事业部门联合赞助。本届 ISIT 分为线上和线下两个渠道进行。其中，线下与会者约 620 余人，线上参加者约 120 人。部分现场参会学者包括：Polar 码发明人 Erdal Arıkan 教授、网络编码发明人 Raymond Yeung 教授、局部修复码研究先驱 Alexander Barg 教授、2023 年香农奖得主 Rüdiger Urbanke 教授等知名专家。IEEE 信息论学会广州分会 (以下简称“分会”) 主席陈立教授率领团队学生吴先章博士、蔡作鑫和赵建国赴台北参会。

本届 ISIT 大会的主旨演讲嘉宾包含 2022 年菲尔兹奖得主 Maryna Viazovska 教授和 2023 年香农奖得主 Rüdiger Urbanke 教授。其中，Urbanke 教授题为“w?nder, ??rrow, ?d?pt, repea?”的演讲引起了热烈的反响。从 Turbo 码引发的现代编码革命，到 LDPC 码的重新发现，到 Polar 码首次达到信道容量，再到 RM 码文艺复兴回归大众视野，Urbanke 教授分享了自己三十年来从事信息论与编码研究的经历，为领域学者们提供了深远的启示。在演讲的最后，Urbanke 教授还展示了一项特别的才艺 — 香农最擅长的杂耍抛接球，赢得了在场学者们的隆重掌声。

本次大会还设有工业论坛环节。来自华为公司无线技术实验室的张华滋博士为到场嘉宾分享了关于 Polar 码代数性质的最新工作。他介绍了一种基于 Polar 码的代数性质在平均统计意义上分析码重谱的方法。在后续的提问环节中，Polar 码发明人 Arıkan 教授对此工作表现出

浓厚的兴趣，与张华滋博士进行了热烈的讨论。分会主席陈立教授也向张华滋博士提出了自己的疑问和见解。

在各分会场中，陈立教授团队成员吴先章博士作题为“Coded Caching Design for Dynamic Networks with Reduced Subpacketizations”的报告；蔡作鑫作题为“Modified PAC Codes”的报告；赵建国作题为“Systematic Encoding of Elliptic Codes with Dynamic Information Sets”，均引发了现场观众的讨论。其中，蔡作鑫的工作引起了 Arıkan 教授的注意，他关切地询问了该工作后续的研究计划。

29 日晚，大会晚宴于台北君悦酒店隆重举行。众学者齐聚一堂，共赏台北特色美味佳肴。晚宴过程中，大会共同主席陈伯宁教授介绍了本届 ISIT 的总体情况。随后，万众瞩目的 2024 年香农奖获得者谜底揭晓 — 来自耶鲁大学的 Andrew Barron 教授荣获该奖。晚宴还公布了学会接下来的会议活动安排：ISIT 2024 将在雅典举办；分会成员黄绍伦教授介绍了 ITW 2024 将在深圳举办；陈立教授宣布了 ISIT 2026 将在广州举办。值得一提的是，这将是首届在中国内地举办的 ISIT，中国信息论学群将竭尽全力办好这次盛会。

本届 ISIT 所有论文作者中，共有 161 位来自中国内地，包括西安电子科技大学白宝明教授团队、广西师范大学程民权教授团队、北京航空航天大学黄勤教授团队、电子科技大学韩永祥教授团队、浙江大学张朝阳教授团队、香港中文大学 (深圳) 杨升浩、沈颖祺教授团队、南开大学符方伟教授团队、清华大学夏树涛教授团队以及华为公司研究团队等；12 位来自中国香港，包括香港中文大学研究团队、香港科技大学研究团队等。ISIT 2023 为信息论与编码领域的学者提供了一个具有重要价值的交流平台。通过这一平台，来自世界各地的学者们互相交流思想、分享成果，共同为推动信息论的发展做出贡献。

刘凡博士获得 2023 年 IEEE 通信学会莱斯论文奖
Dr. Fan Liu won the 2023 IEEE ComSoc Stephan O. Rice Prize

Congratulations to Dr. Fan Liu of Southern University of Science and Technology on receiving the 2023 IEEE Communications Society Stephan O. Rice Prize, the IEEE Transactions on Communications (TCOM) Best Paper Award, for his paper "Joint Radar and Communication Design: Applications, State-of-the-Art, and the Road Ahead," *IEEE Transactions on Communications*, vol. 68, no. 6, pp. 3834-3862, June 2020. The award is only given to one paper each year published in the IEEE TCOM in the previous 3 calendar years. It is named after Stephen O. Rice, a pioneer in the fields of information and communication theory. In addition to Dr. Fan Liu, the author team also compromises world-renowned researchers in the field of wireless communications and radar, namely, Christos Masouros, Athina Petropulu, Hugh Griffiths, and Lajos Hanzo.

About the Paper: Next-generation wireless networks such as 6G have been envisioned as key enablers for many emerging applications. Among many visionary assumptions about 6G networks, a common theme is that sensing will play a more significant role than ever before. Indeed, by equipping the 6G radio access network (RAN) with the active sensing functionality, future wireless systems will go beyond classical communication and provide ubiquitous sensing services to measure or even to image surrounding environments. This sensing functionality and the corresponding ability of the network to collect sensory data from the environment are seen as the foundation for learning and building intelligence in the future smart world, and may find extensive usage in numerous location / environment-aware scenarios. Towards that end, there is a strong need to jointly design the sensing and communication operations in 6G networks, which motivates the recent research topic of Integrated Sensing and Communications (ISAC). As a representative ISAC solution, dual-functional radar-communication (DFRC) has received tremendous attentions from both industry and academia.

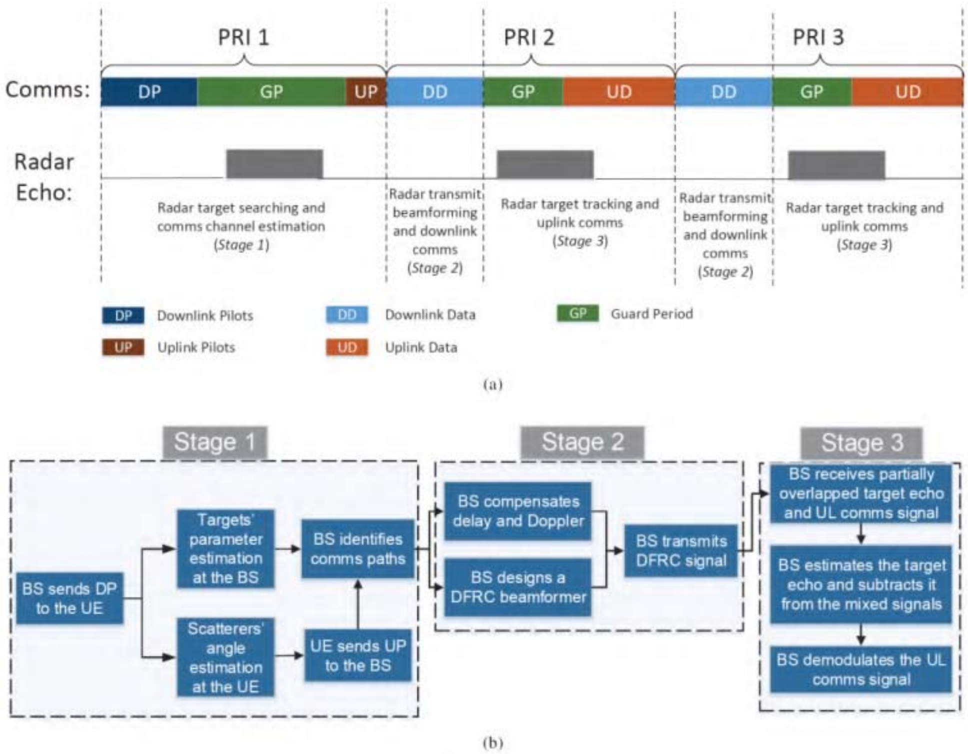


Fig. 1. The proposed DFRC signal frame structure and signal processing flow chart.

The practical deployment of DFRC over existing wireless infrastructures requires innovative designs of novel transceiver and frame structures that are compatible with the state-of-the-art cellular communication system, which is perhaps one of the most challenging issues in the DFRC research. The enclosed paper was the very first attempt to solve this problem, which appeared at a time when the topic of ISAC / DFRC was still at its infancy, particularly in the wireless community. It presents an overview of the existing DFRC techniques, followed by a technical contribution on the design of a massive MIMO mmWave DFRC system. The originality and creativity of the work are evidently demonstrated by three facts: (i) This paper was the first to design a novel DFRC frame structure complies with state-of-the-art time-division duplex (TDD) protocols, which can be split into three stages for unifying similar radar and communication operations, namely, target search and channel estimation, radar beamforming and downlink communication, and target tracking and uplink communication. (ii) This paper was the first design of mMIMO mmWave DFRC system based on the hybrid analog-digital array, in conjunction with the novel channel estimation, joint beamforming, and joint reception signal processing algorithms for DFRC. (iii) This paper was a seminal work that triggered the extensive growth and expansion of the field of ISAC, not only in the community of wireless communications, but also in that of the signal processing, mobile computing, radar systems, and information theory.

At the time when the paper was submitted, most of the DFRC works focused on embedding the communication functionality into the radar systems, namely, the radar-centric DFRC. This paper brought a paradigm shift to the field by showing the feasibility of communication-centric DFRC, which paved the way for the current and future ISAC research for 6G networks. As per Google Scholar, this paper has been cited over 735 times since its publication in June 2020, which is the Top 2 cited TCOM paper published between 2020-2022, and has been the Top 2 popular article in TCOM for more than 12 months.

喜讯 • GOOD NEWS •

2024 IEEE 国际信息论研讨会 (ITW 2024) 将在中国深圳举办
IEEE ITW 2024 Will Be Hosted in Shenzhen, China

2024 年 IEEE Information Theory Workshop (ITW 2024) 预定于 2024 年 11 月 24-28 日在中国深圳博林天瑞喜来登酒店举办，由清华大学深圳国际研究生院主办。本次研讨会的提案已于 2023 年 6 月 25 日向 IEEE 信息论学会理事会 (BoG) 进行汇报，经过 BoG 成员审议后，获得全票通过，确定深圳获得 ITW 2024 的主办权，继 1988 年北京、2006 年成都、2018 年广州后，第四次在中国内地举办 ITW，对于信息论在国内的发展，以及推动国内信息论学群与国际信息论学会更进一步的合作有着重大战略意义。此次国际学术盛会将汇聚国内外信息论领域的顶尖学者专家，共同探讨信息科学的最新进展和未来发展方向。欢迎广大学者积极参加！

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2026 IEEE 国际信息论年会 (ISIT 2026) 将在中国广州举办
IEEE ISIT 2026 Will Be Hosted in Guangzhou, China

The IEEE International Symposium on Information Theory (ISIT) is a flagship annual conference of the IEEE Information Theory (IT) Society. It galvanizes high quality research papers and top researchers of information theory and coding each year. During last October's IT Society Board of Governors meeting, the board approved that ISIT 2025 (later postponed to 2026) to be hosted in Guangzhou. The ISIT 2026 bidding team is composed by its general co-chairs (in alphabetical order): Li Chen, Pingzhi Fan and Raymond W. Yeung. Li Chen presented the proposal during the meeting. ISIT first started London in 1950. Over its history of more than 70 years, this is the first time that ISIT lands on mainland China. ISIT 2015 took place in Hong Kong, for which Raymond W. Yeung was the general co-chair. It was just hosted in Taipei this year. The Chinese IT community are enthusiastic about this coming Guangzhou ISIT. It is hoped that ISIT 2026 can promote and further proliferate IT research and applications in China, which will also be an effective platform for building and forging global research collaborations.

Guangzhou, the capital city of the southern Guangdong province, is also known as the South Gate of China. The city has a rich history of more than two thousand years. It is in the center of the Guangdong-Hong Kong-Macau Greater Bay Area (GBA) which is the information technology hub of China. It is home to several world-renowned brands, including Huawei, ZTE, Tencent, BYD, DJI and ect.. In recent years, several new universities were also established in the GBA area, including the Chinese University of Hong Kong (Shenzhen), Shenzhen Tsinghua International Graduate School, the Southern University of Science and Technology. They all have IT faculties. Together with Sun Yat-sen University that already has a history of IT research, the area consists of a large IT community with active research and education. Since 1990s, IT research in mainland China have also progressed remarkably, with an ever-growing research community and impact. Guangzhou also hosted the 2018 IEEE Information Theory Workshop (ITW), for which Pingzhi Fan and Li Chen were the general co-chairs. Pingzhi Fan was also the general co-chair of the 2006 ITW in Chengdu.

新锐风采 • NEW TALENTS •

刘雷 (Lei Liu)，浙江大学百人计划研究员，博士生导师，2022 年度国家优秀青年基金 (海外) 获得者。2017 年获西安电子科技大学 (XDU) 通信与信息系统博士学位；2014 年-2016 年，获国家留学基金委 (CSC) 资助，在新加坡南洋理工大学 (NTU) 电气与电子工程学院进行博士联合培养；2016 - 2017 年，在新加坡科技与设计大学 (SUTD) 从事博士后研究；2017 - 2019 年，在香港城市大学 (CityU) 电子工程学院担任研究员；2019 - 2023 年，在北陆先端科学与技术大学院大学 (JAIST) 信息学院担任助理教授；2023 年加入浙江大学信息与电子工程学院。中国通信学会高级会员，2020 年度 IEEE TCOM 期刊模范审稿人 (入选率<2%)；担任信息论旗舰会议 IEEE ITW 2021 组委会成员、出版联合主席、稀疏信号处理分会主席，国际通信与信号处理大会 WCSP 2023 信息论与编码分会联合主席。

主要研究消息传递理论与算法及其在信号处理、无线通信、编码和信息论领域的应用，是国际上最早展开记忆消息传递研究的学者之一。主要贡献包括：突破现有 AMP 类算法的矩阵局限和高复杂度瓶颈，率先提出记忆消息传递 (MAMP) 范式，发明普适、低复杂度且最小均方误差最优 MAMP 算法，在信号处理、无线通信、人工智能等领域有巨大的应用前景[1-3]；提出离散大规模 MIMO 低复杂度且容量最优 AMP 类编译码算法，为 5G+/6G 通信极具潜力的解决方案[4-7]；给出非正交多址接入 (NOMA) 系统并行迭代 Turbo-LMMSE 算法的最优编译码准则和高斯容量最优性证明，应用于 3GPP 5G NOMA 标准提案[8-10]。

部分重要学术论文：

[1] **L. Liu**, S. Huang and B. M. Kurkoski, "Memory AMP," *IEEE Trans. Inf. Theory*, vol. 68, no. 12, pp. 8015-8039, Dec. 2022.

[2] **L. Liu**, S. Huang and B. M. Kurkoski, "Sufficient statistic memory AMP," arXiv:2112.15327, submitted to *IEEE Trans. Inf. Theory* (under first revision).

[3] F. Tian, **L. Liu** and X. Chen, "Generalized memory approximate message passing for generalized linear model," *IEEE Trans. Signal Process.*, vol. 70, pp. 6404-6418, Oct. 2022.

[4] **L. Liu**, C. Liang, J. Ma and L. Ping, "Capacity optimality of AMP in coded systems," *IEEE Trans. Inf. Theory,* vol. 67, no. 7, 4929-4445, July 2021.

[5] **L. Liu**, S. Liang and L. Ping, "Capacity optimality of OAMP: Beyond IID sensing matrices and Gaussian signaling," arXiv:2108.08503, submitted to *IEEE Trans. Commun.* (under second revision).

[6] **L. Liu**, Y. Cheng, S. Liang, J. H. Manton and L. Ping, "On OAMP: Impact of the orthogonal principle," submitted to *IEEE Trans. Commun.* (early access).

[7] Y., Chi, **L. Liu**, G. Song, Y. Li, Y. L. Guan and C. Yuen, "Constrained capacity optimal generalized multi-user MIMO: A theoretical and practical framework," *IEEE Trans. Commun.*, vol. 70, no. 12, pp. 8086-8104, Dec. 2022.

[8] **L. Liu**, Y. Chi, C. Yuen, Y. L. Guan and Y. Li, "Capacity-achieving MIMO-NOMA: Iterative LMMSE detection," *IEEE Trans. Signal Process.*, vol. 67, no. 7, 1758-1773, Apr. 2019.

[9] Y. Chi, **L. Liu**, G. Song, Chau Y., Y. L. Guan and Y. Li, "Practical MIMO-NOMA: Low complexity and capacity-approaching solution," *IEEE Trans. Wireless Commun.*, vol 17, no. 9, pp. 6251-6264, Sept. 2018.

[10] Y. Hu, C. Liang, **L. Liu**, C. Yan, Y. Yuan and L. Ping, "Interleave-division multiple access in high rate applications," *IEEE Wireless Commun. Lett.*, vol. 8, no. 2, 476-479, Oct. 2019.

新锐风采 • NEW TALENTS •

Xianzhang Wu (吴先章) received the B.S. degree in mathematics and applied mathematics from Minjiang University, Fuzhou, China, in 2014 and the M.S. degree in 2018 in applied mathematics from Fuzhou University, Fuzhou, China. From 2019 to 2023, he pursued the Ph.D. degree in Communication and Information System from Sun Yat-sen University, under the supervision of Prof. Li Chen.

He is a newly graduated Ph.D. in the area of coded caching. His thesis is entitled "Design of High-performing Coded Caching Schemes", which focuses on the design of coded caching schemes with a small subpacketization level and flexible system parameters. The thesis proposes the construction of placement delivery arrays (PDAs) by introducing proper orthogonal arrays (POAs) from the combinatorial design perspective. Some novel PDA based coded caching schemes are obtained by a delicate selection of POAs. The thesis also introduces the design of coded caching schemes based on the injective arc coloring of regular directed graphs. It is shown that the injective arc coloring of a regular digraph can yield a PDA with the same number of rows and columns. This provides a new method for constructing PDAs from the graph coloring perspective. Based on this, some new coded caching schemes that can support a flexible number of users are proposed with a linear subpacketization level and a non-negligible coding gain. Furthermore, the design of dynamic coded caching schemes utilizing combinatorial techniques is also explored.

His key publications include:

[1] **X. Wu**, M. Cheng, L. Chen, C. Li, and Z. Shi, Design of coded caching schemes with linear subpacketizations based on injective arc coloring of regular digraphs, *IEEE Trans. Commun.*, vol. 71, no. 5, pp. 2549-2562, May 2023.

[2] **X. Wu**, M. Cheng, C. Li and L. Chen, Design of placement delivery arrays for coded caching with small subpacketizations and flexible memory sizes, *IEEE Trans. Commun.*, Vol.70, No.3, pp. 7089-7104, Nov. 2022.

[3] **X. Wu**, M. Cheng, C. Li and L. Chen, Design of coded caching schemes through proper orthogonal arrays, *IEEE Int. Symp. Inf. Theory (ISIT),* pp. 1306-1311, Jul. 2022.

[4] **X. Wu**, M. Cheng, L. Chen, and C. Li, Coded caching design for dynamic networks with reduced subpacketizations, *IEEE Int. Symp. Inf. Theory (ISIT),* 2023.

[5] **X. Wu**, J. Liu, Sharp upper bounds for the adjacency and the signless Laplacian spectral radius of graphs, *Appl. Math J Chinese Univ. (Ser B),* vol. 34, no. 1, pp. 100-112, Mar. 2019.

[6] J. Liu, **X. Wu**, J. Chen, B. Liu, The Aα spectral radius characterization of some digraphs, *Linear Algebra Appl.*, vol. 563, pp. 63–74, Feb. 2019.

新锐风采 • NEW TALENTS •

Guanming Zeng (曾冠铭) received a B.S. degree in telecommunication engineering from School of Electronic and Information Technology, Sun Yat-sen University, Guangzhou, China, in 2018, and a Ph.D. degree in telecommunication engineering at Department of Electronic Engineering, Tsinghua University, Beijing, China, in 2023. His research interests include tracking, telemetry and command systems for satellite constellations, satellite communication networks, etc. He served as a reviewer of IEEE Transactions on Wireless Communications, IEEE Transactions on Communications, IEEE Transactions on Network Science and Engineering.

His doctoral dissertation mainly studied the link resource scheduling technology of networked telemetry system for low-earth-orbit satellite constellations. Specifically, his dissertation analyzed the capacity boundary of low-earth-orbit satellites that networked telemetry system can support, and proposed resource scheduling methods for the stable and burst data transmission requirements of networked telemetry system.

His key publications include:

[1] **G. Zeng**, Y. Zhan, H. Xie and C. Jiang, "Resource Allocation for Networked Telemetry System of Mega LEO Satellite Constellations," *IEEE Trans. Commun.*, vol. 70, no. 12, pp. 8215-8228, Dec. 2022.

[2] **G. Zeng**, Y. Zhan and H. Xie, "Channel Allocation for Mega LEO Satellite Constellations in the MEO–LEO Networked Telemetry System," *IEEE Int. Things Journal,* vol. 10, no. 3, pp. 2545-2556, Feb.1, 2023.

[3] **G. Zeng**, Y. Zhan and X. Pan, "Failure-Tolerant and Low-Latency Telecommand in Mega-Constellations: The Redundant Multi-Path Routing," *IEEE Access*, vol. 9, pp. 34975-34985, 2021.

[4] Y. Zhan, **G. Zeng** and X. Pan, "Networked TT&C for mega satellite constellations: A security perspective," *China Commun.*, vol. 19, no. 9, pp. 58-76, Sept. 2022.

[5] Y. Zhan, **G. Zeng**, and C. Duan, "A high order statistics based multipath interference detection method," *IET Commun.*, vol. 15, no. 12, pp. 1586-1596, 2021.

[6] **G. Zeng**, Y. Zhan, H. Xie and C. Jiang, "Networked Satellite Telemetry Resource Allocation for Mega Constellations," *IEEE Int. Conf. Commun. (ICC)*, pp. 4583-4588, 2022.

[7] **G. Zeng**, Y. Zhan, "Multi-agent Deep Reinforcement Learning Based Channel Allocation for Networked Satellite Telemetry System," *IEEE Int. Conf. Commun. (ICC)*, 2023.

[8] Y. Zhan, **G. Zeng** and D. Xie, "Influence of Phase Noise on Digital Receiver of Deep Space Communications," *IEEE Int. Conf. Commun. Technol. (ICCT),* pp. 1020-1024, 2020.

[9] W. Jiang, Y. Zhan, **G. Zeng** and J. Lu, "Probabilistic-Forecasting-Based Admission Control for Network Slicing in Software-Defined Networks," *IEEE Int. Things Journal,* vol. 9, no. 15, pp. 14030-14047, 2022.

[10] X. Pan, Y. Zhan, **G. Zeng** and X. Wang, "TT&C Capacity Analysis of mega-constellations: How many satellites can we support?," *IEEE Int. Conf. Commun. (ICC)*, pp. 2393-2398, 2022.

[11] H. Xie, Y. Zhan, **G. Zeng** and X. Pan, "LEO Mega-Constellations for 6G Global Coverage: Challenges and Opportunities," *IEEE Access,* vol. 9, pp. 164223-164244, 2021.

征稿启事 • CALL FOR PAPERS•

2023 IEEE 全球通信大会暨超越 5G 信道编码研讨会
IEEE GC 2023 Workshop on Channel Coding beyond 5G

IEEE GLOBECOM 2023 Workshop on Channel Coding beyond 5G

https://globecom2023.ieee-globecom.org/workshop/ws11-channel-coding-beyond-5g

Call for Workshop Papers

Channel coding is a fundamental component in wireless communication. From 2G to 5G, wireless systems have always adopted state-of-the-art channel coding technologies. For example, convolutional codes for 2G, turbo codes for 3G and 4G, as well as polar and low-density parity-check (LDPC) codes for 5G. In turn, the standardization and applications of state-of-the-art channel coding technologies have accelerated the research and development of channel coding. What will channel coding be as the standards continue to evolve? According to past experiences, channel coding schemes need to deliver performance surpassing previous generations: faster data rates, higher reliability, lower complexity, and lower power consumption. They also need to meet a more diverse range of KPIs that are not present in previous generations. As for 6G, some applications will raise the peak data rate to the Tbit/s level (the current eMBB data plane decoding rate is 10-20 Gbit/s), eliminating the block decoding error floor for URLLC, and improving the short block length decoding performance for mMTC toward the finite-length performance bound. In contrast to past experiences, the channel coding performance now has almost reached the theoretical Shannon limit for an additive white Gaussian noise (AWGN) channel, and Moore's law almost reached the physical limits. Will future standards follow the same path that led us to where we are now, or take a different path guided by new theoretical foundation or evaluation methodologies? Do we need revolutionary channel coding schemes, or design principles? Many fundamental problems remain open.

This workshop aims at bringing together academic and industrial researchers to discuss channel coding beyond 5G. Topics of interest include but are not limited to:

- Novel design principles and coding schemes toward 6G
- Channel coding requirements and applications for 6G
- Polar coding and decoding
- Probabilistic coding, e.g., turbo, LDPC, etc.
- Joint design of algebraic and polar/probabilistic coding
- High-throughput coding schemes
- Coded modulation and shaping
- Rate matching and HARQ schemes
- Coding and decoding schemes for URLLC/mMTC/etc
- Artificial intelligence/machine learning based coding
- Joint source and channel coding
- Efficient decoding algorithms
- Hardware architecture and implementations
- Testbed and field trials of channel coding schemes
- Performance bounds on coding and decoding

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- Prof. Qin Huang, Beihang university, China

Important Dates

Paper submission deadline: July 15, 2023

Acceptance announcement: September 1, 2023

Final paper submission: October 1, 2023

Submission Guidelines

The workshop accepts only original and previously unpublished papers. All submissions must be formatted in standard IEEE camera-ready format (double-column, 10pt font). The maximum number of printed pages is six including figures without incurring additional page charges (6 pages plus 1 additional page allowed with a charge for the one additional page of USD 100 if accepted)

征稿启事 • CALL FOR PAPERS•

2024 IEEE 国际信息论年会 (ISIT 2024)

IEEE ISIT 2024

Call for Papers ISIT 2024

We invite you to join us for the 2024 IEEE International Symposium in Information Theory (ISIT 2024) that will take place from

July 7 to July 12 in Athens, Greece.

Athens is the oldest European capital city, loved for its history, impressive ancient landmarks, outstanding museums, vibrant neighborhoods, cultural events, mediterranean cuisine, and beautiful beaches. ISIT 2024 will be an in-person conference only, and will feature contributed papers, the Shannon lecture and plenary talks, tutorial sessions, social, mentoring and outreach events, as well as, for the first time this year, satellite workshops.

We encourage interested authors to submit previously unpublished contributions from a broad range of topics related to information theory and its connections with other areas, including but not limited to the following.

- Algebraic Aspects of Coding Theory
- Blockchains and Distributed Computing
- Coding for Computation and Storage
- Control and Information Theory
- Code Based Cryptography
- Combinatorics and Information Theory
- Communication Theory
- Complexity and Computation Theory
- Compressed Sensing and Sparsity
- Deep Learning in Coding and Communications
- Distributed and Federated Learning
- Emerging Applications of Information Theory
- Information Theory and Statistics
- Information and Coding Theory in Biology
- Information Theory in Computer Science
- Information Theoretic Cryptography
- Modern Coding Theory
- Network Coding and Applications
- Network Information Theory
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Important Dates

Paper submission deadline: January 29, 2024

Acceptance notification: April 15, 2024

Final manuscript submission: May 6, 2024

Early registration deadline: May 6, 2024

Deadline for workshop proposals submission: Sept 15, 2023

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2024 IEEE 国际信息论及其应用研讨会 (ISITA 2024)
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In 2024, ISITA will be held on November 10–13 at National Taiwan University of Science and Technology (Taiwan Tech), Taipei, TAIWAN.

Call for Papers

Interested authors are invited to submit papers describing novel and previously unpublished results on topics in information theory and its applications, including, but not limited to:

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- Coding Theory
- Communication Theory
- Computation and Complexity in Information Theory
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悼念 • EULOGY•

In Memoriam: Ning Cai (1947-2023)
深切悼念蔡宁教授 (1947-2023)

杨伟豪
香港中文大学
Raymond W. Yeung
The Chinese University of Hong Kong
whyeung@ie.cuhk.edu.hk

Ning Cai received his Bachelor's degree from Beijing Normal University in 1982, his Master's degree from The Chinese Academy of Sciences (CAS) in 1984, and his PhD degree from Bielefeld University (Germany) in 1988.

Ning was born in an academic family. His father, CAI Changnian (蔡长年), was an electrical engineer and an educator. He was a Vice President of Beijing Institute of Post and Telecommunications, which later on became Beijing University of Post and Telecommunications (BUPT). In 1962, he authored the first Chinese textbook on information theory. Ning's elder sister, Anni CAI (蔡安妮), was on the faculty of BUPT and is now retired.

Ning was a mathematician by training. His Master thesis advisor at CAS was ZHANG Zhaozhi (章照止), a top expert in cryptography in China, and his PhD thesis advisor at Bielefeld was Rudolf Ahlswede, an eminent information theorist who also had made fundamental contributions to combinatorics.

I met Ning in 1997 when I was invited by Ahlswede to visit him for two weeks at Bielefeld before ISIT that was held in Ulm, Germany. During the visit I mainly spent my time with Ning who was then a researcher in Ahlswede's group. We started to work on the max-flow min-cut theorem for network coding. Later on, together with Ahlswede and Bob Li (my colleague at CUHK), the work was published in the paper "Network information flow" that appeared in the IT Transactions in 2000. This paper won the 2018 ACM SIGMOBILE Test-of-Time Paper Award.

Another award-winning paper I wrote with Bob and Ning was the paper "Linear network coding" that appeared in the IT Transactions in 2003. This paper won the 2005 IEEE Information Theory Society Paper Award. It was the first time for over thirty years that this paper award, first established in 1962, was won by Asian researchers. In 1974, the award was shared by Dick Blahut and Arimoto for their works on computing the channel capacity and the rate-distortion function that are now known as the Blahut-Arimoto algorithms.

Ning visited me at CUHK a few times in the 2000s and we continued to collaborate very closely. Our most important works during this period of time were network error correction and secure network coding.

In 2006, Bob, Ning, and myself received the IEEE Eric E. Sumner Award "for pioneering contributions to the field of network coding." We were most honored by this recognition.

When I wrote my first book, *A First Course in Information Theory* (Kluwer 2002), Ning helped proofread the manuscript very thoroughly. He suggested the elegant definition of strong typicality therein that not only simplifies the existing definitions but also provides deeper insight into the notion. As a matter of fact, this definition of strong typicality subsequently led to the work of a unified typicality by my former student Siu Wai HO in his PhD thesis.

My first book evolved into the second book, *Information Theory and Network Coding* (Springer 2008). Ning took the lead to translate the book into Chinese and published it as 信息论与网络编码

(高等教育出版社, 2011). It was a very major undertaking by Ning and his team, and I thank them for their excellent work.

In 2006, Ning joined Xidian University and stayed there until 2016. Then he moved to ShanghaiTech University where he held a position until he died.

Ning had been very productive in research throughout the decades. Before I met him, he mostly worked with Ahlswede and they together published many important results on the arbitrarily-varying channel and various combinatorial problems.

Ning was one of my most important collaborators. I last met him in Shanghai when I visited in summer 2018, before the outbreak of COVID. A true gentleman and a distinguished scholar, he will be sorely missed by myself and many others. Personally, I owe him much for what he did for me.