# WBMS (Wireless Battery Management System) for EV (Electrical Vehicle)

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# IoT-based Monitoring and Control Systems for EVs

- Due to their increased energy density, Lithium-ion batteries must be monitored to ensure proper operation in EVs. Cell current, voltage, and temperature must be maintained within safe limits.
- In a conventional Lithium-ion battery pack, the pack is segmented into clusters of battery cells, called modules. Each module has a respective Module Management System (MMS). Modules are usually connected in series and parallel to supply the appropriate amount of current and voltage for a given application.
- The parallel groups of modules are controlled by Battery Management System (BMS) and each BMS feeds back the master Battery Energy Storage System (BESS). As the information passes from cell voltage to MMS, and then to the BMS, and before arriving at the BMS for processing, noise and latency are of greater concern.
- When such a network is utilized in large-scale systems, such as public transportation, the challenges of routing data-lines through various devices, such as vehicles, become a complicated task to manage.

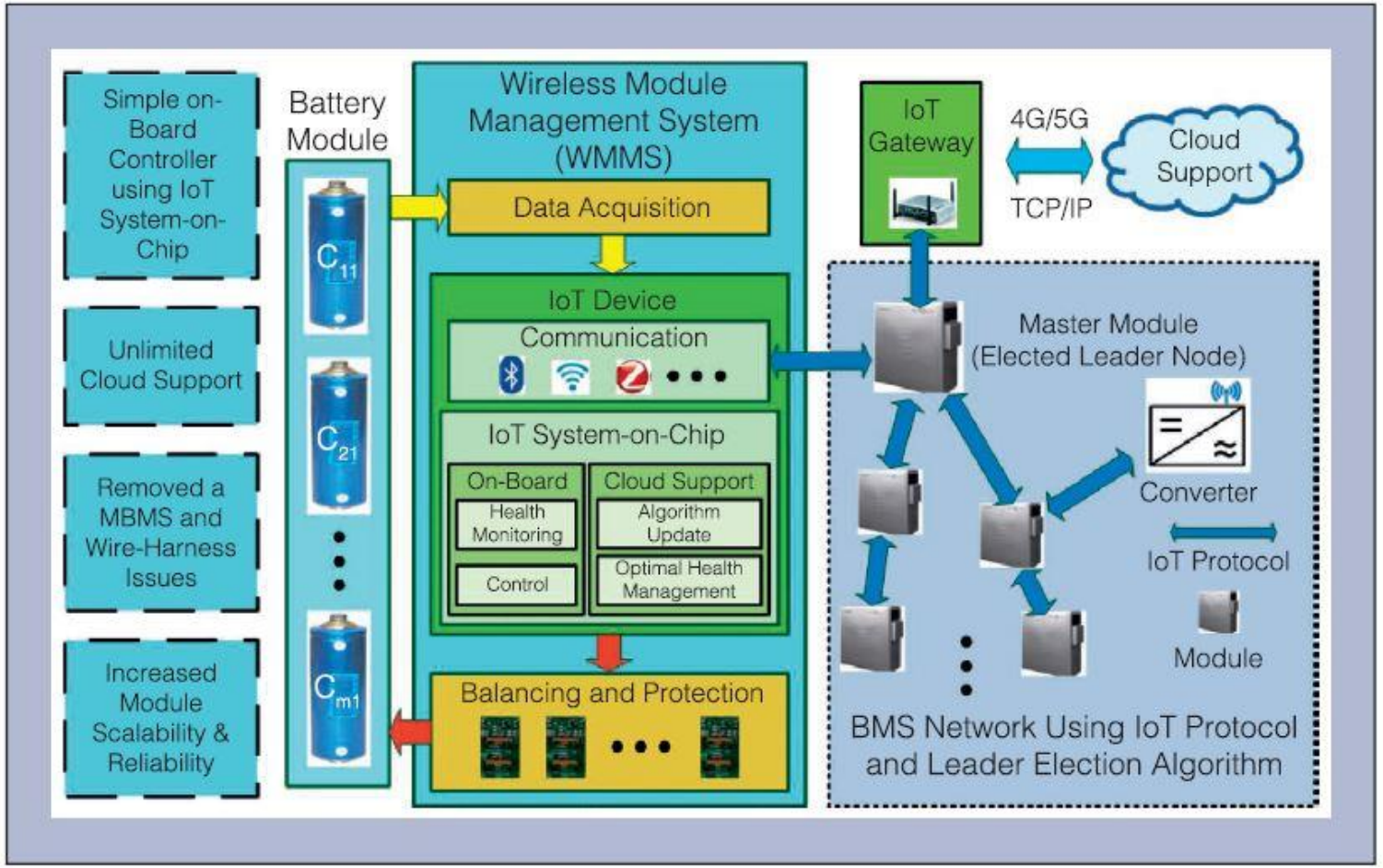
Ref: Fazel Mohammadi, and Rashid Rashidzadeh, “An Overview of IoT-Enabled Monitoring and Control Systems for Electric Vehicles,” in IEEE Instrumentation & Measurement Magazine, pp.91~97, May 2021.

# Wireless Battery Management Systems (WBMSs)

- BMS usually supports module communication through wired systems. However, using wired networks adds to the complexity of certain issues, such as difficulty in manufacturing, increased wiring costs, and complex design procedures for battery packets due to isolation concerns.
- To minimize the wiring complexity in BMSs, research studies on Wireless Battery Management Systems (WBMSs) have been carried out. The WBMS not only minimizes the wiring complexity but also supports location positioning for battery modules.
- IoT can provide a reliable solution to the BMS problem. IoT devices containing a communication component and a system-on-chip Integrated Circuit (IC) form the central element of a WBMS.
- The communication subsystem uses IoT protocols and IoT gateways to communicate with external systems, such as the converter and the internal modules.
- Linear Technologies Corporation has introduced a WBMS with an embedded smart mesh, in which different nodes are wirelessly connected to their neighboring nodes. The main node in this system may be overloaded due to multi-directional data collection, which can lead to the network slowdown. The following Figure shows the schematic of WBMS proposed by Linear Technologies Corporation.

Ref: Fazel Mohammadi, and Rashid Rashidzadeh, “An Overview of IoT-Enabled Monitoring and Control Systems for Electric Vehicles,” in IEEE Instrumentation & Measurement Magazine, pp.91~97, May 2021.

# The schematic of WBMS proposed by Linear Technologies Corporation




Ref: T. Faika, T. Kim, and M. Khan, "An Internet of Things (IoT)-based network for dispersed and decentralized wireless battery management systems," in Proc. 2018 IEEE Transportation Electrification Conf. Expo, Jun. 2018.

# Cloud Battery Management Platform (CBMP)

- In the MMS, IoT sensors measure the current, voltage, and temperature of a battery at a given time. As the nodes (or EVs) cannot store a large amount of data, the data is sent to a cloud server using TCP/IP protocol via an IoT gateway where the data is stored in a cloud data storage.
- The MMS, on the other hand, receives the results of health monitoring processes from the Cloud Battery Management Platform (CBMP). The CBMP is used to support the battery health monitoring system to detect any defects in battery cells, as shown in the following Figure.
- The BMS usually supports module communication through wired systems. However, using wired networks adds to the complexity of certain issues, such as difficulty in manufacturing, increased wiring costs, and complex design procedures for battery packets due to isolation concerns.

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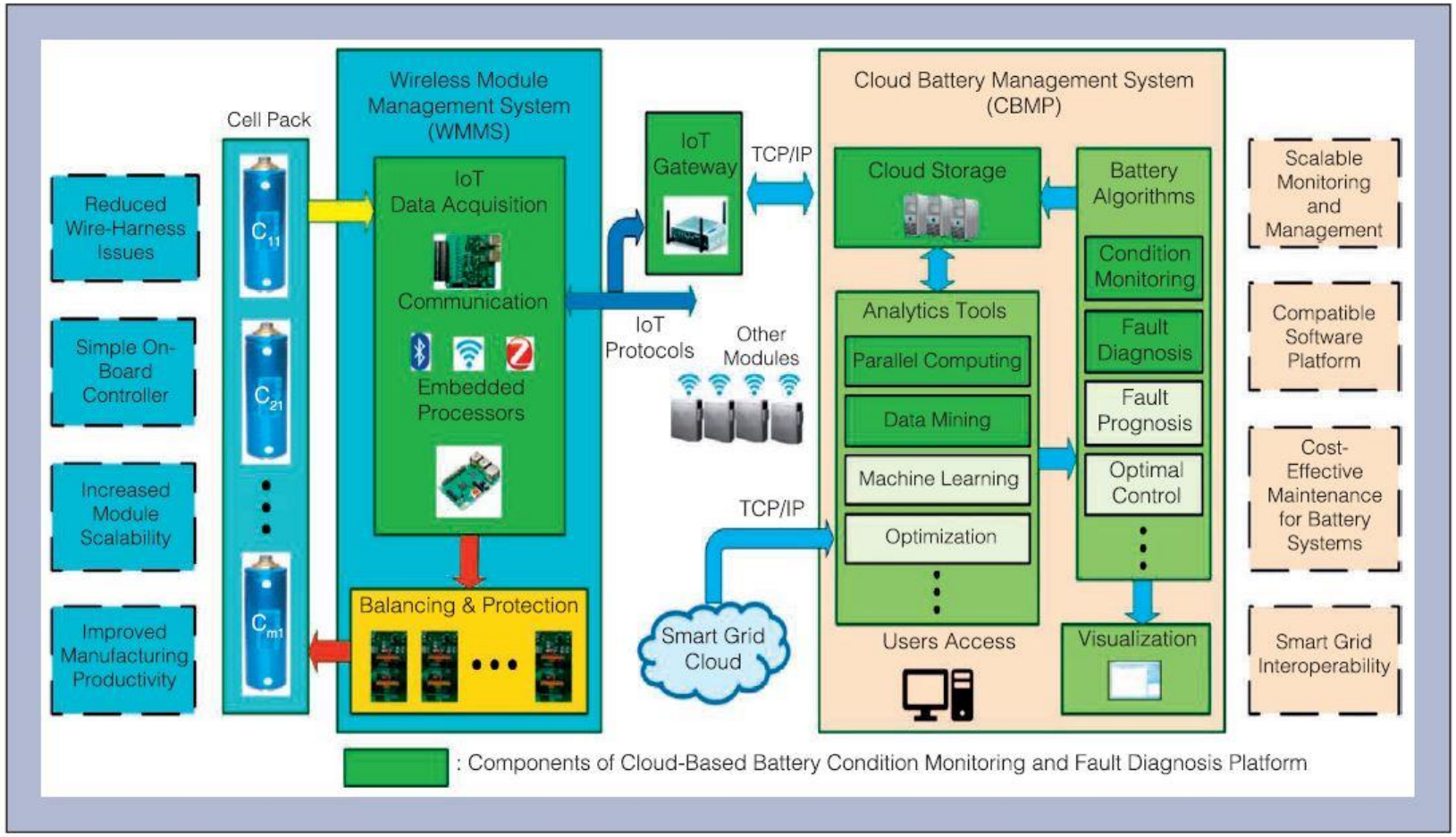
# Cloud Battery Management Platform (CBMP)




Ref: A. Adhikaree, T. Kim, J. Vagdoda, A. Ochoa, P. J. Hernandez, and Y. Lee, "Cloud-Based Battery Condition Monitoring Platform for Large-Scale Lithium-Ion Battery Energy Storage Systems Using Internet-of-Things (IoT)," 2017 IEEE Energy Conversion Congress and Exposition (ECCE), 2017.

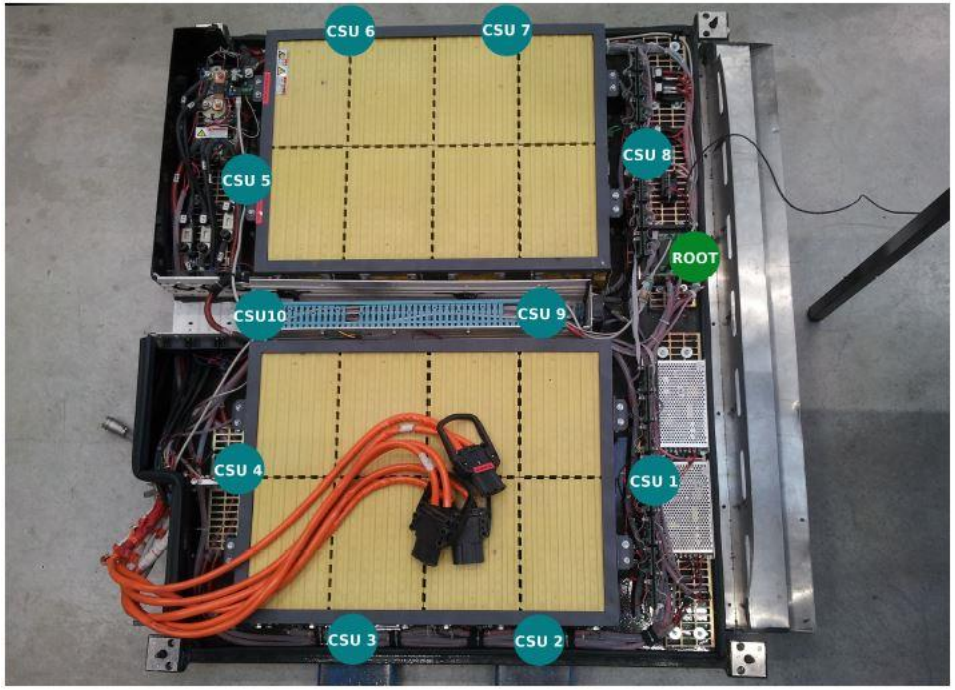
# IEEE 802.15.4-2015 TSCH based Wireless Network for Electric Vehicle Battery Management

- The wireless nodes that have been used in these experiments are Texas Instruments I3Mote CC2650, using IEEE Std 802.15.4-2015 TSCH(Time Slotted Channel Hopping) in the 2.4GHz band.
- The topology was forced to be star (i.e. all nodes have exactly one link with the root, with one up-link timeslot and one down-link timeslot per slot frame).
- The positions of the nodes is shown the following Figure. These are not actual Cell Sensor Units (CSUs), but development boards, powered by their own coin cell battery, and not wired to the pack.

✓ in today's EVs a battery pack is divided into modules made of a series of usually 6 to 16 cells. Each module is supervised by a board named Cell Sensor Unit (CSU)

Ref: Guillaume Le Gally, Nicolas Montavonty and Georgios Z. Papadopoulos, "Enabling IEEE 802.15.4-2015 TSCH based Wireless Network for Electric Vehicle Battery Management," in ISCC 2020, 2020.

# Picture of a Renault Fluence Battery pack



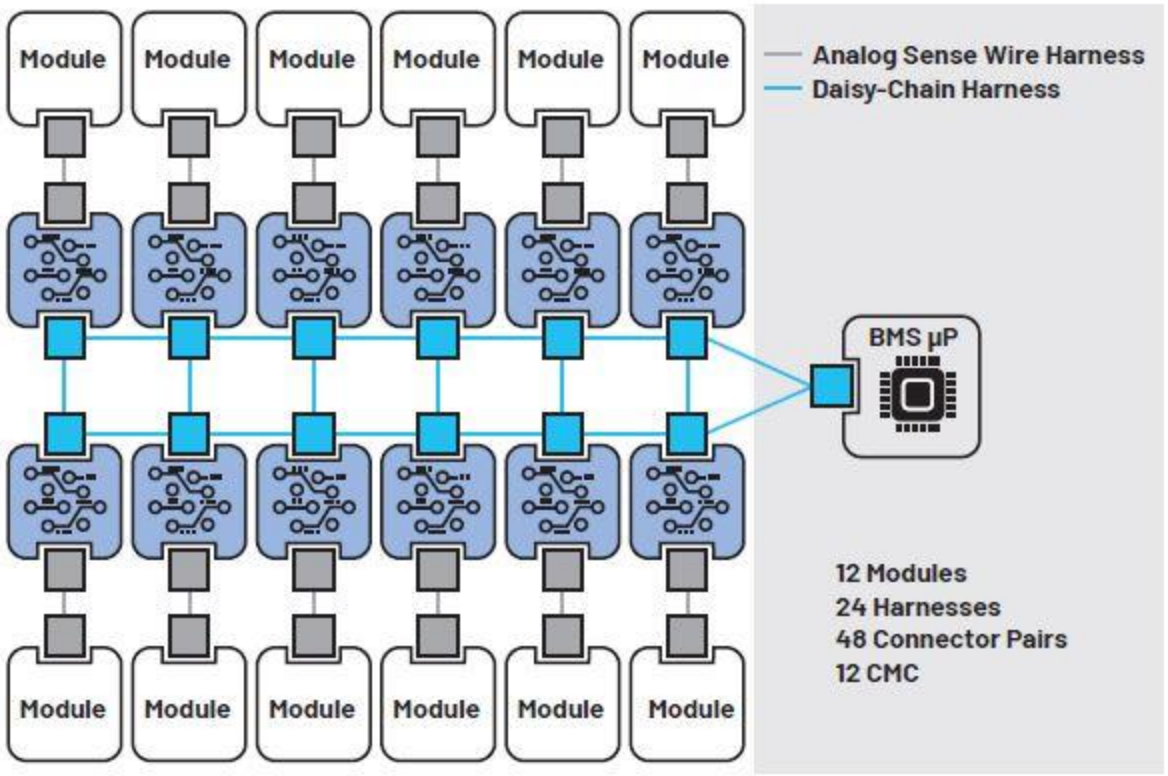


# Analog Devices' development of the WBMS technology

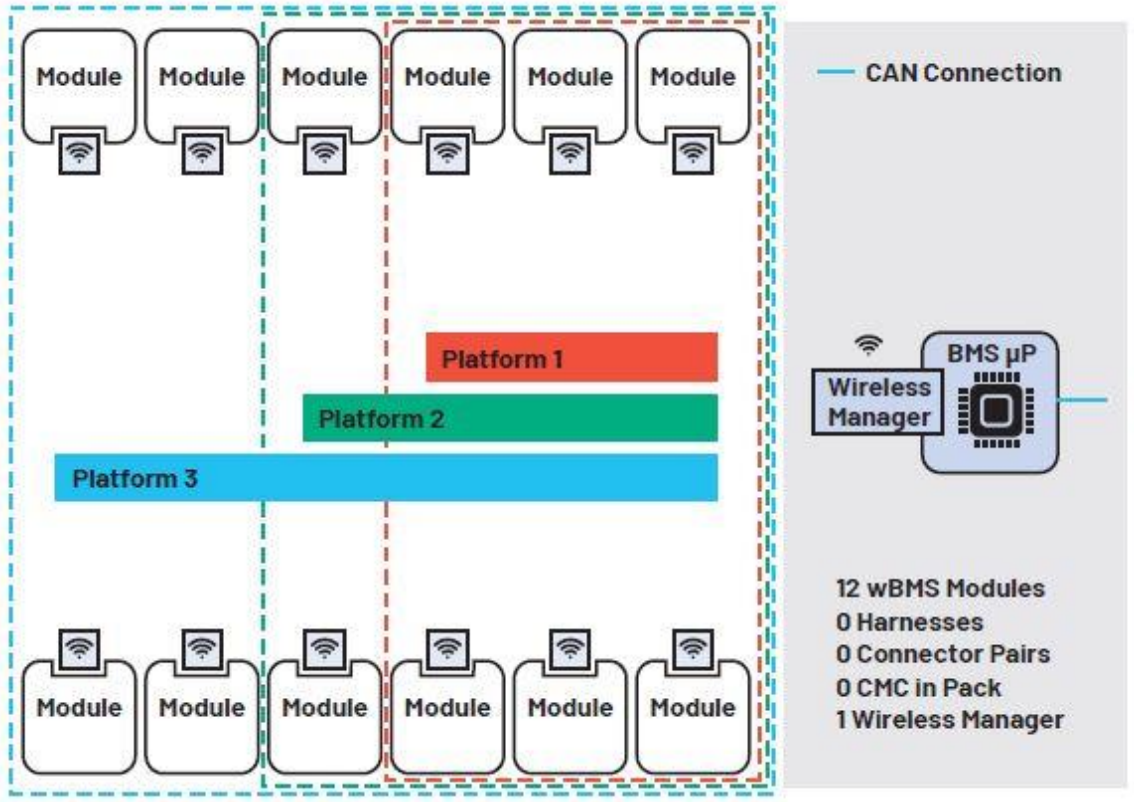
- WBMS technology developed by Analog Devices and pioneered by General Motors in its modular Ultium batteries, promises to give car manufacturers a new competitive edge across the whole of a battery's life, starting from when battery modules are first assembled, to operation in an EV, beyond to disposal, and even into the battery's second life.
- Following GM's release of the Hummer EV, the first of many models to feature a WBMS, Analog Devices ran a series production program that demonstrated how wire-free technology enables transformation of the design, production, servicing, and disposal of EV batteries.

Ref: Norbert Bieler, Paul Hartanto-Doeser, "wBMS Technology: The New Competitive Edge for EV Manufacturers," Analog Devices.

# The advantage provided by the Analog Devices modular and scalable WBMS system platform




A typical complex, multicomponent wired BMS network




The simpler arrangement made possible by Analog Devices' WBMS technology

# WBMS technology eliminates the signal wiring harness

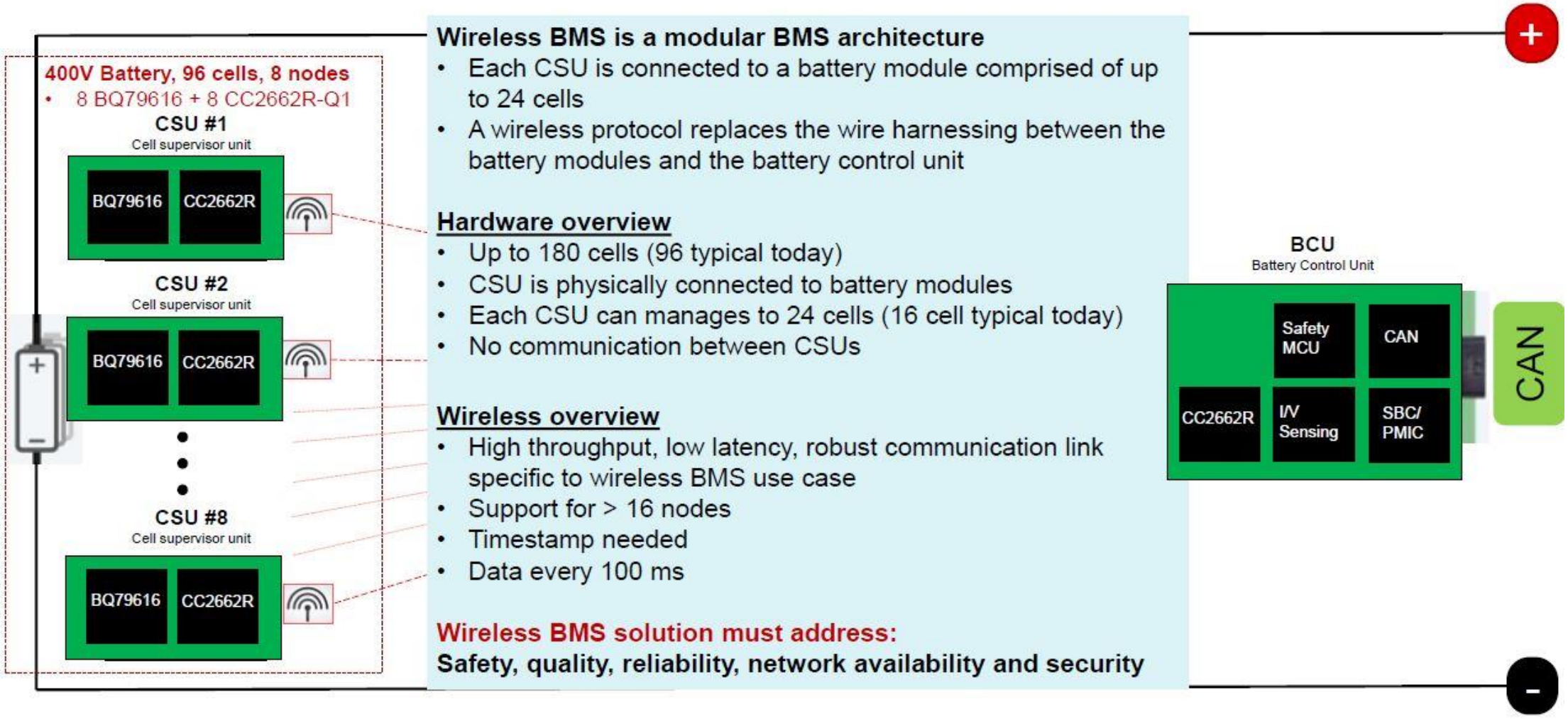
WBMS technology eliminates the signal wiring harness to enable automated, robotic production of complete battery packs.

# TI’s development of the WBMS technology

- TI’s new advancements in wireless BMS improve range, reliability and safety.
- TI’s Wireless BMS solution empowers automakers worldwide to build reliable and efficient EVs.
  - The industry’s first wireless BMS TÜV SÜD assessed for enabling ASIL (Automotive Safety Integrity Level) D functional safety systems
  - A wireless protocol that securely enables the industry’s best network availability
  - Provides freedom to develop reliable, system-level designs across multiple platforms

Ref: Mark Ng, Jon Nafziger, “TI Live! Battery Management Systems Seminar,” Texas Instruments.

# TI's Wireless BMS overview

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# TI's 2.4-GHz WBMS

**Wireless connection between battery packs and battery management system to replace traditional, wired connections**

## Why wireless BMS?

| | |
|---|---|
| Increases EV range | • Reduces overall vehicle weight by replacing heavy battery-management wiring with high-reliable, secure wireless connections |
| Improves time to market | • Eliminates development costs & complexity associated with routing a labyrinth of battery-management cabling |
| Enhances vehicle scalability | • Manufacturers can address multiple EV vehicle and market segments with a single modular wBMS platform |
| Reduces warranty expense | • Removes the need for costly repairs due to common cable breaks and harness failures in traditional wired systems |

## Getting started

1. Request SDK download
2. Request wBMS development kit
3. Download documentation
4. Request functional safety assessmer

Three questions to ask about wireless BM for hybrid and electric vehicles


Why wireless for battery management systems (BMS)?

SimpleLink™ wireless MCU CC266C2R-Q1 — Texas Instruments

**CC2662R-Q1** Automotive qualified SimpleLink™ wireless MCU for use in wireless battery management systems

BMS battery monitor BQ79616-Q1 — Texas Instruments

**BQ79616-Q1** Automotive ASIL D compliant battery monitor for use in wireless battery management systems

**Fixed-low-latency protocol with high throughput and high reliability for ultra-low packet error rate**

## Why TI?

| | |
|---|---|
| Best network availability | • TI's wireless protocol for BMS via the CC2662R-Q1 MCU offers the industry's highest network availability greater than 99.999% |
| System-level functional safety compliance | • Industry's first TÜV SÜD assessed safety concept for wBMS<br>• System-level ASIL D compliance<br>• AEC-Q100 functional safety Quality-Managed wireless MCU<br>• AEC-Q100 functional safety compliant battery monitor |
| Flexible battery architecture | • Industry-best scalable solution with support for up to 100 nodes |
| Low power | • Up to 10X lower power consumption than competition |

Ref: Mark Ng, Jon Nafziger, "TI Live! Battery Management Systems Seminar," Texas Instruments.

# Wrap-Up

- This contribution presented overview and implementation of Wireless Battery Management System for Electrical Vehicles.
  - IoT-based Monitoring and Control Systems for EVs
  - Wireless Battery Management Systems (WBMSs)
  - Cloud Battery Management Platform (CBMP)
  - IEEE 802.15.4-2015 TSCH based Wireless Network for Electric Vehicle Battery Management
  - Analog Devices' development of the WBMS technology
  - TI's development of the WBMS technology

# Thank you very much!

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