

AOFS Communication Protocols & Standards

AOFS systems rely on **robust, flexible communication protocols** to connect Field, Farm, and HQ controllers, as well as sensors and actuators. Protocols are selected based on **range, power requirements, reliability, and operational constraints**

1. Overview

- Communication is **layered**:
 - **Field Controller Layer**: short-range, low-power, real-time sensor and actuator connectivity
 - **Farm Controller Layer**: aggregation, supervisory control, and moderate-range communication
 - **HQ / Federated Layer**: long-range, optional cloud or networked data aggregation and research integration
- Protocols are **optional, configurable, and modular**
- All protocols must **respect AOFS principles**:
 - Offline-first operation
 - Safety-critical logic cannot be overridden remotely
 - Actions are auditable and logged

2. Recommended Protocols

- **MQTT** - lightweight publish/subscribe messaging for telemetry and asynchronous updates
- **AMQP** - robust messaging with guaranteed delivery, suitable for HQ/Farm Controller links
- **Zigbee** - low-power mesh networks for local sensors and actuators
- **Z-Wave** - low-power mesh for home/farm automation devices and actuators
- **EnOcean** - energy-harvesting wireless sensors and switches

3. Layer Mapping Guidance

- **Field Controller Layer**
 - Zigbee, Z-Wave, EnOcean for sensor/actuator connectivity
 - MQTT for telemetry aggregation to Farm Controller
- **Farm Controller Layer**
 - MQTT or AMQP for Field→Farm aggregation
 - Optional Zigbee/Z-Wave for direct sensor integration
- **HQ / Federated Layer**
 - MQTT or AMQP for data sync
 - Optional internet-based services for forecasting, optimization, and research integration

4. Notes & Best Practices

- AOFS does **not mandate a specific protocol**; multiple protocols may coexist
- Protocol selection should consider **latency, reliability, power, and range**
- Offline-first principle: all safety-critical functions **must function without network connectivity**
- Optional online connections (e.g., for forecasts, research data) must **never override safety-critical rules**
- Protocols should be **auditable and loggable** to maintain operational traceability

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