Wireless Powered Mobile Edge Computing Networks: A Survey

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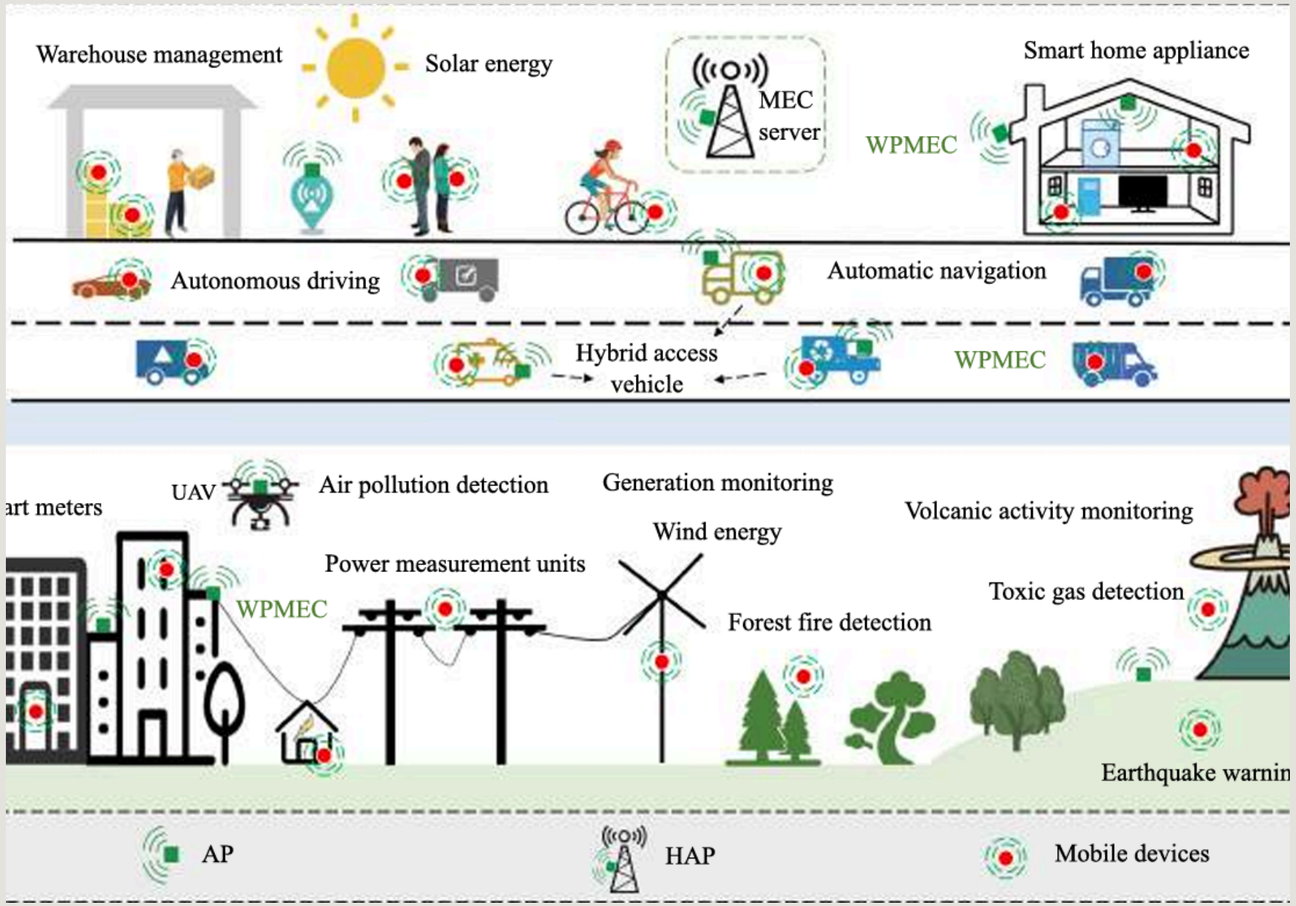
Introduction

What is WPMEC(Wireless Powered Mobile Edge Computing)?

🔌 Wireless Power Transfer (WPT) + 💻 Mobile Edge Computing (MEC)
📱 Devices can charge wirelessly and offload tasks to edge servers
⚡ Helps extend battery life and boost computing performance

Why WPMEC & Where It’s Used



Why it's needed:

- Limited device battery
- Rising data & low-latency demand
- Remote areas lack charging

Applications:

- IoT: Smart homes, cars
- Sensor Networks: Monitoring, alerts
- Smart Grids: Power systems, meters

Comparison and Contributions

Compared to WPT & MEC Surveys:

- WPT surveys focus on energy transfer only (e.g., RF, SWIPT)
- MEC surveys cover offloading, resource use, ML, IoT, security
- But both ignore the combination of energy + computing

WPMEC is different:

- Solves both energy & computing limitations
- Enables real-time, energy-efficient smart systems
- Supports dynamic scenarios (e.g., mobile IoT, UAVs)

This Study Offers:

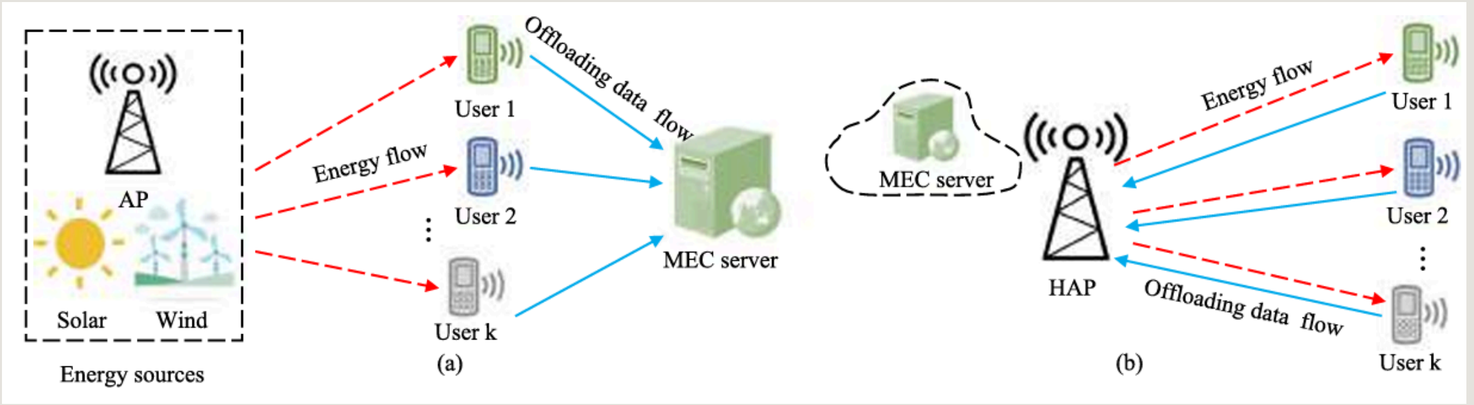
- System models & key techniques
- Offloading + resource allocation approaches
- Challenges & future directions (UAVs, security, time scheduling)

Network	Focuses	Ref.	Contributions
WPT	Renewable EH	[42]	Investigate RF energy-harvesting networks
		[92]	Investigate architectures of EH-enabled sensor networks
	RF-enabled WPT	[5]	Summarize applications and challenges of WPCN
		[99]	Summarize applications of EH communication networks
		[2]	Survey energy beamforming techniques in WPCNs
		[7]	Investigate related techniques for WPCNs
		[57]	Summarize techniques for RF wireless networks
MEC	Security	[82]	Analyze security and privacy of the MEC system
		[81]	Reveal security vulnerabilities in MEC systems
	Application scenarios	[76]	Survey IoT applications and synergies with MEC
		[79]	Summarize architectures of MEC-related Industrial IoT
		[90]	Survey mobile augmented reality based on MEC and 5G
	Resource management	[91]	Discuss the smart resource deployment for MEC
		[83]	Survey service migration and resource allocation in MEC systems
		[50]	Investigate resource management of MEC systems
		[43]	Investigate resource allocation in MEC systems
	Related technologies	[85]	Survey the use of ML technology in MEC systems
		[60]	Summarize the use of game theory in MEC systems
		[18]	Summarize the use of deep learning in MEC systems
WPMEC	Resource allocation, related technologies, and solutions	This article	Summarize basic models, key issues, techniques, solutions, challenges, and open issues for computation offloading and resource allocation in WPMEC systems

System Models of WPMEC

Architecture:

- Combines energy (WPT) + computing (MEC)
- Devices get energy from APs or solar/wind
- Edge servers handle task processing
- Two types:
  - Distributed: Energy and server are separate
  - Centralized: HAP does both energy + computing



Offloading Types:

- Binary: Full task is offloaded or done locally
- Partial: Task is split—part local, part offloaded

Key Metrics:

- Operators care about: energy used, efficiency, task completion
- Users care about: delay, speed, amount of data processed

Literature Review

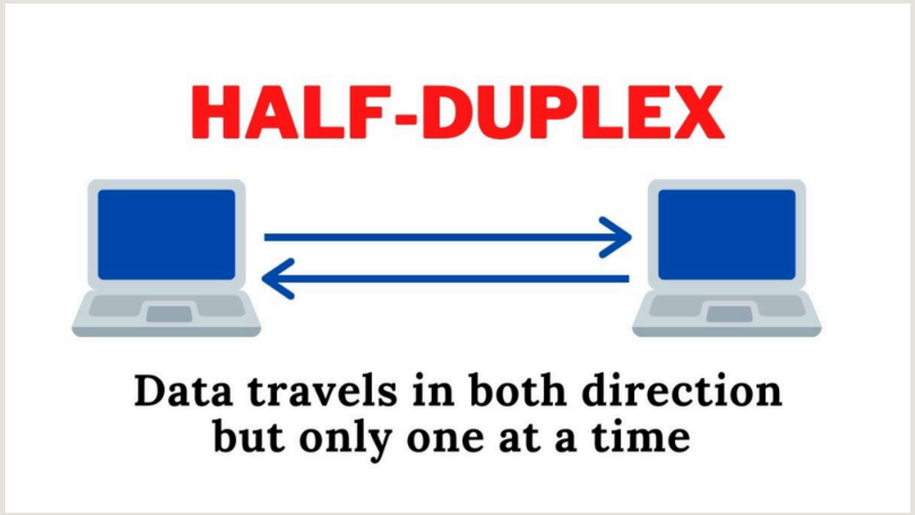
Sr. no	Paper	Understanding
1	Wireless Powered Mobile Edge Computing: Dynamic Resource Allocation and Throughput Maximization	This paper improves resource allocation in wireless MEC systems with energy limits, boosting performance using smarter algorithms.
2	Energy-Efficient Cooperative Resource Allocation in Wireless Powered Mobile Edge Computing	This research boosts energy efficiency in wireless powered MEC by letting devices share computing resources. Their cooperative approach cuts energy use and improves performance.
3	A Survey on Mobile Edge Computing: The Communication Perspective	This paper introduces mobile edge computing, showing how it reduces latency and saves bandwidth by moving processing closer to users. It explains key concepts in simple terms for beginners.

Challenges in Wireless Powered Mobile Edge Computing

1. Half-duplex Constraints
2. Doubly far-near effect
3. Signal transmission attenuation
4. Renewable energy intermittency
5. Random task arrivals & imperfect CSI

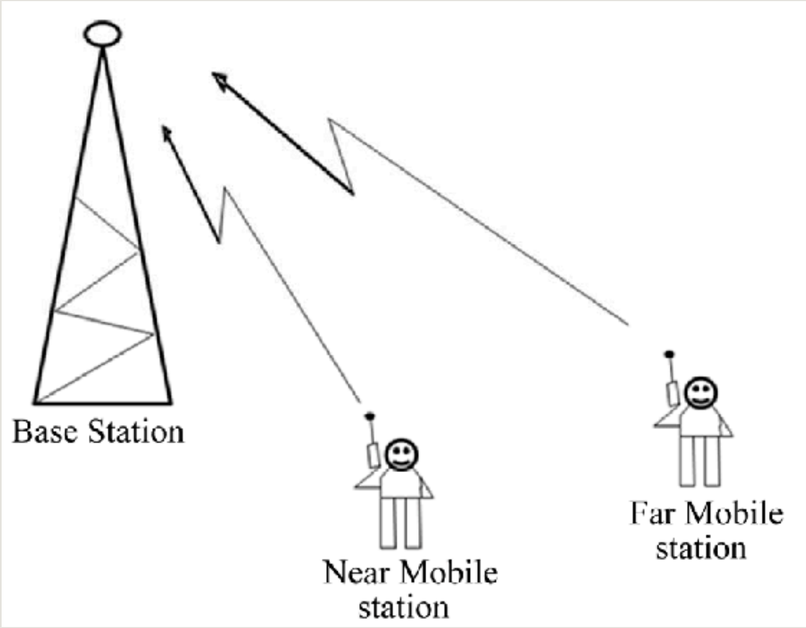
Half-duplex Constraints

- Devices cannot charge and offload tasks at the same time.
- Creates a conflict in time allocation between energy harvesting and computation.



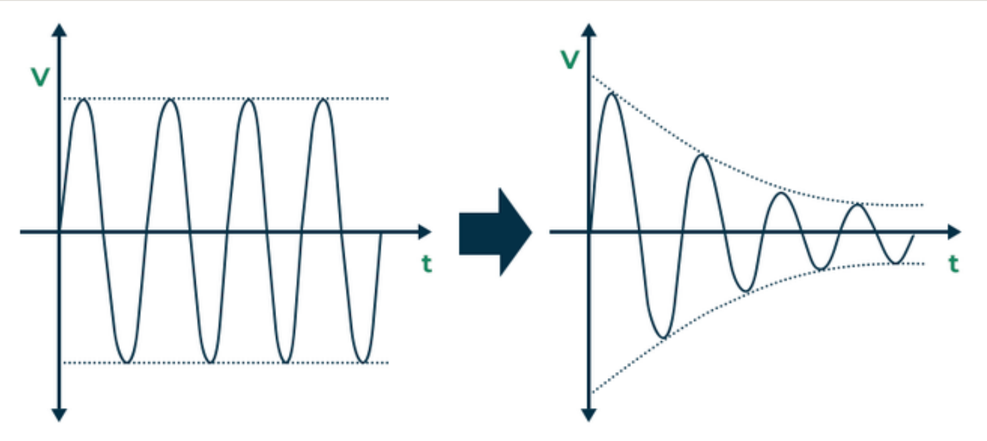
Doubly Far-Near Effect

- Farther users harvest less energy and have weaker offloading performance.
- Leads to unfairness among users in the network.



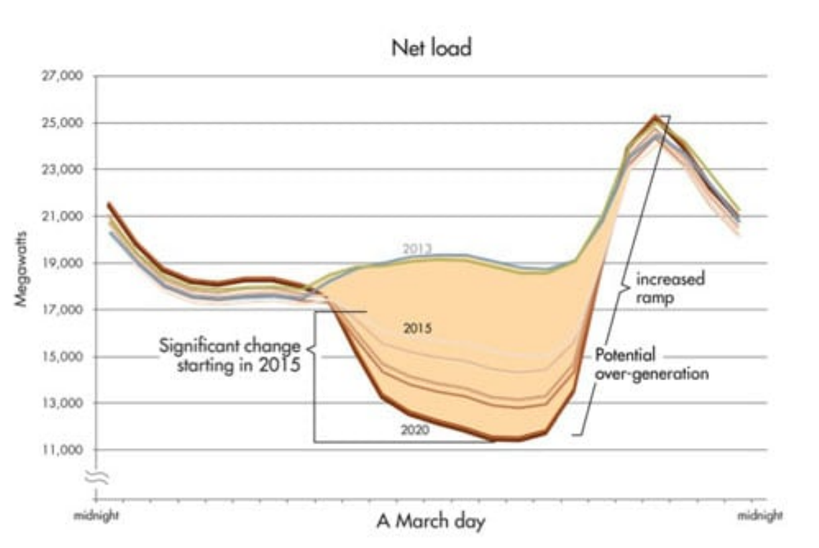
Signal transmission attenuation

- RF energy and task signals weaken over distance.
- Causes low energy harvesting and inefficient communication.



Renewable energy intermittency

- Solar, wind energy are unstable and weather-dependent.
- Makes energy supply unpredictable for devices.



Optimization Techniques in WPMEC

Convex Optimization Methods

- Lagrangian Dual Method
- ADMM
- Coordinate Descent
- Generalized Benders Decomposition
- Successive Convex Approximation (SCA)
- Dinkelbach Method
- Lyapunov Optimization

Machine Learning and Deep Reinforcement Learning

Types

- Supervised
- Unsupervised
- Reinforcement

Advantages

- Adaptability to dynamic environments
- Handles big data

DRL Algorithms

- Deep Q Networks
- Deep deterministic Policy Gradients

Modern Approaches in WPMEC

Time Allocation Strategies

Schedule phases: WPT, Offloading, Computing, Downloading

Simultaneous Wireless Information and Power Transfer (SWIPT)

Energy + data transmitted together

Queueing-based Solutions

Handle random task arrivals and intermittent energy

Non-Orthogonal Multiple Access(NOMA)

Multiple users
sharing spectrum resources

Energy Beamforming (EB)

Direct focused energy transmission

Open Research Areas in WPMEC

- Incentives for Cooperation
  - User/UAV relaying
- Energy Harvesting and Transmission
  - Hybrid energy, multi-antenna
- Dynamic Time Allocation
  - Changing channels, battery
- Security Issues
  - Privacy, Radiation Safety
- Fairness in Resource Allocation
- Real-world Deployment Challenges
  - ML improvements

Conclusion

This is a comprehensive and specific review of research on WPMEC, which is a deep integration of MEC and WPT. Specifically, we review basic models, existing issues, and key technologies of WPMEC. Next, we summarize the latest research related to resource allocation and computation offloading in WPMEC systems. Finally, we point out some research challenges and future research directions. We believe that this article will facilitate the further development of WPMEC, because it will be an important building block for future wireless networks to achieve energy self-sufficiency and intelligent operation of devices.

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Thank You