nRF52840 vs ESP32: Architecture Comparison for Mesh Operators

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When selecting hardware for a mesh deployment, the choice of microcontroller architecture is often the single most consequential decision you will make. Two families dominate the mesh radio space: Nordic Semiconductor's nRF52840 and Espressif's ESP32 line. Each makes very different trade-offs, and understanding them will inform whether you reach for a RAK4631 or a T-Beam.

nRF52840 -- The Power-Sipping Workhorse

Attribute	Value
Core	ARM Cortex-M4F at 64 MHz (single core)
Flash	1 MB internal
RAM	256 KB SRAM
Radio	Bluetooth 5 / 802.15.4 (Thread, Zigbee) / ANT / 2.4 GHz proprietary -- no WiFi
Operating voltage	1.7-5.5 V native; 3.3-3.7 V typical
Deep-sleep current	approximately 0.5 uA (System OFF), approximately 2 uA (System ON)
Hardware AES	Yes -- AES-128/256 in hardware

The nRF52840's headline feature is its power envelope. A node built around this chip, such as the RAK4631 WisBlock or the Heltec Mesh Node T114, can run for weeks or months on a modest LiPo battery or small solar panel. The integrated hardware AES engine handles Meshtastic/MeshCore

packet encryption without burning CPU cycles.

ESP32 -- The Feature-Rich Generalist

Attribute	Value
Core	Dual-core Xtensa LX6/LX7 at 240 MHz
Flash	4-16 MB (external)
RAM	520 KB SRAM (original ESP32) / 512 KB SRAM (ESP32-S3), plus optional PSRAM
Radio	WiFi 802.11 b/g/n plus BLE 4.2/5.0
Operating voltage	3.3 V (LDO required from LiPo)
Minimum sleep current	10-20 mA (WiFi stack overhead; modem-sleep)

The ESP32's dual-core design and WiFi radio make it vastly more capable at network-layer tasks. It can run an MQTT broker client to bridge LoRa packets to the internet, host a local web configuration interface, and handle more complex packet routing logic -- the WiFi bridging and web-portal tasks in particular are out of reach for the nRF52840, which lacks WiFi entirely.

Power Budget Implications

In solar or battery-only deployments where average current draw matters more than peak performance, the nRF52840 wins decisively. As an approximate, configuration-dependent figure, a typical RAK4631 deployment draws on the order of 5-8 mA average in active receive mode. A T-Beam (ESP32 + always-on GPS + LoRa RX) in the same role draws roughly 40-80 mA average, with the GPS module a large contributor to that current. These are board-level estimates, not chip specs, and vary with duty cycle and configuration. At 100 mAh of daily budget (a small 2W panel in winter), that difference means the RAK4631 runs indefinitely while the T-Beam is power-constrained.

Firmware Support Matrix

- **Meshtastic:** supports both nRF52840 (RAK4631, T114) and ESP32 (T-Beam, Heltec, T3-S3)
- **MeshCore:** supports nRF52840 (RAK4631, T114) and ESP32-S3 (T-Deck, T3-S3); does not support the original ESP32

Decision Framework

- Need WiFi for MQTT internet bridging? -- **ESP32 required**

- Need a web-based config portal? -- **ESP32 required**
- Deploying a solar or battery node for months unattended? -- **nRF52840 strongly preferred**
- Running at a fixed AC-powered location with internet access? -- Either works; ESP32 adds more flexibility
- Maximising range per milliwatt? -- Both chips drive the SX1262 identically; chip choice does not affect RF performance

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