

FOR EVALUATION

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PacketFive

TORUS FACILITY AGGREGATION GATEWAY

CONCEPT

TORUS-MEG

TORUS-MEG-DS-001

Facility gateway that aggregates a data center sensor ring, fuses events at the edge, and bridges the campus perimeter and data hall approaches to TORUS-CCISRT.

1 Description

TORUS-MEG is the facility gateway of the TORUS Unattended Facility Sensing platform for AI/HPC data centers. It receives LoRa uplinks from a ring of TORUS-SN ground nodes, timestamps and correlates their events against a disciplined clock, runs edge fusion and (where visual masts are attached) on-device inference, then forwards a prioritised event stream to the TORUS-CCISRT command plane over Ethernet, Wi-Fi, LTE/5G, satellite, or facility network backhaul.

It is designed for unattended campus perimeters, utility yards, and remote facility edges. A solar-and-battery power path, a wide-input DC front end, and a rugged sealed enclosure let a single MEG anchor a data center perimeter for months, storing and forwarding when the backhaul link is intermittent.

- **Multi-channel LoRa concentrator** - 8-channel 433 MHz receive, so one gateway serves a large facility field of nodes concurrently
- **Edge compute** - NVIDIA Jetson Orin-class module for sensor fusion and thermal/visual inference at the edge
- **Flexible backhaul** - Gigabit Ethernet, Wi-Fi, LTE/5G cellular, or satellite; automatic store-and-forward
- **Disciplined time** - GNSS receiver provides UTC and node almanac/time sync
- **Off-grid power** - solar MPPT + LiFePO4 pack, wide-input DC, PoE/mains option
- **Secure facility integration** - secure element / TPM, signed firmware, encrypted store-and-forward
- **Visual-mast ready** - camera (GMSL/USB3) and LiDAR (Ethernet) interfaces for the visual domain
- **Rugged** - sealed IP67 enclosure, wide operating temperature, pole or wall mount

2 Block diagram

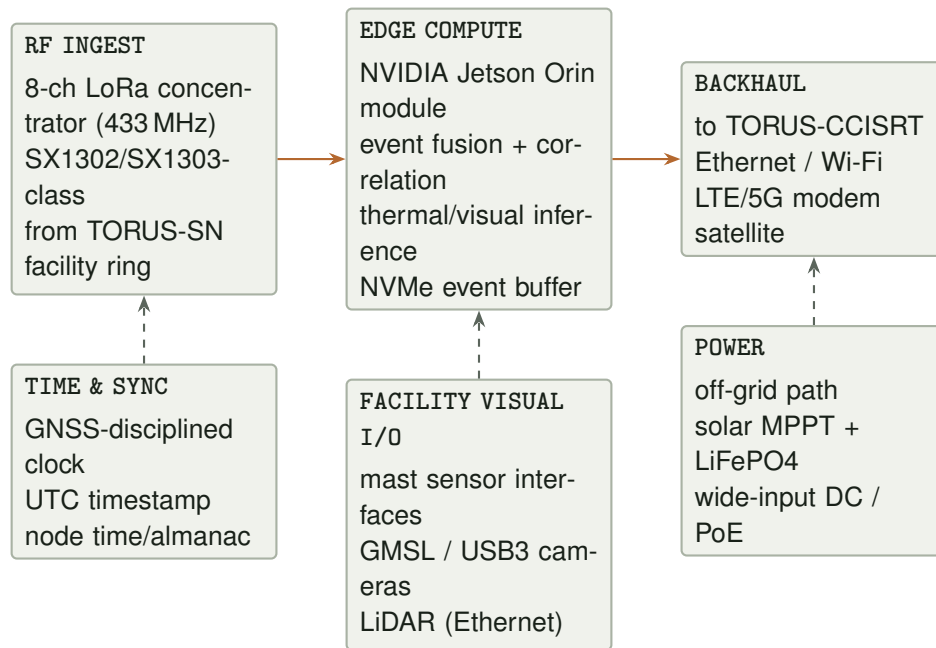


Figure 1: TORUS-MEG subsystem block diagram.

3 Preliminary specifications

Parameter	Target	Notes
LoRa ingest	8 channels, 433 MHz EU ISM	Concentrator-class receiver; serves tens of nodes per gateway
Node capacity	Up to ~100 nodes / gateway	Duty-cycle and report-interval dependent
Edge compute	NVIDIA Jetson Orin NX / Nano	Fusion + optional visual inference; module choice by power budget
Backhaul	Ethernet / Wi-Fi / LTE-5G / SATCOM	Prioritised store-and-forward on link loss; northbound API path to TORUS-CCISRT integrations
Time source	GNSS-disciplined, UTC	Also serves node time-sync and GNSS almanac
Local storage	NVMe SSD (event + clip buffer)	Sized for days of events and short thermal/video clips
Power input	Solar MPPT + LiFePO4; 9-36 V DC; PoE+	Off-grid autonomy target measured in months

Parameter	Target	Notes
Enclosure	IP67, pole/wall mount	Wide operating temperature; passive cooling
Security	Secure element / TPM, signed FW	Encrypted store-and-forward; optional on-prem-only mode

TORUS-MEG is at concept / design-study stage. Values are design targets, not measurements; component selections below are candidates pending detailed design.

4 Clustering and high availability

A single gateway anchors one facility ring. AI/HPC data center campuses can span distances larger than one gateway's radio reach, so TORUS-MEG is **cluster aware**: multiple gateways federate to extend and join sensor networks without a single point of failure.

Capability	Behaviour
Chain / extend	Gateways relay along a corridor to reach node groups beyond one gateway's range, forming a linear chain
Aggregate / join	Independent sensor networks federate into one facility operating picture; events keep their originating <code>gatewayId</code>
High availability	Peer gateways form a cluster with leader election and health checks; on a node or link loss, a standby peer assumes the coverage
Partition tolerance	A gateway that loses backhaul keeps sensing and stores events locally, then reconciles on rejoin (store-and-forward)
Load sharing	Overlapping coverage is balanced across cluster members to spread ingest and inference load

Clustering and HA algorithms (membership, leader election, replication) are a design target for the detailed-design phase; the event contract already carries the gateway identity needed to federate cleanly.

5 Candidate components

Function	Candidate	Role
LoRa concentrator	Semtech SX1302 / SX1303 (8-ch)	Multi-channel 433 MHz receive from the node ring
Edge compute	NVIDIA Jetson Orin NX	Fusion, correlation, thermal/visual inference
Cellular backhaul	Quectel RM5xx (5G) / EG25 (LTE)	WAN uplink where no fixed network exists

Function	Candidate	Role
GNSS timing	u-blox timing receiver	UTC discipline + node almanac
Power	MPPT charger + LiFePO4 pack	Off-grid solar autonomy
Root of trust	TPM 2.0 / secure element	Signed firmware, key storage

6 Design notes and open items

Open items

1. **Edge module vs power** - the Jetson Orin gives visual-domain inference headroom but raises the solar/battery budget; a lower-power SoM may be offered as a node-only-aggregation variant.
2. **Concentrator sourcing** - 433 MHz 8-channel concentrator front-end and filtering to be finalised for EU ISM duty-cycle rules.
3. **Backhaul matrix** - which WAN options ship as standard vs modular is a product decision driven by target deployments (campus perimeter, utility yard, or data hall approaches).
4. **Mesh option** - node-to-node relay for sites larger than a single gateway's RF reach is under evaluation.

TRADEMARKS & THIRD-PARTY NOTICE

TORUS is an independent platform. Company names and product model numbers referenced in this document (including but not limited to Semtech (SX1302/SX1303), NVIDIA (Jetson, Orin), Quectel, u-blox, and their respective product identifiers) are used solely for engineering and bill-of-materials identification. Their use does not imply any affiliation with, sponsorship by, or endorsement by those companies. Supply of any such third-party product or component to the designers, manufacturers, integrators, or evaluators of the TORUS platform remains at the sole discretion of the respective owning company, organisation, or legal entity. All trademarks are the property of their respective owners.