LoRaWAN-integrated Wearable Sensor Networks for Remote Human Activity Recognition: Applications, Challenges, and Solutions.

Abstract

This poster presents a survey's findings on how **LoRaWAN technology** teams up with wearable sensors to advance remote **HAR**. **Major applications:** ADL, healthcare, elderly care, tracking, etc. We explore the core features of LoRaWAN, how it works with different **types of sensors** like body-worn, hybrid, and object-mounted, and the latest breakthroughs. **15** implemented systems were reviewed to derive a general system design, emphasizing their vital uses in remote HAR. **Challenges tackled:** wearability, power needs, data security, etc. **Proposed solutions: advanced** edge data processing, safer communication protocols, etc.

Background Information

Long Range Wide Area Network (LoRaWAN):

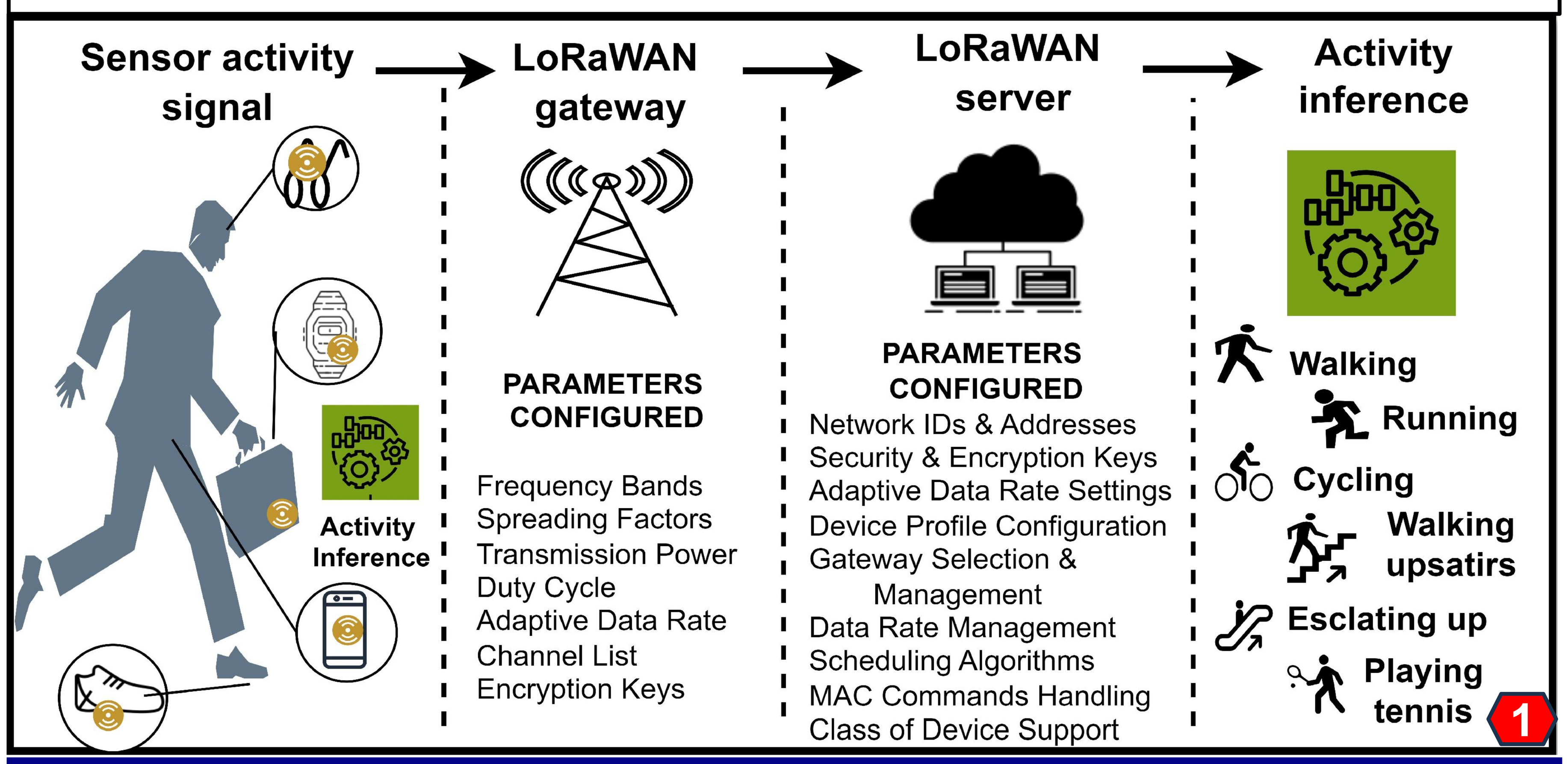
- A protocol established in 2015 by the **LoRa Alliance** [1].
- It based on a **chirp spread spectrum** strategy [2], which spreads the transmission over a wider bandwidth than the actual data rate.
- Strengths: **Low-power**, wide-area networks (LPWANs), offering **long-range** wireless communication with **minimal** energy consumption.

Human Activity Recognition (HAR):

- HAR involves use of **sensor data** to identify human activities [3].
- These sensors can be embedded in devices worn by users (phones, smartwatches or clothing) and are capable of detecting a wide range of motions.
- HAR is crucial in healthcare for monitoring patients, in sports for tracking performance, in smart homes for enhancing security and automation, etc.

Integration of LoRaWAN and HAR:

- Integrating LoRaWAN with wearable sensors for HAR presents a **robust** architecture (Fig. 1) for remote monitoring.
- Several **technical, ethical, … considerations** are involved: sensor design, integration, wireless data transfer, data processing, etc



Motivation, RQs & Contributions

Motivation:

- Advances in LoRaWAN and wearable sensors drive huge potential in remote human activity recognition (HAR); for ADL, healthcare, elderly care, etc.
- LoRaWAN's low-power, long-range capabilities; crucial for enhancing remote monitoring systems' scalability and feasibility over technologies like Wi-Fi.

Research Questions:

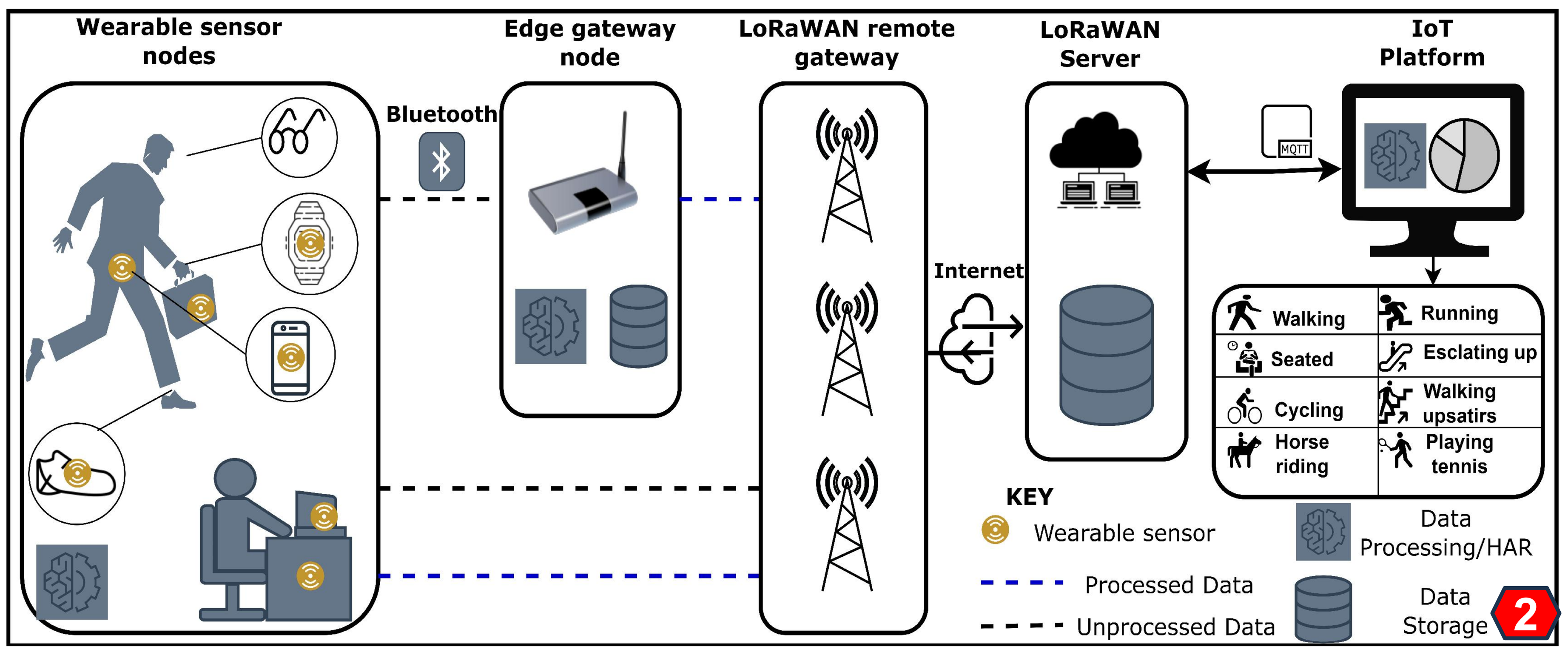
1. How are LoRaWAN and wearable sensors **applied** in real-world HAR systems?
2. What roles do LoRaWAN **parameters** and edge data processing play in optimizing HAR systems?
3. What are the primary **challenges** and **research** directions in implementing this technology in HAR?

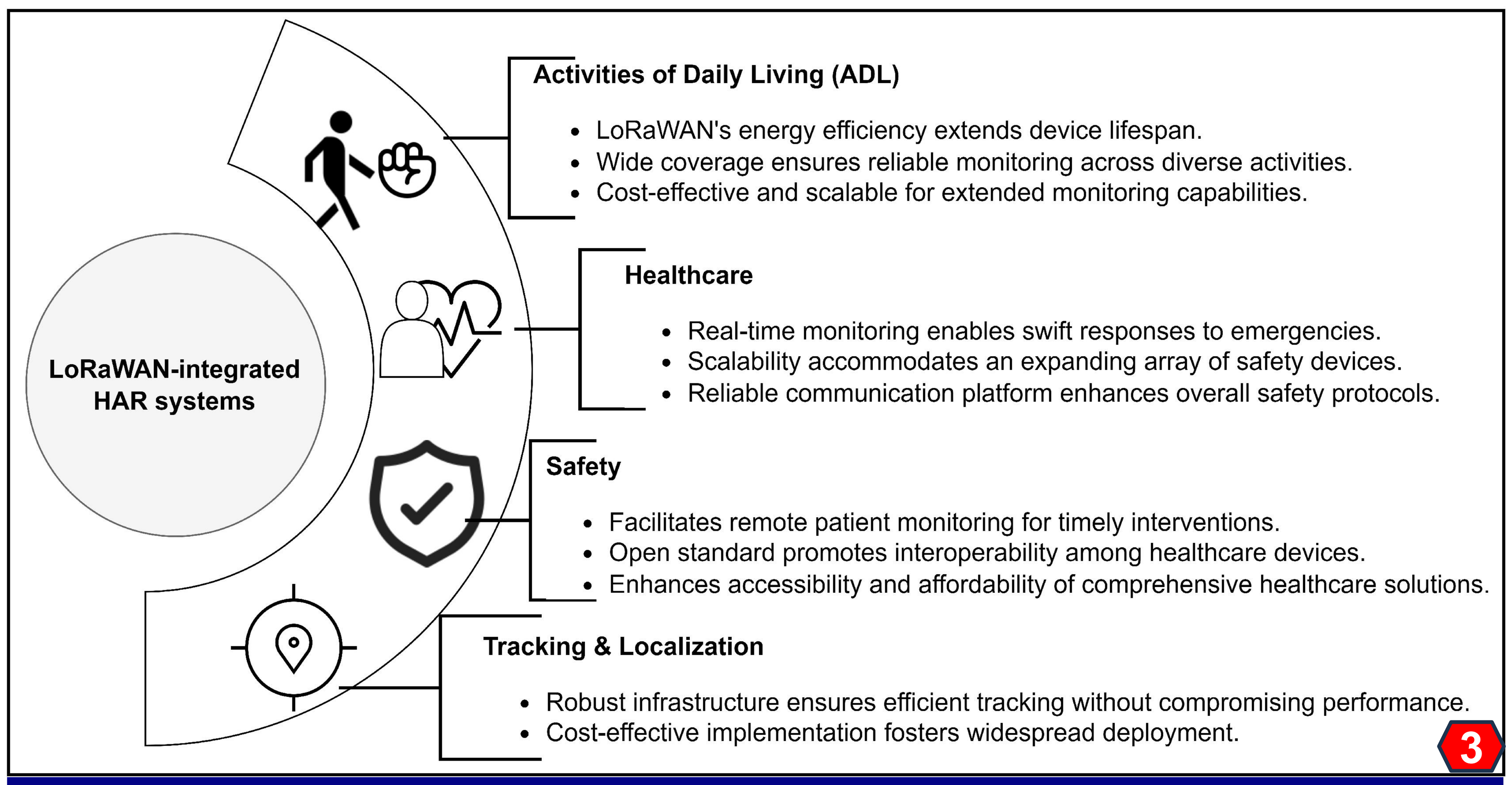
Research Contributions:

- Updates on LoRaWAN-integrated wearable sensors for HAR, focusing on technological improvements.
- An intensive evaluation of their real-life applications in HAR fields.
- Assessment of systems performance, highlighting energy efficiency and data security.
- Suggestion enhancements in sensed data accuracy, network scalability, etc.

Survey Findings

- A typical state-of-the-art LoRaWAN-integrated HAR system architecture is illustrated in Fig. 2. The key applications of these systems and their principal justifications are highlighted (Fig. 3).
- The major challenges with the proposed directions in the reviewed systems are presented in the next section (Table. 1).





Major Challenges & Future Directions

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CHALLENGES	PROPOSED FUTURE DIRECTIONS
End Devices Wearability: Achieving optimal wearability with current devices remains challenging due to their size and comfort issues.	Develop materials and designs for lightweight, integrated wearables that enhance comfort and style, focusing on miniaturization and everyday usability.
Energy Consumption and Management: Continuous sensor operation and data transmission significantly drain battery life.	Implement advanced energy harvesting and power management algorithms to extend battery life and optimize energy use based on activity context.
Payload Size, Data Rate, and ADR: Limited bandwidth restricts data detail and frequency, affecting the efficiency of HAR systems.	Optimize payload size and data rate, and employ advanced adaptive data rate mechanisms to improve communication efficiency in bandwidth-limited environments.
Number of Sensors: Determining the optimal number of sensors is crucial to balance data accuracy with system complexity.	Use intelligent algorithms to dynamically adjust sensor numbers and types, minimizing system complexity while maintaining accuracy.
Data Processing: Reliance on cloud-based processing introduces significant latency, impacting system responsiveness.	Advance edge computing capabilities to enable more on-device processing, reducing latency and enhancing operational efficiency.
Range of Communication: Physical and environmental barriers often degrade signal strength, limiting long-range communication.	Optimize network infrastructure and device hardware to enhance long-range communication capabilities, especially in challenging environments.
Data Security: Existing security measures are insufficient, especially given the vulnerabilities in scenarios using LoRa independently of LoRaWAN.	Strengthen security with lightweight encryption, efficient key management, and novel technologies like blockchain to enhance data integrity and privacy in wearable networks.

Conclusion

- LoRaWAN improves wearable sensors applied in HAR.
- Challenges like wearability, energy use, directing future research towards developing more efficient, user-friendly devices.
- Advances in sensor tech, ML, and IoT will improve wearable systems, hence adaptable, high-impact solutions for diverse user needs.

Main References

[1] https://lora-alliance.org/

[2] B. Reynders and S. Pollin, "Chirp spread spectrum as a modulation technique for long range communication," 2016 Symposium on Communications and Vehicular Technologies (SCVT), Mons, Belgium, 2016, pp. 1-5, doi: 10.1109/SCVT.2016.7797659.

[3] O. D. Lara and M. A. Labrador, "A Survey on Human Activity Recognition using Wearable Sensors," in *IEEE Communications Surveys & Tutorials*, vol. 15, no. 3, pp. 1192-1209, Third Quarter 2013, doi: 10.1109/SURV.2012.110112.00192

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