Tsinghua University

Introduction of Research on Wireless Transmission Theories and Technologies

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Department of Electronic Engineering,

Tsinghua University

June 2019

Outline

1 Lab introduction

2 Research works

3 Results and awards

4 Future works

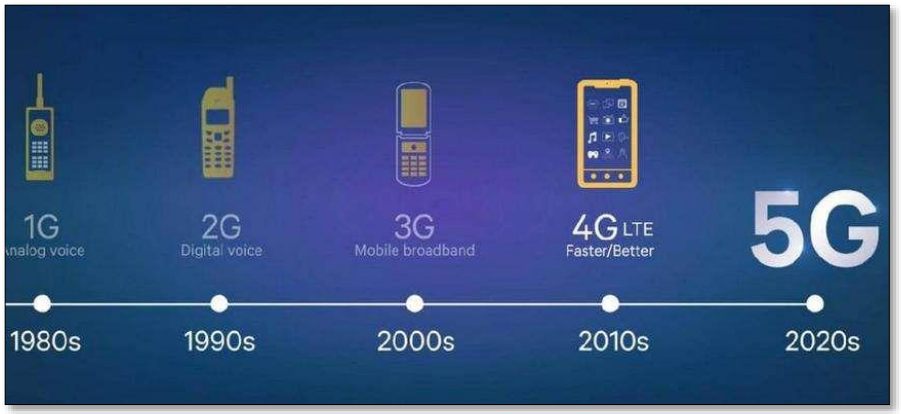
Affiliation

- **Department of Electronic Engineering, Tsinghua University**
  - University ranking: No. 17 in the world (No. 1 in China), QS 2019
  - EE ranking: No. 12 in the world (No. 1 in China), QS 2019

- **Beijing National Research Center for Information Science and Technology**

Research directions

- **Wireless transmission theories and technologies**
  - **5G/6G wireless communications**
    - ✓ **Massive MIMO**
    - ✓ **Millimeter-wave/THz communications**
    - ✓ **New waveforms (NOMA, FTN, OTFS, etc.)**
    - ✓ **Reconfigurable intelligent surface (RIS)**
    - ✓ **Channel coding (LDPC/Polar codes)**
  - **Machine learning for wireless communications**
  - **Compressive sensing for wireless communications**
  - **Advanced prototype and demo platform**



Research group

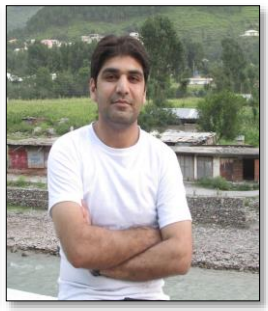
- **Professors**


- **Postdoc**

- **Secretary**

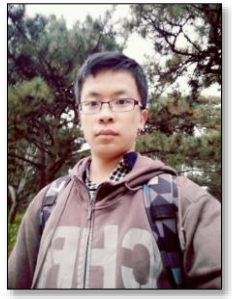
- **Graduate students (12 Ph.D students + 2 Master students)**











Research feature

- **Consider both the basic research as well as the major industrial applications**
  - **Basic research on the fundamental theory with international academic impact, as well as the potential applications in strategical industry of China**
  - **Supported by governments (e.g., 973 plan, 863 program, NSFC, etc.) as well as industry (e.g., British Telecom., Huawei, China Mobile, etc.)**

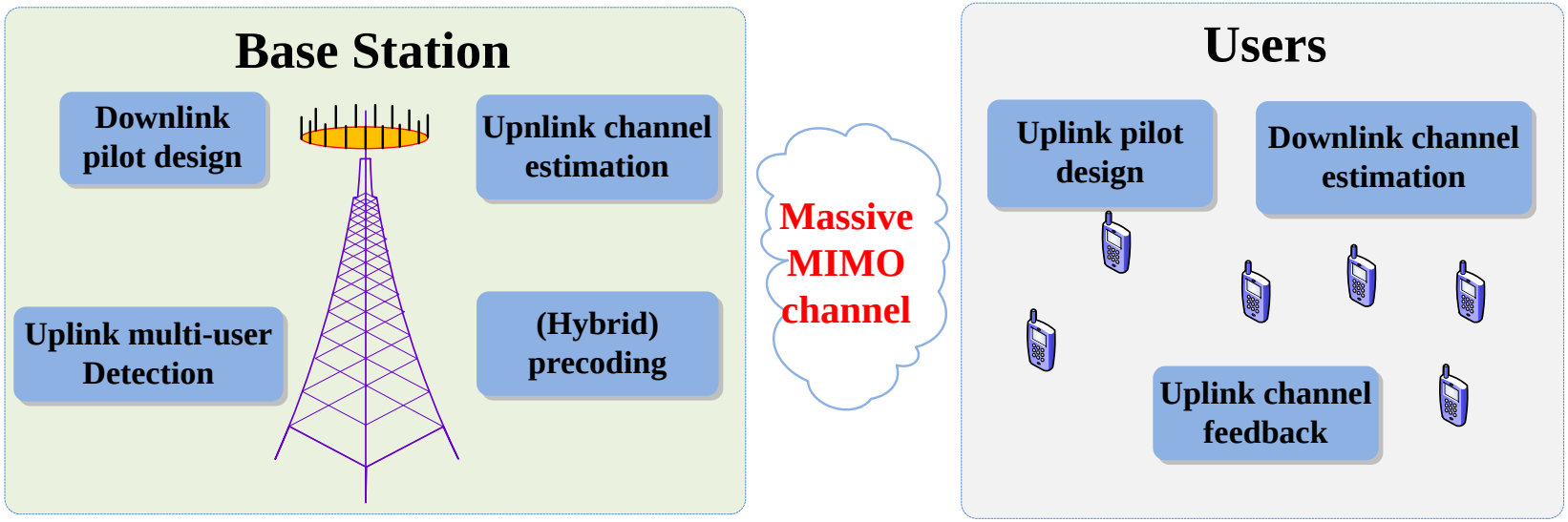
- **Major projects**
  - **The first group of 863 Projects on 5G Research (2014-2016)**
  - **The first group of Major Projects on 5G commercialization (2018-2019)**
  - **Principle investigator (PI) of many national projects from NSFC, MOST**

International cooperation

No.	Country	Organization	Collaborator	Achievements
1	UK	University of Southampton	Prof. Lajos Hanzo Fellow of the Royal Academy of Engineering IEEE Fellow	1 joint project (finished) 8 joint papers
2	USA	The University of Texas at Austin	Prof. Robert Heath IEEE Fellow	Co-supervisor of a Ph.D. student 4 joint papers
3	USA	University of Wisconsin-Madison	Prof. Akbar Sayeed IEEE Fellow	Co-supervisor of a Ph.D. student 3 joint papers
4	USA	Columbia University	Prof. Xiaodong Wang Fellow of the National Academy of Sciences	Co-supervisor of a Ph.D. student 4 joint papers
5	Japan	Tohoku University	Prof. Fumiyuki Adachi One creator of WCDMA IEEE Fellow	5 joint papers
6	Korea	Seoul National University	Prof. Byonghyo Shim Expert in Wireless	1 joint project (ongoing) 5 joint papers
7	Canada	University of Waterloo	Prof. Sherman Shen Fellow of the Royal Society of Canada IEEE Fellow	Co-supervisor of two Ph.D. students 1 joint paper

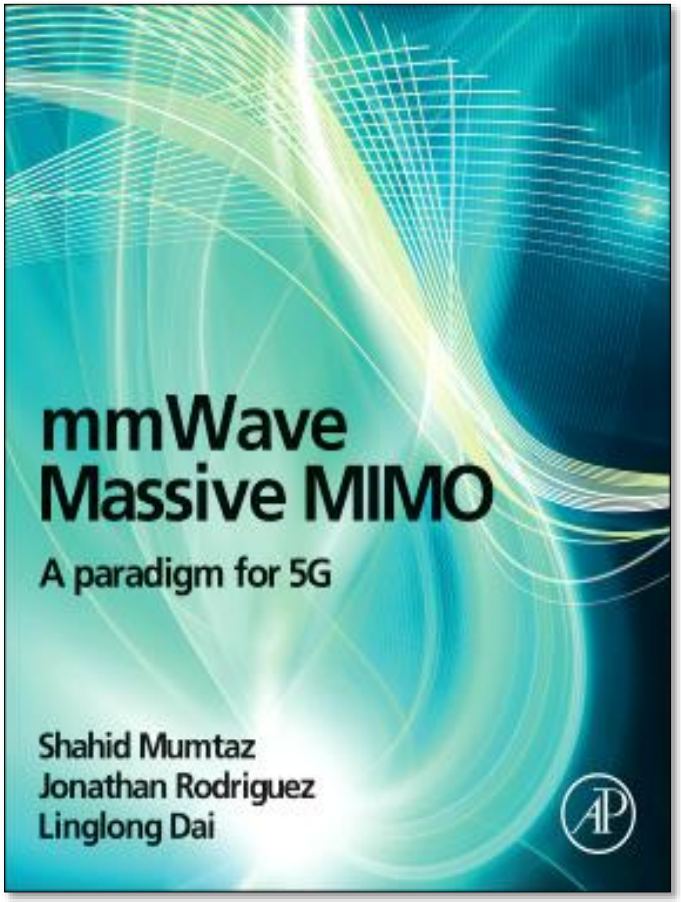
Example: Research on massive MIMO

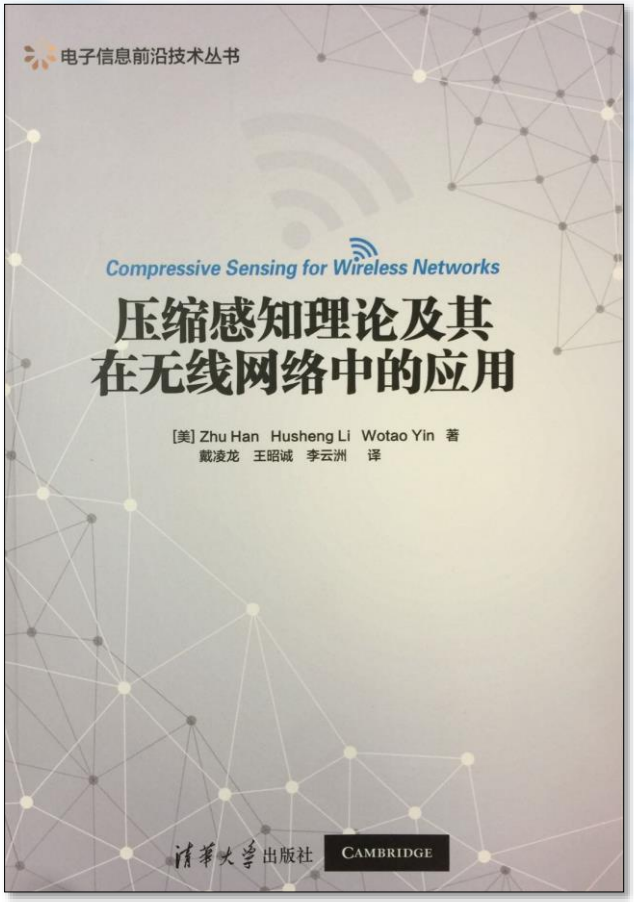
- **Pilot design** and downlink **channel estimation** based on compressive sensing
- **Uplink pilot decontamination** based on graph coloring
- Low-overhead **codebook design** based on channel subspace
- Efficient **channel feedback** based on low-rank matrix completion
- Low-complexity uplink multi-user MIMO **signal detection**
- Energy-efficient SIC-based **hybrid precoding** design
- **Performance analysis** of massive MIMO with practical constraints
- **Integration** of massive MIMO with mmWave, THz, NOMA, lens antenna, etc.



Books

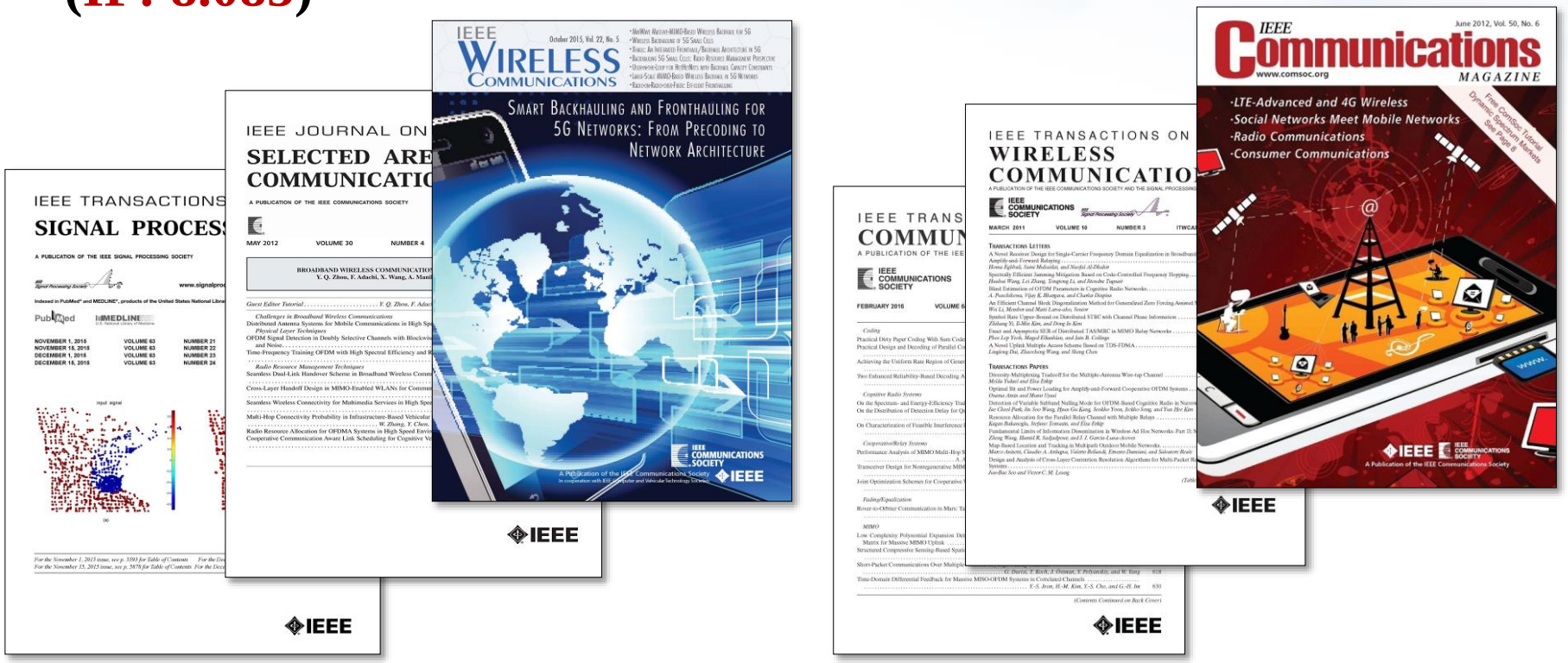
- **Publish 1 book and translate 1 book**





Paper publication

- Publish 112 papers (70 journal papers and 42 conference papers)
- 62 IEEE journal papers (IEEE TSP/JSAC/TWC/TCOM, etc.)
- 13 papers on *IEEE Journal on Selected Areas in Communications* (IF: 8.085)



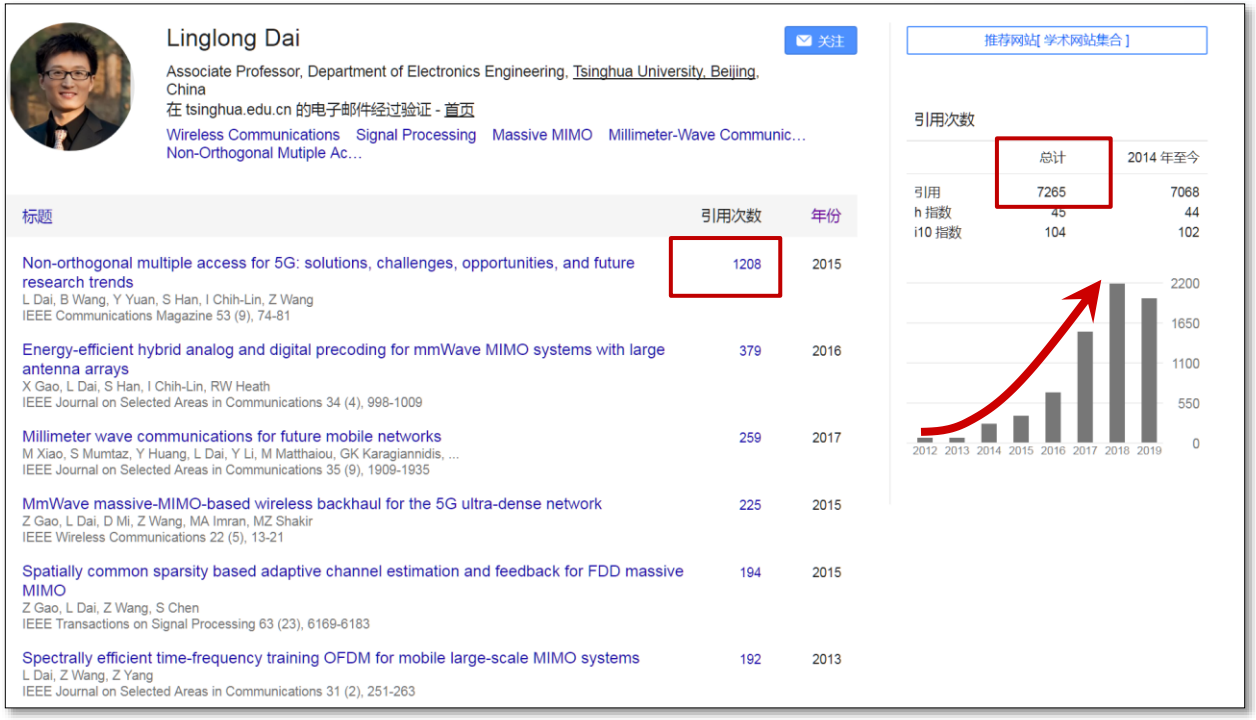
Paper publication

- **Top 10 out of 89 SCI journals** in the area of telecommunications

Rank	Journal	IF 2017	No. of papers
1	IEEE Communications Surveys & Tutorials	17.188	2
2	IEEE Communications Magazine	10.435	4
3	IEEE Wireless Communications	8.972	2
4	IEEE Journal on Selected Areas in Communications	8.085	13
5	IEEE Internet of Things Journal	7.596	/
6	IEEE Network	7.230	/
7	Vehicular Communications	5.108	/
8	IEEE Transactions on Wireless Communications	4.951	2
9	IEEE Vehicular Technology Magazine	4.429	/
10	IEEE Transactions on Vehicular Technology	4.066	12

Paper citation

- Google scholar citation: 7200+, Highest citation: 1200+
- ESI Top 1% Highly Cited Papers: 13
- ESI Top 0.1% Hot Paper: 3
- The citers include 8 academicians from U.S., Canada, U.K., 10 Editors of the top IEEE journals, and 60 IEEE Fellows



Linglong Dai

关注

Associate Professor, Department of Electronics Engineering, Tsinghua University, Beijing, China
在 tsinghua.edu.cn 的电子邮件经过验证 - 首页

Wireless Communications Signal Processing Massive MIMO Millimeter-Wave Communic… Non-Orthogonal Mutiple Ac…

推荐网站[学术网站集合]

引用次数

	总计	2014 年至今
引用	7265	7068
h 指数	45	44
i10 指数	104	102

标题	引用次数	年份
Non-orthogonal multiple access for 5G: solutions, challenges, opportunities, and future research trends L Dai, B Wang, Y Yuan, S Han, I Chih-Lin, Z Wang IEEE Communications Magazine 53 (9), 74-81	1208	2015
Energy-efficient hybrid analog and digital precoding for mmWave MIMO systems with large antenna arrays X Gao, L Dai, S Han, I Chih-Lin, RW Heath IEEE Journal on Selected Areas in Communications 34 (4), 998-1009	379	2016
Millimeter wave communications for future mobile networks M Xiao, S Mumtaz, Y Huang, L Dai, Y Li, M Matthaiou, GK Karagiannidis, ... IEEE Journal on Selected Areas in Communications 35 (9), 1909-1935	259	2017
MmWave massive-MIMO-based wireless backhaul for the 5G ultra-dense network Z Gao, L Dai, D Mi, Z Wang, MA Imran, MZ Shakir IEEE Wireless Communications 22 (5), 13-21	225	2015
Spatially common sparsity based adaptive channel estimation and feedback for FDD massive MIMO Z Gao, L Dai, Z Wang, S Chen IEEE Transactions on Signal Processing 63 (23), 6169-6183	194	2015
Spectrally efficient time-frequency training OFDM for mobile large-scale MIMO systems L Dai, Z Wang, Z Yang IEEE Journal on Selected Areas in Communications 31 (2), 251-263	192	2013

Patents

- **10 granted patents**

No.	Title	Number	date	Inventors
1	时域同步正交频分复用系统中的 CP-OFDM 信号重构方法及装置	ZL200810118118.9	2011-12-28	Jian Fu, Linglong Dai, Jian Song, Jun Wang, Jintao Wang, Zhixing Wang
2	TOA 定位的估计方法及基于该估计方法的精确定位方法	ZL200910237602.8	2012-02-08	Zhaocheng Wang, Linglong Dai, Jun Wang, Zhixing Yang
3	上行多用户时域同步频分多址接入方法	ZL201010129747.9	2013-01-30	Jian Song, Linglong Dai, Jian Fu, Zhixing Yang
4	基于广播电视网的物联网组网方法及其路由方法	ZL201010218532.4	2013-06-05	Zhaocheng Wang, Depeng Jin, Yong Li, Linglong Dai, Changyong Pan
5	基于时频二维训练的 OFDM 块传输方法	ZL 201110124559.1	2013-08-07	Zhaocheng Wang, Linglong Dai, Zhixing Yang
6	基于物理层管道技术的定位方法	ZL201110188004.3	2014-01-29	Zhaocheng Wang, Ruifeng Ma, Linglong Dai, Zhixing Yang
7	基于压缩感知理论的TDS-OFDM传输方法	ZL201210054244.9	2014-07-02	Zhixing Yang, Linglong Dai, Zhaocheng Wang, Changyong Pan
8	一种球解码方法及球解码器	ZL201310174342.0	2016-06-22	Chen Qian, Linglong Dai, Zhaocheng Wang
9	基于信道空时相关性的稀疏MIMO-OFDM信道估计方法	ZL201410025293.9	2017-01-11	Linglong Dai, Zhen Gao, Chao Zhang, Zhaocheng Wang
10	信道时域相关性低复杂度压缩感知的信道估计方法及装置	ZL201310745257.5	2017-02-15	Linglong Dai, Zhen Gao, Chao Zhang, Zhaocheng Wang

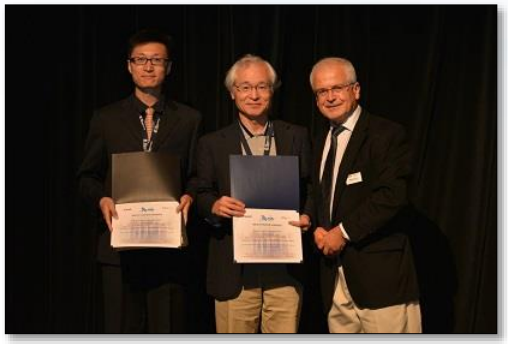
Patents

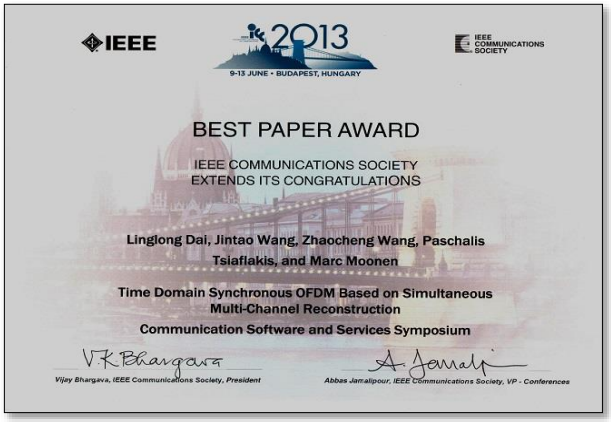
- **10 issued patents**

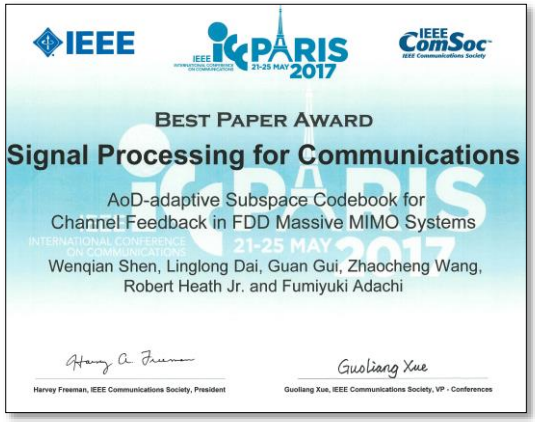
No.	Title	Number	date	Inventors
1	一种多载波Large-Scale MIMO系统的发射信号配置及信道估计的方法和设备	201410099131.X	2014-03-17	Linglong Dai, Zhen Gao, Zhaocheng Wang
2	一种多载波Large-Scale MIMO系统的重叠导频方法	201410140828.7	2014-04-09	Linglong Dai, Zhen Gao, Zhaocheng Wang
3	低复杂度的毫米波MIMO模拟波束赋形方法	201510050035.0	2015-01-30	Xinyu Gao, Linglong Dai, Zhaocheng Wang, Jinhui Chen
4	Interference Coordination of Small Cell Cluster in Ultra Dense Networks (UDN) with Base Station (BS) Assisting Information	FAI16GB3312X	2016-04-30	Yang Yang, Linglong Dai, Yuan Zhang, Richard MacKenzie, and Mo Hao
5	一种低复杂度的毫米波波束空间收发设计方案	201610839401.5	2016-06-24	Xinyu Gao, Linglong Dai, Sen Wang, Shuangfeng Han, Chih-Lin I
6	一种基于子空间的码本设计方法	201610056982.5	2016-07-24	Wenqian Shen, Linglong Dai, Yi Shi, Leiming Zhang
7	基于角度的重叠导频设计方法	201610074557.7	2016-09-25	Linglong Dai, Chen Hu, Jianjun Li, Yi Shi, Leiming Zhang
8	Multi-Resolution Beam Management in Millimetre-Wave Communications Systems for 5G	201810589433.3	2018-06-08	Linglong Dai, Wenqian Shen, Jianjun Li, Richard MacKenzie, and Mo Hao
9	低成本低能耗的模数混合波束赋型技术	201710034980.4	2017-01-18	Xinyu Gao, Linglong Dai, Yi Shi, Leiming Zhang
10	一种FD-MIMO系统中的参考信号设计方法	201710030892.3	2017-02-22	Jianjun Li, Linglong Dai, Sen Wang, Shuangfeng Han, Chih-Lin

Awards

- **2018 IEEE ComSoc Asia-Pacific Outstanding Paper Award**
- **2018 IEEE ICC Best Paper Award (Top 1.5%)**
- **2017 NSFC Outstanding Young Scholar Award**
- **2017 IEEE ComSoc Asia-Pacific Outstanding Young Researcher Award**
- **2017 IEEE VTC-Fall Best Student Paper (Top 0.2%)**
- **2017 IEEE ICC Best Paper Award (Top 1.2%)**
- **2016 Electronics Letters Best Paper Award (Top 0.1%)**
- **2016 URSI AP-RASC Young Scientist Award**
- **2015 IEEE Trans. Broadcast. Best Paper Award**
- **2014 IEEE ICC Best Paper Award (Top 1.8%)**







Awards

- **2013 IEEE ICC Best Paper Award (Top 1.3%)**
- **2013 National Excellent Doctoral Dissertation Nomination Award**
- **2013 Excellent postdoctoral (Top 0.8%)**
- **2012 Beijing Excellent Doctoral Dissertation Award**
- **2011 Excellent graduates of Tsinghua University**
- **2011 Tsinghua Excellent Doctoral Dissertation Award**
- **2011 Academic Star of Tsinghua (Top 0.05%)**
- **2010 First price of GE Technology Innovation Award**
- **2010 First class of comprehensive scholarship**
- **2009 Outstanding student leaders**


清华大学优秀博士后
证 书

经校博士后管理委员会批准，戴凌龙博士荣获2013年“清华大学优秀博士后”奖。

清华大学

编号：201301

二〇一三年四月二十二日


荣誉证书

戴凌龙：

您的《新一代中国地面数字电视演进标准的关键技术研究》被评为2012年北京市优秀博士学位论文。

编号：201217

二〇一二年八月


授予 戴凌龙 同学

优秀博士毕业生

荣誉称号

清华大学

二〇一一年七月


荣誉称号

电子工程系 戴凌龙：

在清华大学课程学习、科研工作中，秉承“严谨、勤奋、求实、创新”的优良学风，成绩优秀、成果突出，被授予“学术新秀”荣誉称号。特发此证，以资鼓励。

清华大学研究生院

二〇一一年七月

Projects

No.	Project name	Project source	Time	Role
1	Wideband Transmission Theory and Technologies	National Natural Science Foundation of China	2017/01-2019/12	PI
2	Key Signal Processing Technologies for 5G Millimeter-Wave Massive MIMO with Lens Array	Royal Academy of Engineering, UK	2017/04-2019/03	PI
3	New Multiple Access Technique with Massive Connectivity and Low Latency for 5G	Korea National Research Foundation, Korea	2017/03/-2019/02	PI
4	Research on Non-Orthogonal Multiple Access (NOMA) for 5G	National Natural Science Foundation of China	2016/01-2019/12	PI
5	Low-Cost Architecture for High-Frequency Communications	Huawei	2018/09-2019/09	PI
6	Basic Theory for Capacity-Approaching and Highly Reliable Broadband Spectrum Communication	National Key Basic Research Program	2015/01-2017/12	PI
7	5G System Design, Key Technology Research and Standardization	China Mobile	2015/04-2016/04	PI
8	Green Heterogeneous Sensor Networks Based on Broadcasting for Smart City	China MOST	2015/04-2017/03	PI
9	Spectrum-Efficient TFT-OFDM Based on Time-Frequency Training	National Natural Science Foundation of China	2013/01-2015/12	PI
10	Transmission Mechanism and Channel Capacity Analysis of Broadband Spectrum Communication	National Key Basic Research Program	2013/01-2014/12	PI

Academic services

- **Editor, IEEE Transactions on Communications (IF: 4.058)**
- **Editor, IEEE Transactions on Vehicular Technology (IF: 4.066)**
- **Area Editor, IEEE Communications Letters (IF: 1.988)**
- **Co-Chair, 5G Signal Processing of IEEE Communications Society**


IEEE TRANSACTIONS ON
COMMUNICATIONS
A PUBLICATION OF THE IEEE COMMUNICATIONS SOCIETY

DECEMBER 2016 VOLUME 64 NUMBER 12 IECMBT (ISSN 0090-6778)


IEEE TRANSACTIONS ON
VEHICULAR
TECHNOLOGY
A PUBLICATION OF THE IEEE VEHICULAR TECHNOLOGY SOCIETY

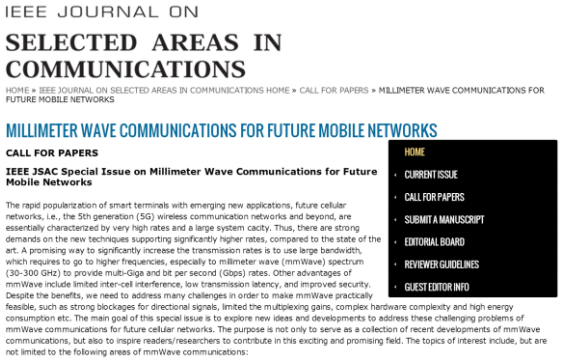
DECEMBER 2016 VOLUME 65 NUMBER 12 ITVTAB (ISSN 0018-9545)


IEEE
COMMUNICATIONS
LETTERS
A PUBLICATION OF THE IEEE COMMUNICATIONS SOCIETY

DECEMBER 2016 VOLUME 20 NUMBER 12 ICLEF6 (ISSN 1558-2558)

Academic services

- **Guest Editor, IEEE Journal on Selected Areas in Communications** (topic: mmWave communications) **(IF: 8.085)**



IEEE JOURNAL ON
SELECTED AREAS IN COMMUNICATIONS

HOME » IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS HOME » CALL FOR PAPERS » MILLIMETER WAVE COMMUNICATIONS FOR FUTURE MOBILE NETWORKS

MILLIMETER WAVE COMMUNICATIONS FOR FUTURE MOBILE NETWORKS

CALL FOR PAPERS

IEEE JSAC Special Issue on Millimeter Wave Communications for Future Mobile Networks

The rapid popularization of smart terminals with emerging new applications, future cellular networks, i.e., the 5th generation (5G) wireless communication networks and beyond, are essentially characterized by very high rates and a large system cacity. Thus, there are strong demands on the new techniques supporting significantly higher rates, compared to the state of the art. A promising way to significantly increase the transmission rates is to use large bandwidth, which requires to go to higher frequencies, especially to millimeter wave (mmWave) spectrum (30-300 GHz) to provide multi-Giga and bit per second (Gbps) rates. Other advantages of mmWave include limited inter-cell interference, low transmission latency, and improved security. Despite the benefits, we need to address many challenges in order to make mmWave practically feasible, such as strong blockages for directional signals, limited the multiplexing gains, complex hardware complexity and high energy consumption etc. The main goal of this special issue is to explore new ideas and developments to address these challenging problems of mmWave communications for future cellular networks. The purpose is not only to serve as a collection of recent developments of mmWave communications, but also to inspire readers/researchers to contribute in this exciting and promising field. The topics of interest include, but are not limited to the following areas of mmWave communications:

- HOME
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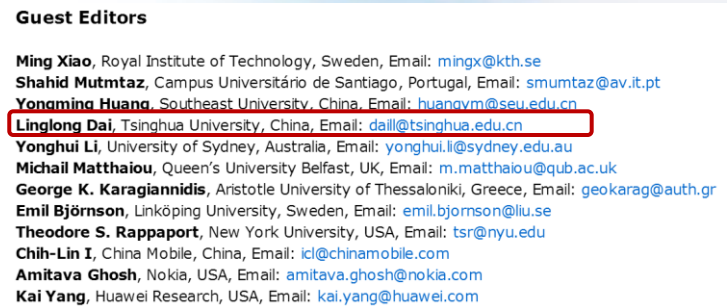
- GUEST EDITOR INFO



Guest Editors

Ming Xiao, Royal Institute of Technology, Sweden, Email: mingx@kth.se
Shahid Mutmtaz, Campus Universitário de Santiago, Portugal, Email: smumtaz@av.it.pt
Yongming Huang, Southeast University, China, Email: huangym@seu.edu.cn
Linglong Dai, Tsinghua University, China, Email: daill@tsinghua.edu.cn
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Theodore S. Rappaport, New York University, USA, Email: tsr@nyu.edu
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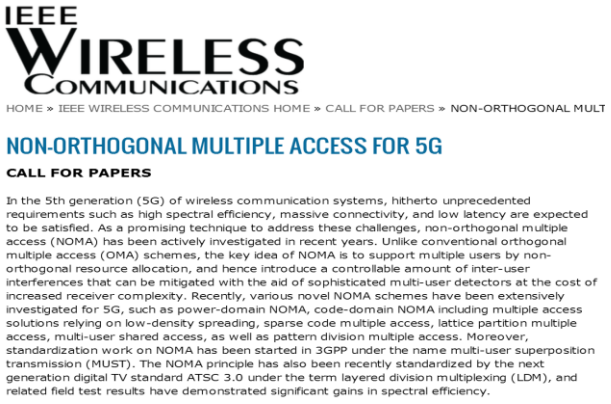
Amitava Ghosh, Nokia, USA, Email: amitava.ghosh@nokia.com
Kai Yang, Huawei Research, USA, Email: kai.yang@huawei.com

- **Leading Guest Editor, IEEE Wireless Communications** (topic: non-orthogonal multiple access) **(IF: 8.972)**



IEEE WIRELESS COMMUNICATIONS

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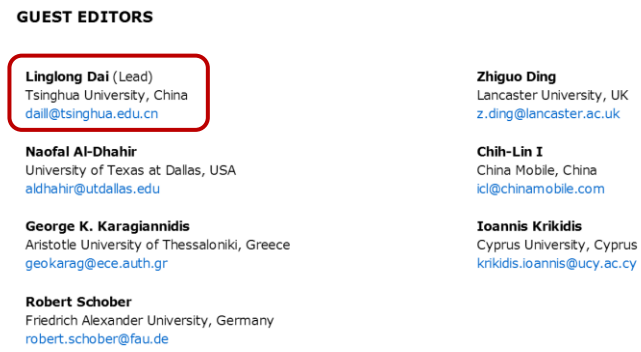
NON-ORTHOGONAL MULTIPLE ACCESS FOR 5G

CALL FOR PAPERS

In the 5th generation (5G) of wireless communication systems, hitherto unprecedented requirements such as high spectral efficiency, massive connectivity, and low latency are expected to be satisfied. As a promising technique to address these challenges, non-orthogonal multiple access (NOMA) has been actively investigated in recent years. Unlike conventional orthogonal multiple access (OMA) schemes, the key idea of NOMA is to support multiple users by non-orthogonal resource allocation, and hence introduce a controllable amount of inter-user interferences that can be mitigated with the aid of sophisticated multi-user detectors at the cost of increased receiver complexity. Recently, various novel NOMA schemes have been extensively investigated for 5G, such as power-domain NOMA, code-domain NOMA including multiple access solutions relying on low-density spreading, sparse code multiple access, lattice partition multiple access, multi-user shared access, as well as pattern division multiple access. Moreover, standardization work on NOMA has been started in 3GPP under the name multi-user superposition transmission (MUST). The NOMA principle has also been recently standardized by the next generation digital TV standard ATSC 3.0 under the term layered division multiplexing (LDM), and related field test results have demonstrated significant gains in spectral efficiency.



GUEST EDITORS

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Prototype 1: Wireless communication with large antenna array

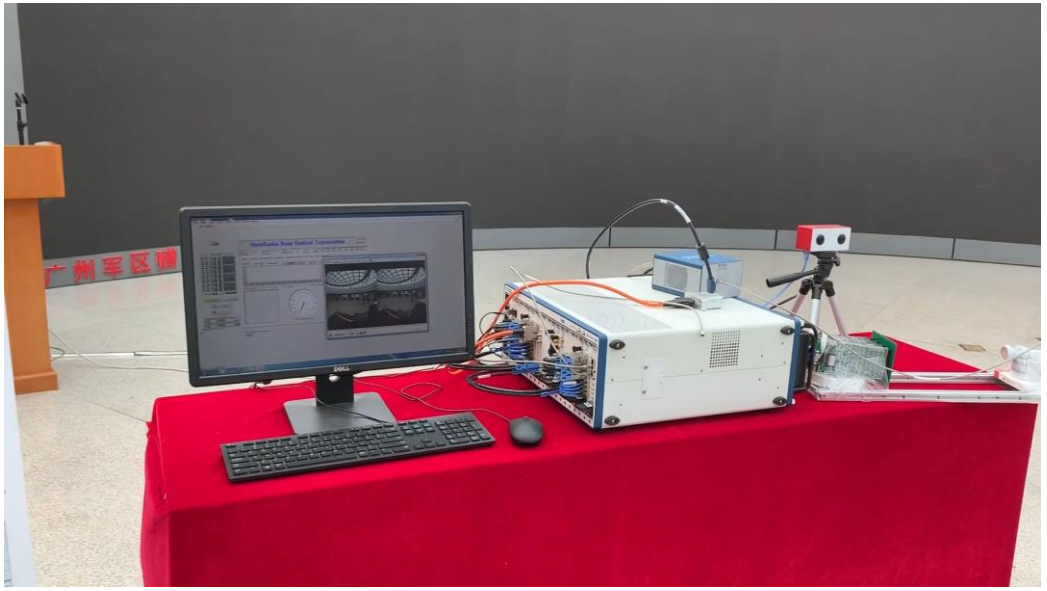
- **Wireless communication based on 256-element large intelligent surface**
  - **New antenna array design and verification at 2.3 GHz**
  - **Real-time VR video transmission**

256-element surface array at the BS

Real-time video Demo

Prototype 2: DL-based millimeter-wave communication

- **Deep learning (DL) based mmWave communication**
  - **DL-based end-to-end communications**
  - **256-element antenna array**
  - **28 GHz, 1.6 Gbps**

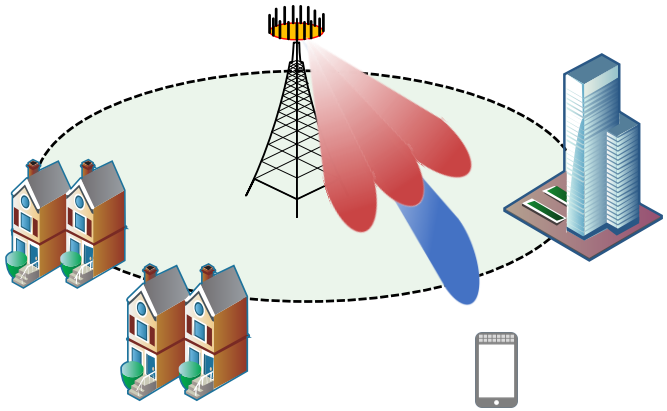


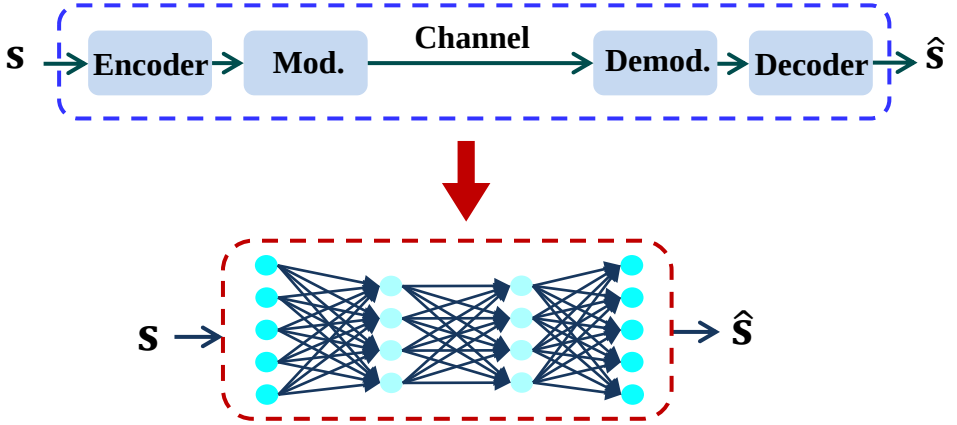
Exhibit@IEEE ICC 2019, May 2019

Real-time video Demo

Research plan

- **6G technologies**
  - THz communications, RIS, OTFS, Polar codes, etc.
- **Machine learning for future wireless communications**
  - ML-based algorithm design (signal detection, precoding, channel estimation, codebook design, channel feedback, etc.)
  - ML-based architecture design (joint receiver design, autoencoder-based joint transceiver design, etc.)
- **Prototype for THz and ML**





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