Title

Metasource-Based Physical-Layer Security for Future Wireless Networks

Duration

Full day (3 hours)

Presenter

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Bio

Yuli Yang received the Ph.D. degree in communications and information systems from Peking University (China).

She is a Senior Lecturer in Communications and Networks, with the University of Essex (UK). Prior to joining the University of Essex, she was with the University of Lincoln (UK), the University of Chester (UK), Meliksah University (Turkey), and King Abdullah University of Science & Technology (Saudi Arabia) on various academic positions. Her industry experience includes working with Bell Labs Shanghai (China) as a Research Scientist and with Huawei Technologies (China) as an Intern Researcher.

Her research interests include modelling, design, analysis, and optimisation of wireless systems and networks, specifically in physical-layer security, permutation-based modulation/transmission, and ultra-reliable low-latency communications.

Description

The physical-layer security (PLS) is a promising concept to complement the cryptographic technologies at upper layers in wireless networks. Various channel-based approaches, e.g., secret-key extraction, directional modulation, and artificial-noise injection, have been conceived to exploit wireless channel characteristics in providing PLS.

Recently, legitimate channel-gain-mapped sources have been developed to constitute a novel technology of the physical-layer secret key generation, referred to as metasource-based secret key (MBSK). In contrast to the channel-based approaches, the MBSK technology not only promotes the actual realisation of the PLS concept but also induces green communications for future wireless networks.

This tutorial introduces the MBSK technology through discussing its design principles, the latest advantages, the challenges, and the road ahead in the research. Our hope is to facilitate researchers who might have interests in the PLS concept would like to kick-start their understanding of recently developed techniques in the MBSK realm.

The content of this tutorial is as below:

1. Information-theoretic PLS models
    - Shannon's communications security
    - Wyner's wiretap channel
2. Metrics for PLS evaluation
    - Secrecy rate
    - Error probability difference between Bob and Eve
    - Secrecy energy efficiency
    - Secrecy margin
3. Channel-based PLS techniques
    - Secret-key distillation
    - Directional modulation
    - Artificial-noise injection
4. Metasource-based PLS techniques
    - Modulation mapping pattern
    - Constellation design pattern
    - Channel-coding pattern
5. The road ahead
    - MBSK generation methods
    - MBSK pattern design
    - Rich scattering propagation
    - Cross-layer security
    - Federated learning for privacy

Expected audience

The researchers who are interested in physical-layer security.

The number of attendees in the tutorial will depend on the number of attendees in the conference.

Recent publications (* denoting the corresponding author)

Journal Articles

[J1] **Y. Yang**, C. Xu, and L. Hanzo, "Source-Difference-Based Mapping Improves Spatial Modulation", *IEEE Open Journal of Vehicular Technology*, vol. 4, pp. 517-529, Aug. 2023.

[J2] D. Zheng, **Y. Yang***, M. Ma, W. Li, and B. Jiao, "Joint Precoding and Array Design for Broadcast in the Internet of Unmanned Aerial Vehicles", *IEEE Internet of Things Journal*, vol. 10, no. 14, pp. 12638-12650, Jul. 2023.

[J3] W. Li, **Y. Yang***, and B. Jiao, "Permutation-Based Transmissions in Finite Blocklength Regime: Efficient and Effective Resource Utilisation", *IEEE Transactions on Communications*, vol. 71, no. 6, pp. 3251-3262, Jun. 2023.

[J4] **Y. Yang**, and L. Hanzo, "Permutation-Based Short-Packet Transmissions Improve Secure URLLCs in the Internet of Things", *IEEE Internet of Things Journal*, vol. 10, no. 12, pp. 11024-11037, Jun. 2023.

[J5] **Y. Yang***, and B. Jiao, "Dynamic Pilot Design for Multicast in the Internet of Vehicles Running at Different Speeds", *IEEE Internet of Things Journal*, vol. 10, no. 12, pp. 10307-10317, Jun. 2023.

[J6] W. Li, D. Zheng, **Y. Yang***, and B. Jiao, "Power Indexed Adaptive Modulation to Improve Spectral Efficiency", *IEEE Wireless Communications Letters*, vol. 12, no. 5, pp. 818-822, May 2023.

[J7] W. Yin, Z. Kong, Y. Liu, **Y. Yang** and L. Hanzo, "Artificial-Noise-Aided CQI-Mapped Generalized Spatial Modulation", *IEEE Transactions on Vehicular Technology*, vol. 72, no. 4, pp. 5338-5343, Apr. 2023.

[J8] H. Yao, L. Shu, F. Yang, Y. Jin, and **Y. Yang**, "The Phototactic Rhythm of Pests for the Solar Insecticidal Lamp: A review", *Frontiers in Plant Science*, 13:1018711, DOI: 10.3389/fpls.2022.1018711, Jan. 2023.

[J9] W. Li, D. Zheng, **Y. Yang***, and B. Jiao, "Grouping Length Permutation Encapsulated Packets to Improve Spectral Efficiency", *IEEE Communications Letters*, vol. 26, no. 9, pp. 2037-2041, Sep. 2022.

[J10] D. Zheng, and **Y. Yang***, "Pseudo-Doppler Aided Cancellation of Self-Interference in Full-Duplex Communications", *Frontiers in Signal Processing*, 2:965551, DOI: 10.3389/frsip.2022.965551, Aug. 2022.

[J11] **Y. Yang***, and W. Li, "Security-Oriented Polar Coding Based on Channel-Gain-Mapped Frozen Bits", *IEEE Transactions on Wireless Communications*, vol. 21, no. 8, pp. 6584-6596, Aug. 2022.

[J12] P. Si, Z. Fu, L. Shu, **Y. Yang**, K. Huang, and Y. Liu, "Target-Barrier Coverage Improvement in an Insecticidal Lamps Internet of UAVs", *IEEE Transactions on Vehicular Technology*, vol. 71, no. 4, pp. 4373-4382, Apr. 2022.

[J13] M. Yin, **Y. Yang***, J. Wu, and B. Jiao, "Opportunistic Bits in Short-Packet Communications: A Finite Blocklength Perspective", *IEEE Transactions on Communications*, vol. 69, no. 12, pp. 8085-8099, Dec. 2021.

[J14] D. Zheng, **Y. Yang***, L. Wei, and B. Jiao, "Decode-and-Forward Short-Packet Relaying in the Internet of Things: Timely Status Updates", *IEEE Transactions on Wireless Communications*, vol. 20, no. 12, pp. 8423-8437, Dec. 2021.

[J15] **Y. Yang**, and L. Hanzo, "Permutation-Based TCP and UDP Transmissions to Improve Goodput and Latency in the Internet of Things", *IEEE Internet of Things Journal*, vol. 8, no. 18, pp. 14276-14286, Sep. 2021.

[J16] F. Yang, L. Shu, **Y. Yang**, G. Han, S. Pearson, and K. Li, "Optimal Deployment of Solar Insecticidal Lamps over Constrained Locations in Mixed-Crop Farmlands", *IEEE Internet of Things Journal*, vol. 8, no. 16, pp. 13095-13114, Aug. 2021.

[J17] L. Wei, **Y. Yang***, and B. Jiao, "Secrecy Throughput in Full-Duplex Multiuser MIMO Short-Packet Communications", *IEEE Wireless Communications Letters*, vol. 10, no. 6, pp. 1339-1343, Jun. 2021.

[J18] F. Yang, L. Shu, **Y. Yang**, Y. Liu, and T. Gordon, "Improved Coverage and Connectivity

via Weighted Node Deployment in Solar Insecticidal Lamp Internet of Things", *IEEE Internet of Things Journal*, vol. 8, no. 12, pp. 10170-10186, Jun. 2021.

[J19] Z. Zhou, **Y. Yang***, M. Ma, and B. Jiao, "Distortion Reduction in Fractional Delay Filters", *IEEE Signal Processing Letters*, vol. 28, pp. 588-592, 2021.

[J20] Y. Liu, **Y. Yang**, L. Yang, and L. Hanzo, "Physical Layer Security of Spatially Modulated Sparse-Code Multiple Access in Aeronautical *Ad-hoc* Networking", *IEEE Transactions on Vehicular Technology*, vol. 70, no. 3, pp. 2436-2447, Mar. 2021.

[J21] **Y. Yang***, "Permutation-Based Transmissions in Ultra-Reliable and Low-Latency Communications", *IEEE Communications Letters*, vol.25, no.3, pp. 1024-1028, Mar. 2021.

[J22] M. Yin, **Y. Yang***, and B. Jiao, "Security-Oriented Trellis Code Design for Spatial Modulation", *IEEE Transactions on Wireless Communications*, vol.20, no.3, pp. 1875-1888, Mar. 2021.

[J23] **Y. Yang**, M. Ma, S. Aissa, and L. Hanzo, "Physical-Layer Secret Key Generation via CQI-Mapped Spatial Modulation in Multi-Hop Wiretap Ad-Hoc Networks", *IEEE Transactions on Information Forensics and Security*, vol. 16, pp. 1322-1334, 2021.

[J24] M. Ma, S. Tian, Y. Chen, L. Wang, **Y. Yang**, L. Wan, B. Jiao, and H. V. Poor, "A Prototype of Co-Frequency Co-Time Full Duplex Networking", *IEEE Wireless Communications*, vol.27, no.1, pp.132-139, Feb. 2020.

[J25] **Y. Yang***, and M. Guizani, "Mapping-Varied Spatial Modulation for Physical Layer Security: Transmission Strategy and Secrecy Rate", *IEEE Journal on Selected Areas in Communications*, vol.36, no.4, pp.877-889, Apr. 2018.

Conference Papers

[C1] **Y. Yang***, "Secure and Timely Status Updates in the IoT using Short-Packet Permutation-Based Transmissions", *IEEE Vehicular Technology Conference (VTC)*, Hong Kong, Oct. 10th–13th, 2023, pp.1-6.

[C2] **Y. Yang***, M. Guizani, and B. Jiao, "Difference Based Spatial Modulation", *IEEE International Wireless Communications & Mobile Computing Conference (IWCMC),* Dubrovnik, Croatia, May 30th – Jun. 3rd, 2022, pp.295-299.

[C3] B. Jiao, D. Zheng, M. Yin, and **Y. Yang**, "A Possibility: Beyond the Channel Capacity in the Low SNR Regime", *IEEE International Conference on Microwaves, Antennas, Communications and Electronic Systems (COMCAS)*, Tel Aviv, Israel, Nov. 4-6th, 2019, pp.1-4.

Relevance

This tutorial is on the up-to-date physical-layer security technologies for future wireless networks. The physical-layer security (PLS) is a promising concept to complement the cryptographic technologies at upper layers in wireless networks. Various channel-based approaches, e.g., secret-key extraction, directional modulation, and artificial-noise injection, have been conceived to exploit wireless channel characteristics in providing PLS.

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Previous editions:

The tutorial was given once, in the International Wireless Communications & Mobile Computing Conference (IWCMC 2023), on 19th June 2023.

Please refer to the webpage below.

https://iwcmc.org/2023/tutorial-speakers/

In comparison with the previous version, the tutorial for ICCC 2023 will introduce more future research directions, specifically on federated learning based solutions.